Developing distribution grids

A demonstrator delivered during the Grid4EU project has paved the way for the introduction of advanced metering and visualisation on low voltage distribution grids across Europe. **Erik Hamrin** explains.

The four-year Grid4EU project recently reported its findings in Paris. The project was designed in response to a call from the European Commission (EC) for ideas to lay the groundwork for tomorrow's electrical grids. Ambitious renewable energy targets and large-scale introduction of electric vehicles mean that operators will need to make major changes to transmission and distribution grids to keep the lights on.

To address the challenges represented by the changes, ABB was one of 27 partners, alongside utilities, energy suppliers, vendors and research institutes to test the potential for smart grids in areas such as renewable energy integration, electric vehicle development, grid automation, energy storage, energy efficiency and load reduction.

The EC set five main objectives: to develop and test innovative technologies, define standards, guarantee scalability, guarantee replicability across Europe and evaluate the business case and cost-benefits. To achieve these, six demonstrators ran from November 2011 to January 2016 to account for Europe's varying climates, population densities and network topologies, and enable comparison between the different smart grid technologies.

One aspect that was central to Grid-4EU was that by working in partnership, grid operators, academics and technology vendors would each bring the benefits of their experience. This led to a more integrated and rigorous approach than would have been possible by working in isolation – ultimately leading to a better understanding to develop solutions that will improve the reliability of power supply for end customers.

ABB participated in three of the six demonstrators because Grid4EU offered the opportunity to work in partnership with leading grid operators, academics and other smart grid vendors. Of these, Demonstrator 2 (Demo 2) has shown the potential for the introduction of advanced metering technology across Europe.

Performed in Uppsala, Sweden, Demo 2 focused on the development of monitoring functions on the LV distribution network. Metering has great potential for improving grid reliability. In principle, the data from entire fleets of meters can give operators greater visibility of the conditions on the grid, which in turn improves reliability by monitoring for outages, events and power quality issues.

Vattenfall is the DSO (distribution system operator) for the Uppsala area and already has a high degree of advanced meter management (AMM) technology on its networks, with meters distributed across the network at customer premises.

The main idea of the demonstrator was to investigate what functionality could be designed if a system had access to both consumption data and meter events from the customers as well as consumption data and alarms from the secondary substations that supply energy to them.

To realise this functionality, three tasks needed to be accomplished. Firstly the secondary substations needed to be equipped with communication equipment in the form of remote terminal units (RTUs) to gather information. Second was the establishment of interfaces to pass information between the existing AMM and RTU. Lastly a software stack was built to visualise the data.

When all these elements were ready, the project started by looking at how to improve decision-making for network operators and network planning staff by selecting and reporting the best data.

The first of the three tasks was the development of the RTU-cabinets for the secondary substations. A wide variety of secondary substations exist in LV grids, ranging from small pole-mounted stations to big indoor stations in urban areas.

With Grid4EU's objective for scalability in mind, it was obvious that the design of the cabinets needed to be generic to allow all types of substations to be covered by a small set of cabinets.

For the project, ABB developed four modular cabinets to meet the differing requirements of substations in the field. Inside each cabinet an RTU handles communication and multi-meters convert measurements to signals, while a GPRS modem sends data to the LV SCADA in the dispatch centre (DC) where it is processed. The four models range in size to handle between one and 17 sets of signals.

The design of the modules is compact but functional. With Uppsala being in northern Sweden, heaters were included as well as the main functional components. All cables and antennas are contained inside the cabinets, which can be mounted on an outdoor wall. For the very smallest substations, where space is extremely limited, individual DIN-rail modules can be removed from the cabinets and fitted wherever there is room.

A total of 108 cabinets were installed in the field and connected with customers' existing meters. They gave Vattenfall's dispatch centre access to data from both customers' meters and the substations. This opened up the potential to introduce new functionality.

In parallel with the RTU deployment, ABB developed a software stack that combined three components that enabled operators to visualise grid operations.

The first software was ABB's MicroSCADA for supervisory control and data acquisition, which routes data. Second, DMS600 is a distribution management system that maps out the entire low voltage network. Third, the SYS600 Historian database enables logging and reporting of historic data.

Vattenfall's operators and ABB's engineers agreed to prioritise four aspects of grid operation. These were outage detection, visualisation of meter events, monitoring of losses, and visualisation of historic power quality.

For outage detection, alarms were established to monitor the voltage of outgoing feeders in each substation. Voltages were measured on the busbars and sent via the RTUs to the dispatch centre, where the LV SCADA system continuously monitors the feeder's consumption pattern and triggers an alarm when it drops below a set threshold.

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Operators could immediately see which line reported the outage through the map representation of the entire LV network in the distribution management software.

Meter events are treated much the same, as the distribution management system will show operators the type and location of the most important events. Identifying and recording events such as meter failures, tampering or overcurrent identifies trends and problem areas.

Monitoring power losses and visualising historic power quality rely on the SYS600 Historian database.

DSOs monitor power loss to compare supplied energy with billed energy for feeders, groups of feeders and whole substations. The technique identifies faulty meters or even power theft by integrating data from customer meters and substation monitoring, and presenting the differences visually on a graph.

The final set of data that was recorded under the Grid4EU's Demo 2 was measuring and logging of power quality readings. Similarly to power loss, power quality readings were logged using a database.

In the case of Demo 2, Vattenfall established monitoring of the total harmonic distortion on its network. But DSOs can opt to focus on whatever aspect of power quality would be most helpful to them, such as voltage quality.

Demo 2 has been an eye-opener for ABB's Grid Automation team. By working towards the overlying goals of Grid4EU in collaboration with Vattenfall the team has gained deeper knowledge of the needs of DSOs. This is hugely helpful when developing smart grid products.

One insight from working on the LV network has been that such grids are usually not as well documented as the medium and high voltage networks. Plus, their scale is large – in common with many semi-rural and rural parts of Europe, Vattenfall's LV network in Sweden contains tens of thousands of secondary substations. For a bigger rollout to be possible it is vital that any solutions are generic and modular and that they can be built and deployed easily.

Secondly the multitude of data made available during such a deployment means that we must put firm limits on what data to monitor and send. Traffic volume drives cost and as a vendor ABB has the chance to help DSOs minimise these costs. Demo 2 has been instrumental in defining exactly what data should be sent and when.

Now that Grid4EU is finalised, the project has clarified the next steps for grid automation in Europe. The next step in European smart grid is underway under the banner of Horizon 2020. ABB is also making progress on several commercial projects, with more due to start soon. With the market for grid improvements picking up, ABB is looking forward to help drive this change.

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