PLANNING HVDC EMBEDDED TRANSMISSION SYSTEMS – BRAZILIAN EXPERIENCE

The Brazilian interconnect power system presently operates with six HVDC bulk long-distance transmission bipoles links, associated with large hydropower generation. Two of them, with nominal voltage 800 kV [1], are embedded [2] into the AC meshed network. A third 800 kV long distance DC link (Nordeste I), also an embedded link, is currently in its final planning stage, as illustrated in Figure 1. The new bipole has been conceived to carry the surplus power from the Northeast(NE) region, produced from variable renewable generation (VRG), predominantly wind and solar generation, and also to reinforce an existing AC regional interconnection, the North – South transmission corridor.

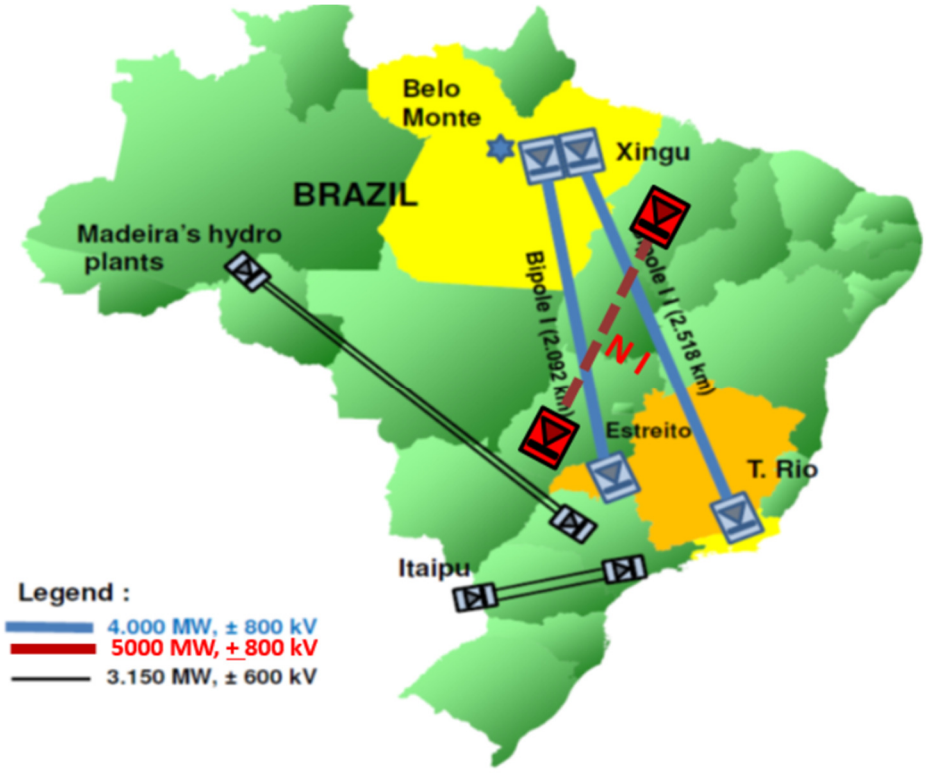

Figure 1 – HVDC links in the Brazilian power network

All these HVDC bipoles systems uses line-commutated converter (LCC) technology, including the new link, as recommended by the planning studies. In addition to the requirements attended during the conception of regular (not embedded) HVDC links with LCC technology, which includes minimum short circuit levels at AC terminals, adequate reactive compensation, frequency control and multi-infeed acceptable dynamic performance, there are other relevant design aspects to consider for the embedded links. Based on the Brazilian experience, some design aspects are detached, as follow.

- ✓ HVDC power flow control to minimize the potencial loop flows (illustrated at Figure 2) and increses in losses. There is a potencial fluctuation in generation and load on the meshed network, especially in aereas with predominnce of VRG, as in some areas of the Northeast.

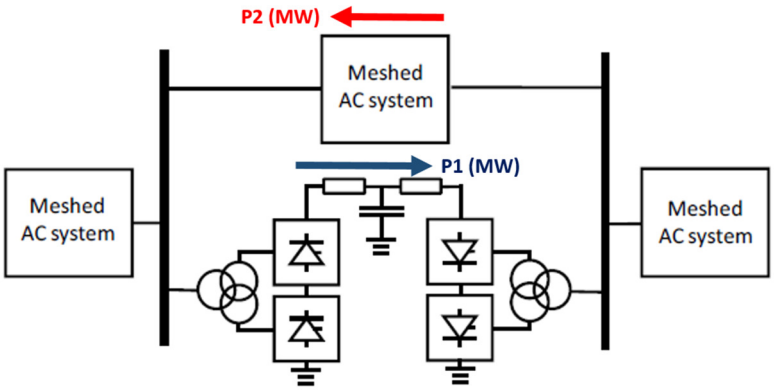

Figure 2 – Loop flow (adapted from [1])

- ✓ HVDC control provided with communication with other bipoles and with strategic AC transmission lines, allowing power transfer (run up/runback), limited to the overload capacity of the HVDC system, contributing for the electromecanic stability, after external events on AC or DC network (For the Belo Monte and Madeira links). As the new link (Nordeste I) was, also, conceived to reinforce the North-South AC corridor, in case of these AC lines became loaded the HVDC shall adjust the North-South flow.

- ✓ Power Oscillation Damping (POD), used for damping power oscillations in the AC system when the oscillation are observed, at least at one end of the HVDC transmission system. The Brazilian HVDC embedded links connect long distant points of the network, ranging from 1500 km to 2500 km.

- ✓ Temporary increase of reactive absorption capacity, provided by converters or compensation elements associated to the HVDC project. This extra reactive support can be necessary in scenarios of substantial load and/or generation reduction, when the AC grid capacity is temporary idle (it is more likely to happen in areas with load and wind generation).

- ✓ Power reversal capability, in addition to the direct transmission, considering the different possibilities of generation and load in the North and Southeast regions. For the regular links in Brazil (not embededd) this capability is not necessary as their are dedicted to transmit from a large generation plant.

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BIBLIOGRAPHY

[1] D. S. Carvalho, A. M. Silva, J.H. Almeida, T.C. Rizzotto, M.J. Ximenes, O.J. Rothstein, R. Ristow, F. Alves, R. Azevedo, J.A. Cardoso, A.Dias Jr., F. C. Jusan, A.M. Pena, R. Broetto, M. P. Monteiro. “A second and longer + 800 kV DC bipole completes Belo Monte’s integration” (paper B4-101, Bienal Cigré, Paris, August 2016.

[2] Influence of Embedded HVDC Transmission on System Security and AC Network Performance, Cigre Brochure 536, JWG C4/B4/C1, April 2013.