Evaluating the UK's first Li-ion grid storage system

Earlier this year, ABB commissioned the first DynaPeaQ Lithium-ion battery based energy storage installation in the UK.

Staff report

Figure 1. Hemsby substation

DynaPeaQ is an ABB grid support system based on the company's SVC Light product combined with Li-ion battery storage. SVC Light is ABB's Statcom concept, utilising voltage source converters connected in a shunt configuration to the grid at the transmission level, as well as at the sub-transmission and distribution levels. IGBTs are utilised as switching devices. It is a fast PWM (pulse width modulation) controlled, IGBT (insulated gate bipolar transistors) based converter used for tasks such as voltage control, flicker mitigation and active filtering.

Its function is to feed the grid with exactly the right amount of reactive and active power needed at each instant, independently of one another, and with a minimum of filter arrangements, improving grid voltage and stability, and levelling out power source fluctuations.

Control of the energy storage system can be achieved from an operator workstation in the control enclosure. An alternative possibility for control could be via web based support.

UK's first dynamic energy storage

Earlier this year ABB commissioned the first UK DynaPeaQ installation. It has been purchased by UK Power Networks and is installed at a substation near Hemsby in Norfolk as part of a collaboration with ABB and Durham University. It is located in an 11 kV grid with considerable penetration of wind power. The project was financially supported through GB regulator Ofgem's Innovation Funding Incentive scheme.

This is a good location for a trial of the 200 kWh storage station because the energy from the 2.25 MW wind farm fed into the power network allows demonstration of the ESS' ability to alter the energy profile and regulate the power flow to compensate for the intermittence of wind input.

The storage system includes eight stacks of 13 Saft lithium-ion battery modules housed in a 25 m^2 building. The modules are continually charged and discharged and enable dynamic control of power in the transmission system. In typical commercial use the rated capacity of a storage system like this would be 20 MW for approximately 15–45 minutes, although DynaPeaQ installations can be scaled up to 50 MW of power for 60 minutes or more. Using this scale of storage strategy, it should be possible to harness power from the wind more efficiently use than would otherwise be possible.

Li-ion battery technology was selected for its long calendar lifetime, high power density, and high round-trip efficiency. Safety and protection is ensured by interlocking and supervision and control from cell to system level.

Test network

The site was selected such that the maximum number of benefits with the energy storage system could be examined at a single installation. The storage device is installed at a normally open point between two primary substations, near the remote ends of 11 kV feeders from the substations. Only one feeder is connected to the ESS at any single moment, but it is easy to switch between feeders, allowing for different operational scenarios. Physical network information such as line and transformer data is provided by the DNO as well as by half-hourly operational data comprising feeder current and distribution grid output.

A mix of permanent, rural and seasonal residences is supplied by the two feeders. The typical loads are 1.15 and 1.30 MW with peaks of 2.3 MW and 4.3 MW respectively. The wind farm (with 2.25 MW installed) is attached midway along the first of these feeders. This installation has fixed speed induction generators, so there is significant reactive power demand while generating.

Daily load profiles show that the two feeders have quite different characteristics because one has a high number of homes heated by night storage heaters. This has lower summer loading than during the winter while the second feeder is the reverse. These dissimilar characteristics mean that events requiring ESS support are likely to occur at different times, maximising the utilisation of the ESS.

A range of modelling and simulation work has been carried out by Durham University to evaluate the most effective way to operate the ESS on a distribution network. This activity has been paid for by the Ofgem funding.

Figure 2. Single-line diagram of DynaPeaQ

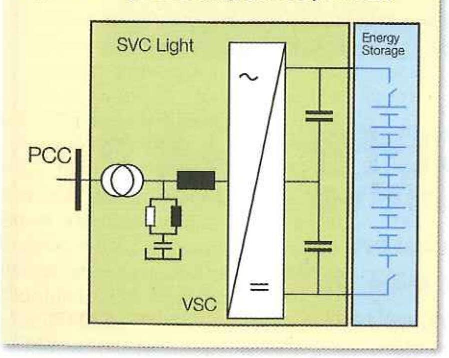
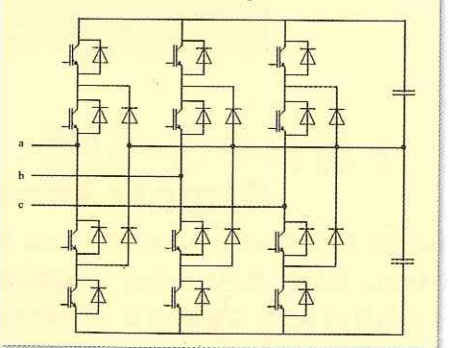


Figure 3. 3-level VSC configuration



Main circuit design

The size of the energy store was determined by the cost that could be reasonably justified as an R&D project. ABB integrated a battery system with an SVC Light based on a VSC to enable independent sourcing or sinking of real power up to 600 kW and reactive power up to 600 kvar (Figure 2). The DC side of the VSC is connected to Li-ion batteries with a capacity of 200 kWh. An ABB MACH 2 control system controls both the VSC and the battery system.

A dry-type step-down transformer rated at 1 MVA is employed to optimise the VSC voltage. The VSC has a nominal rating of 850 kVA. A passive harmonic filter rated at 125 kvar and tuned close to the 37th harmonic is installed to satisfy harmonic requirements at the 11 kV Point of Common Connection (PCC).

The DynaPeaQ has a dynamic reactive power range from 600 kvar inductive to 725 kvar capacitive. The battery storage connected to the DC side of the VSC can deliver 200 kW for one hour, or 600 kW for a short period.

The VSC configuration of diode and IGBT valves in each phase leg is shown in Figure 3. One side of the VSC is connected to a capacitor bank, which acts as a DC voltage source. The converter produces a variable AC voltage at its output by connecting the positive pole, the neutral, or the negative pole of the capacitor bank directly to any of the converter outputs. By use of PWM, an AC voltage of nearly sinusoidal shape is produced without any significant need for harmonic filtering. This contributes to the compactness of the design, as well as robustness from a harmonic interaction point of view.

Battery storage

The battery system of eight identical Li-ion battery stacks in series incorporates DC switches for isolating the battery system from the DC side capacitors at minor contingencies while keeping the VSC in operation, thereby maintaining reactive power control.

Control

The ESS can operate in an automatic mode where local voltage measurements are used to determine the required injection of reactive power to stabilise the voltage at the ESS.

To enable decision making from a wider range of measurements across the network, data would be collected and processed by algorithms on a central control system. Decisions would then be issued as ESS set points for active and reactive power control. MPS