

Unit IV

Management and control hierarchy of storage systems

4.1 Management and control hierarchy of storage systems

In this section the concepts of the management and control of storage systems are introduced. While it is essential to have local management for the safe and reliable operation of the storage facilities, it is equally important to have a coordinated control with other components in the grid when grid-wide applications are desired. The purpose of this section is to help readers visualize the components and their interactions for some of the applications described in this paper.

Many storage systems are connected to the grid via power electronics components, including the converter which modulates the waveforms of current and voltage to a level that can be fed into or taken from the grid directly. Sometimes the converter is connected to a transformer before the grid connection in order to provide the required voltage. The converter is managed by a controller which defines the set-points of the storage system. These set-points can be expressed as the magnitude of active and reactive power, P and Q . Such a controller may also be called control electronics – a controller in this context is simply a representation of the place where intelligence for decision-making is applied.

4.1.1 Internal configuration of battery storage systems

Complex storage systems consisting of batteries are equipped with a Battery Management System (BMS) which monitors and controls the charge and discharge processes of the cells or modules of the batteries. This is necessary in order to safeguard the lifetime and ensure safe operation of the batteries. The diagram in Figure 3-17 shows a possible realization of the internal control architecture for a battery storage system. It should be noted that for bulk energy storage it is very likely that there is a more refined hierarchy for the BMS, which involves a master control module coordinating the charging and discharging of the slave control modules. It is possible that the batteries and converters are from two different manufacturers, and therefore compatibility and interoperability of the two systems regarding both communication and electrical connections is imperative.

4.1.2 External connection of EES systems

The P and Q set-points for an EES for a certain application can be set locally or remotely, depending on the control scheme implemented. The control scheme should in turn be determined by the application. More precisely, the application determines the algorithmic and input/output requirements for the EES system. For instance, an application which requires simple logic using only local measurements can have the set-points determined locally through the storage controller. An example of such an application is load levelling, which only needs to know the loading conditions of the local equipment (e.g. lines, transformers) next to which the EES is installed. The same applies for applications which have pre-determined set-points that do not change during operation. However, set-points for applications which require dynamic adaptation to the network operational environment and much remote data or measurements might be better

determined by a remote controller which can gather these remote inputs more efficiently. One example of such an application is wind power smoothing, which uses wind output forecasts as well as measurements from the wind farm as inputs. Another example is energy time-shifting, making use of dynamic market prices. A generalized setup with remotely determined set-points is shown in Figure 3-18. Batteries and the BMS are replaced by the “Energy Storage Medium”, to represent any storage technologies including the necessary energy conversion subsystem.

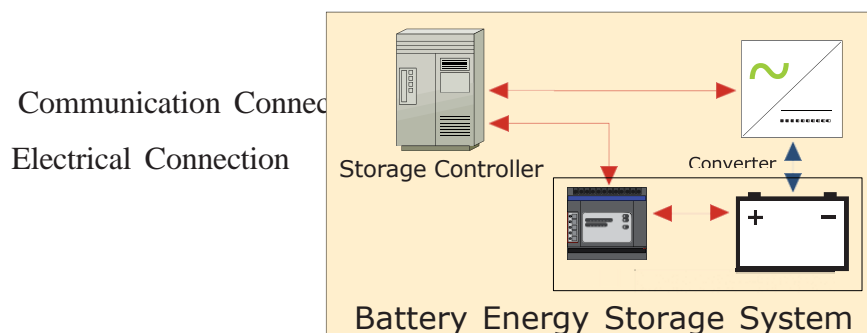


Figure 4-1 | A possible realization of internal control architecture for a battery storage system

4.2 Aggregating EES systems and distributed generation (Virtual Power Plant)

The control hierarchy can be further generalized to include other storage systems or devices connected to the grid, illustrated in Figure 3-19. This diagram represents an aggregation of EES systems and DGs (Distributed Generators) which can behave like one entity, a so-called “VPP with EES” in this example. VPP stands for Virtual Power Plant which, according to one definition, is *the technology to aggregate power production from a cluster of grid-connected distributed generation sources via smart grid technology, by a centralized controller which can be hosted in a network control centre or a major substation*. The integration of distributed energy storage systems at different locations of the grid will further enhance the capabilities of the VPP. It should be noted that in the figure the communication and electrical infrastructures are highly simplified in order to show the general concept but not the details.

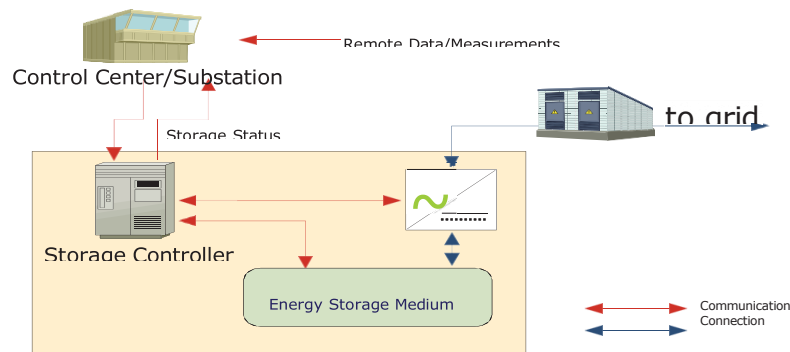
A concrete example of an implementation based on aggregated energy storage systems using batteries is given in the following section on “battery SCADA”.

