North – South 500 kV AC power interconnection: transmission stability improvement by means of TCSC and SC

Since spring of 1999, Eletronorte of Brazil has been operating a Thyristor-controlled Series Capacitor (TCSC) and five fixed Series Capacitors supplied by ABB in Eletronorte’s 500 kV interconnector between its northern and southern power systems. All in all, about 1.100 Mvar of series capacitors have been installed by ABB. The TCSC is located at Imperatriz at the northern end of the power corridor connecting the two systems which were previously not interconnected.

Feasibility studies had been performed regarding the interconnection of the two systems, and a decision was made to go ahead and build the transmission corridor. Both AC and DC alternatives were assessed, and decided in favour of the AC option. It consists of a single 500 kV compact circuit (subsequently doubled), more than 1.000 km long and series compensated in several places along the line. Operation began in 1998. The power transmission capability of the corridor is 1.300 MW.

Efficient exploiting of hydroelectric resources
The two power systems are mainly hydroelectric, comprising more than 95% of the nation’s total volume of power generation and consumption. The “North-South Interconnection” has the purpose of exploiting the hydrologic diversity between the systems, and power flow occurs in both directions, depending on current hydrologic conditions. As a consequence, the risk of energy deficiency in conjunction with the rapidly growing energy demand experienced by the country at present is reduced.

The AC option is highly attractive as it facilitates the making of inexpensive hydro energy available to a rapidly growing federal economy as well as to future development over a vast area having great economical potential. Several hydroelectric plants are expected to be built along the same route in the coming two decades, to be connected to 500 kV AC.

The integration of the national power system will also have other related benefits, as for instance a reduction of the required spinning reserve.

Power oscillation damping
The series capacitors installed in the North-South Interconnection have the task of raising the steady-state and dynamic stability of the intertie. The TCSC at Imperatriz, the first of its kind to be installed in Latin America, has the task of damping low-frequency inter-area power oscillations between the power systems on either side of the interconnection. These oscillations (0.2 Hz) would otherwise have constituted a hazard to power system stability and thereby to power transmission capability. The TCSC efficiently eliminates this obstacle to power transmission.
For power oscillation damping, the TCSC scheme introduces a component of modulation of the effective reactance of the power transmission corridor. By suitable system control, this modulation of the reactance is made to counteract the oscillations of the active power transfer, in order to damp these out.

The boost level, defined as the ratio between the virtual reactance of the series capacitor and the physical capacitor reactance is a key factor. It is a measure of the amount by which the reactance of the series capacitor can be virtually augmented in order to counteract system power oscillations.

The boost level can be varied continuously between 1 and 3. Expressed in terms of degree of compensation, it can be controlled over a range between 5% and 15%. At rated line current, the nominal boost level has been set to 1,20.

**Thyristor valve**

The thyristor valve is mounted at platform level. It is water cooled and utilizes indirect light triggered thyristors. The valve is rated at 1500 A continuous current and at 3000 A for 10 seconds. Furthermore, since the valve has to perform as back-up protection of the TCSC in extreme situations where the main ZnO overvoltage protection is reaching its thermal limit, it needs to be able to withstand fault currents of up to 40 kA (peak) for about 60 ms, equal to the time it takes the by-pass breaker to close and take over the fault current.

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