Mechanically switched capacitor banks

An environment-friendly solution for increasing transmission grid capacity and improving power quality. The increasing connection of renewable energy sources to the power transmission grid creates new reactive power needs to manage power quality.

Power transmission grids are planned, designed and engineered to connect generating plants with load centres. Generating plants include nuclear, coal- or gas-fired thermal plants, or large-scale hydro-electric generating facilities. These base-load generators are operated continuously. One of the key planning criteria is that generating plants should be as close as possible to load centres such as cities or industrial regions to reduce power transmission losses.

The transmission grid is the energy highway between generating plants and load centers. So the grid capacity is dimensioned to carry the flow of base-load energy within designed tolerances for variations. Variations, for example, include the loss of a transmission line, in which case the electricity flow to a load centre is redistributed across other lines to ensure continuity of supply.

Grid capacity is systematically increased according to load growth projections. Dynamics also occur on the grid loading, caused either by the generating plants or the load centers. In addition, seasonal variations in demand are superimposed on the load center growth projections. For example, during the winter, when more heating is required, the load centres’ demand increases, and the loading on the transmission grid increases. Higher currents flow through the transmission lines, which absorb more reactive power. Also, the voltage drop across the transmission line increases due to the higher currents. These effects become more severe when transmission lines are long. That is why generation plants should be close to load centres. When the transmission line reactive power is compensated, the line capacity is improved. Hence a more stable power transfer as well as an improved voltage profile at the load centre. The transmission grid voltage is a key power quality parameter, to be managed within limits by the network operator.

Transmission grids with large wind farms as generating plants

In an existing transmission grid, the required reactive power compensation to manage the power quality is in accordance with the planned energy flow across the grid from base-load generators to load centres. Recent developments in the generating side of the electricity industry have affected the energy flow across grids compared to original planning. In Germany these developments include the unbundling of generation and transmission utilities and strong incentives for renewable energies such as wind power. As a result, an increasing base of large wind farms is being installed in the north of Germany. These wind farms, both onshore and offshore, have capacities of up to a few hundred megawatts. The base-load generators are no longer only thermal or hydro plants.

The impact of these large wind farms on the German transmission grid is two-fold: new feed-in points and long distances from feed-in points to load centers since there are a number of large regional load centers in the central and southern parts of Germany. As a result, the issues that need to be managed are voltage quality and reactive power compensation for stable transmission.

Mechanically switched capacitor banks – a plus for the environment

Areva T&D has designed a reactive power compensation solution based on switched capacitor banks. This solution provides reactive power where it is required at local points along the transmission path and is integrated as a system into existing substations. Its relatively small footprint is a major environmental advantage in comparison to the impact of building a new transmission line. Moreover, as required reactive power is supplied locally, it need not be procured and transmitted from a power plant. This brings about a further major advantage in the reduction of CO₂ emissions.

The reactive power compensation solution has the topology of a mechanically switched capacitor with damping network (MSCDN). Capacitors are combined with air-core reactors, auxiliary capacitors and shunt resistances to form a C-type circuit. As an addition to existing substations, some engineering challenges had to be resolved. For example, space is limited inside a high voltage substation, so the MSCDN is mechanically and electrically optimised to fit into the allocated space.

Reactive power compensation with capacitor banks was used in transmission grids for the very first time in Germany in the summer of 2008. It was commissioned for E.ON Netz. In total, three MSCDN systems were supplied: 300 MVar, 380 kV each for the Holm and Landesbergen substations, and 250 MVar, 380 kV for the Borken substation. These three compensation systems almost double the capacity of the trans-mission path from 1320 MVA, 2000 A to 2070 MVA, 3150 A.

Areva T&D expects the architecture of the future transmission grid in Germany to include more MSCDN solutions. In the summer of 2008, EnBW Transportnetze AG confirmed this trend by ordering two MSCDN systems, this time with the additional environmental requirement for low audible noise.

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