4.3 “Battery SCADA” – aggregation of many dispersed batteries

As progress is realized in battery capabilities and costs, many batteries will be installed both by consumers and in the grid, with large cumulative capacity and correspondingly large effects. Most will be small battery storage systems, dispersed in location and used locally. However, if they are gathered into a virtual assembly and controlled centrally, they may also be used for many utility applications, such as load frequency control, load levelling and control of transmission power flow. To implement such uses, a group of battery manufacturers and electric utilities in Japan is developing technologies for central control of dispersed batteries, named “Battery SCADA”.

Using Battery SCADA distributed batteries can be assembled and managed like a virtual large-capacity

battery, and batteries with different specifications made by different manufacturers can be controlled and used by grid operators in an integrated way. Battery SCADA is shown schematically in Figure 3-20. Information from batteries on both the grid side and the customer side is collected by Battery SCADA, processed, and transmitted to the control centre. Based



on this information and the situation of the network, the control centre sends commands to Battery SCADA, which distributes corresponding commands to each battery system.

Demonstration of this technology will start in 2012 in Yokohama City, Japan, with various types of Li-ion batteries installed on the grid side and in consumer premises, to be controlled by the Battery SCADA.

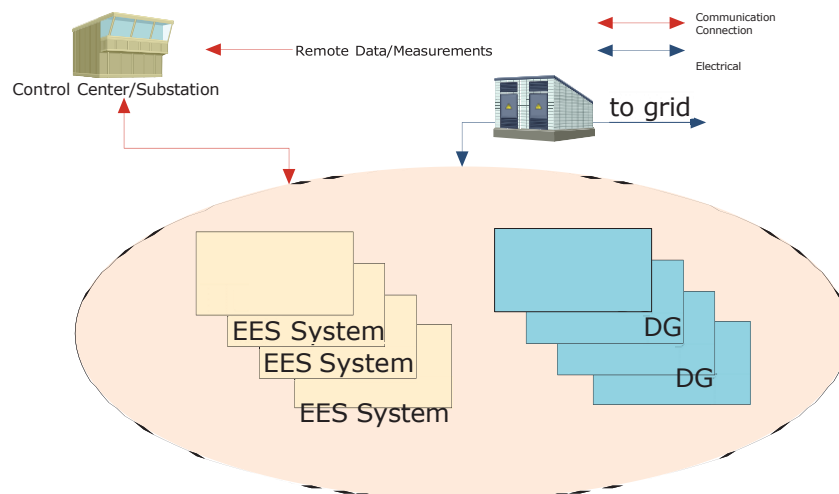


Figure 3-19 | A generalized control concept for aggregated EES systems and DGs (ABB)

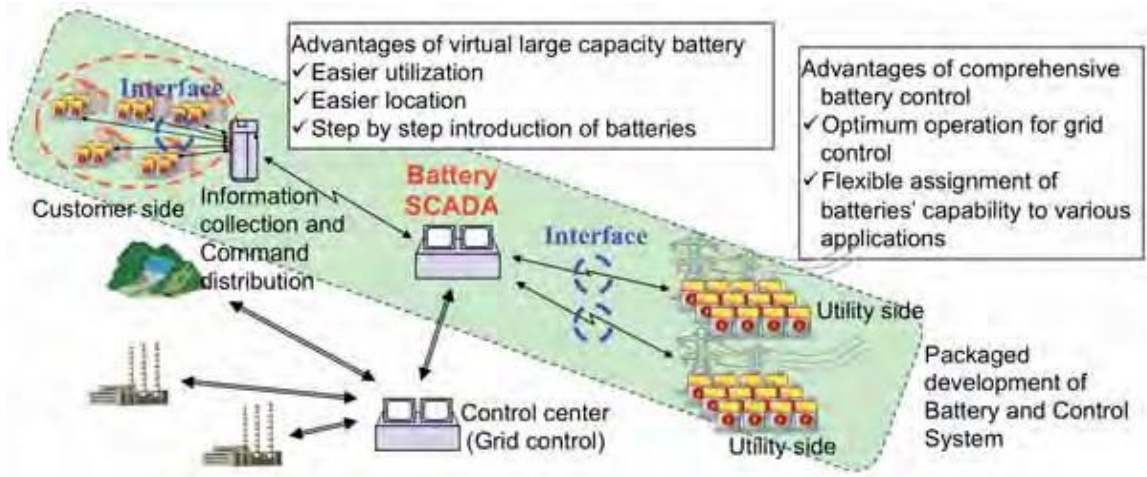


Figure 3-20 | Schematic diagram of Battery SCADA (TEPCO)