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QUESTION N° : 2.3

Contribution for Q 2.3 – In what circumstances are supporting technologies, such as battery energy storage systems or synchronous condensers, needed to complement the capabilities of the power electronic interfaced resources? How are control interactions between these technologies being managed to improve power system technical performance?

South Australia (SA) is one of the five regions of the National Electricity Market (NEM) of Australia. This region has one transmission connected large grid-forming battery energy storage system (BESS), Dalrymple BESS, in operation since April 2018. Another transmission connected large grid-following BESS, Hornsdale Power Reserve (HPR) had two inverters in grid-forming mode online for some time.

The Dalrymple BESS is rated at 30 megawatts (MW) charge and discharge capacity, and has a storage capacity of 8 megawatt hours (MWh). The Dalrymple BESS is connected to a remote part of the SA 132 kV transmission network, which is supplied via a single 132kV circuit. The Dalrymple BESS has demonstrated various key features of a grid-forming BESS while in operation. These are

- Stable operation in a weak grid environment – The battery is connected at the fringe of the network with a long radial connection to the grid. The short-circuit ratio (SCR) at the connection is extremely low, circa 2.0. The BESS has been successfully operating since it was commissioned in April 2018 and has demonstrated stable operation in a weak grid environment.
- Seamless transition to an islanded operation – The BESS is configured to operate in an island mode feeding local load. During planned and unplanned outages of the upstream network, the BESS has successfully transitioned from grid-connected to islanded mode without supply interruption to the local load. Following successful transition to island mode, it has been demonstrated to provide reliable and secure supply to local customers.
- Synthetic inertia response – During an incident which disconnected the SA region from the rest of the NEM regions, the response from Dalrmple BESS has demonstrated synthetic inertial response. Soon after delivering inertial response, the BESS control system took over to provide primary frequency response as per the agreed specifications of frequency control ancillary services.
- Short term overload capacity – The BESS has the capability to provide up to 2 per-unit (pu) current for 2 seconds. These fault current help protection systems identify and clear the faults in the vicinity of the BESS.
- Participation in system integrity protection scheme (SIPS) – The BESS is configured to discharge upon receiving a signal from the SIPS. The signal is initiated from a remote substation which is configured to detect potential loss of synchronism between South Australia and the rest of the NEM regions. The fast discharge of active power within 250 milliseconds (ms) aims to relieve stress on the interconnector to a certain extent. The capability of fast discharge has been demonstrated through field test.
- Black start – The BESS has the capability to behave as a cranking generator. It can provide soft-energization to the nearby 33 kV substation. The feature of soft energization helps to avoid in-rush current associated with transformer energization.

The inverters are configured to change parameters that are suitable for system energization.

The Horsdale Power Reserve (HPR) BESS is located north of Adelaide in South Australia. The HPR BESS is rated at 150 MW discharge and 130 MW charge, and has a storage capacity of 193.5 MWh. Two of the inverters of HPR BESS have been configured into Virtual Machine Mode (VMM). These two inverters have been configured to mimic a synchronous machine, while the remaining inverters have been left in grid-following mode and provide droop-based frequency control. During a system frequency event the response from the grid-forming inverters was captured to understand their behaviour. The response from the grid-forming inverters in VMM is driven by the rate of change of frequency (RoCoF). For a higher RoCoF it provides a larger response and vice-a-versa. This effectively mimics the post-disturbance behaviour of a synchronous machine.