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Engineering of Power Flow Control across the Zambia – Zimbabwe Interconnector with Phase-Shifting Transformers

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***Abstract* — The paper reports the engineering performance evaluation and simulation studies of the phase-shifting transformers (PSTs) applied to the planned interconnector between the national electric grids of Zambia and Zimbabwe, in Africa. This solution was proposed to the Zambezi River Authority, the implementing agent for the Batoka Gorge Hydroelectric Scheme (BGHES), on the Zambezi River, for addressing the issue of controlling power flows across the newly conceived interconnector in a reliable, safe and resilient manner. For the engineering purpose, the feasibility studies have proved and confirmed the expected performances and effectiveness on the controlled interconnector operation. The authors describe the assessment of the viability of this solution from a system operation perspective, having carried out a screening of possible alternatives other than PST-based, and checked the expected PST's capabilities in both static (load flow) and dynamic behaviour through a comprehensive network study campaign.**

***Keywords*—power corridor, phase-shifting transformer, transient stability, power flow control, FACTS**

I. Introduction

The Batoka Gorge Hydroelectric Scheme (BGHES) has been demonstrated to be the least-cost of a series of hydropower investments originally conceived in the '70s as part of a cascade on the Zambezi River Basin, shown in figure 1. The project is being implemented by the Zambezi River Authority (ZRA), an organization equitably owned by the governments of Zambia and Zimbabwe, to develop, operate, monitor and maintain hydropower projects along the Zambezi River common to the two Southern African countries [1]. The power sector of both countries has been struggling with the challenge of supplying reliable electricity to meet the needs of the growing economies and providing universal access to electricity. In this scenario, the hydropower resources of the Zambezi River Basin, with more than 5,000MW already implemented (with Cahora Bassa, Kariba and Kafue Gorge dams) and about 15,000MW of potential, are integral to the development of the power sector in Zambia and Zimbabwe.

As part of the scheme, the project includes two hydropower plants, one per each riverbank, totalling 2,400MW (10,200GWh/y of energy production) with relevant stepping-up substations interconnected via 330kV circuits, and several lines heading to the respective national grids. The rated power of each power plant will be evacuated respectively via 330kV overhead lines (OHLs) towards Zambia, 400kV to Zimbabwe.

The project's extent had to be supported by a suitable power evacuation scheme, capable to operate in the most stringent contingencies also in consideration of the role of the BGHES within the regional generation park.

Fig. 1. BGHES project location

II. Study's Objective

At the feasibility stage of the scheme development, it came to light the need for regulating and controlling the power flow from the BGHES across the 400kV outgoing lines towards Zimbabwe, due to multiple parallel connections. The study's objective was to confirm the suitability of the proposed BGHES transmission scheme with power flows compatible with the interconnected network operation of the target scenario (as shown in figure 2), based on a combined asset of the two national grids with power export. The unit commitment considered for balancing the grid load demand (4,620MW in Zambia, 4,510MW in Zimbabwe, 920MW of

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