Operation of a power grid with 100% generation behind power electronics interface

Nilesh Modi, AEMO

Integration of renewable energy in the grid is growing exponentially worldwide. The majority of these renewable energy resources are connected to the existing grid via power electronics devices. Most of the grid operators have seen a significant uptake in connection of non-synchronous generation. To manage the power system security some grid operators are already restricting the penetration of renewable generation under certain operating conditions. For example, EirGrid restricts non-synchronous generation up to 55%, and AEMO has a requirement for a minimum number of synchronous machines online in South Australia.

Operating a grid where all generation sources are behind power electronics has been achieved in small isolated grids, such as micro grids and offshore grids. However, operating a large grid with 100% of generation behind power electronic devices poses a number of challenges.

The operating procedures and tools developed for the existing power grid is based on the assumption that synchronous machines will dominate the grid. Under the scenario of 100% generation behind power electronics, not only all generating systems would run asynchronously, they also become decoupled from the grid due to the presence of power electronic devices. This poses a significant challenge in terms of operating a large scale power system, achieving supply-demand balance and ensuring system security.

The existing power electronic devices are 'grid following'. They measure voltage and frequency from the grid and inject current into the grid to deliver desired active and reactive power. Going forward, we will need 'grid forming' converters, and they will need to generate frequency.

Currently, imbalance in generation and demand is reflected in the grid frequency. Any material change in frequency (due to a large change in load or generation) is corrected by synchronous machines modifying their output. In the absence of synchronous machines, this needs to be achieved from thousands of power electronics devices. Also, these devices should be able to share continuously changing grid demand and avoid any potential overload. The existing definition of grid stability (in terms of transient and voltage stability) needs to be better understood, for the situation when there is no synchronous generation online. System security needs to be better understood under this new operating regime.