Pumped-Storage Plants improving Brazilian Interconnected System operation when facing high solar and wind sources participation

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***Abstract* — Considering a system based on hydroelectricity, with a significant penetration of renewables (wind and solar) and high barriers to build new dams and reservoirs; this paper presents the benefits that the installation of pumped-storage power plants (PSP) could add to such system, improving its efficiency and respecting the expanding boundaries. A case study was developed considering sixteen hydroelectric plants from a real cascade, one equivalent PSP and five wind farms. Through an evolutionary algorithm, the PSP operation was optimized focusing on minimizing the spillage that could be used to generate power in a convenient moment. To prove this concept, three different hydrologic scenarios were analyzed: wet, dry and medium seasons; based on the real water inflow of the river, according to historical measurements. This investigation makes possible to conclude that a PSP can effectively reduce the effects of intermittency of wind and solar generation, optimizing a subsystem having a topological structure commonly found in the Brazilian Interconnected System.**

***Index Terms* — Energy Storage, Pumped-Storage Plants, Renewable Energy, Wind Integration, Solar Integration.**

I. INTRODUCTION

The Brazilian Electric System has a unique characteristic: based on hydro and thermal generation it contains traces of almost every kind of generation plant and is moving toward a large wind and solar penetration. According to the Regulatory Agency responsible for Electric Energy (ANEEL), in June of 2016 the installed capacity in the Brazilian Interconnected System (BIS) was 144,129 MW [8], where hydroelectricity share corresponded to 64.5%.

The BIS is divided into four very particular subsystems, with their own characteristics and limitations. To fully understand the BIS, it is important to comprehend the role that each subsystem plays in the generation and consumption, as well as the transmission limitations between each system. In Fig. 1 it shows the energy exchange balance between each subsystem in 2015 [14]. The largest part of the Brazilian generation capacity is located in the southeast/center-west subsystem, where is also concentered the largest energy demand and the main hydroelectric reservoirs in the BIS. However, today, most of the unexplored hydroelectric potential is in the North Subsystem, a geologically flat region embraced by the Amazon Rainforest.

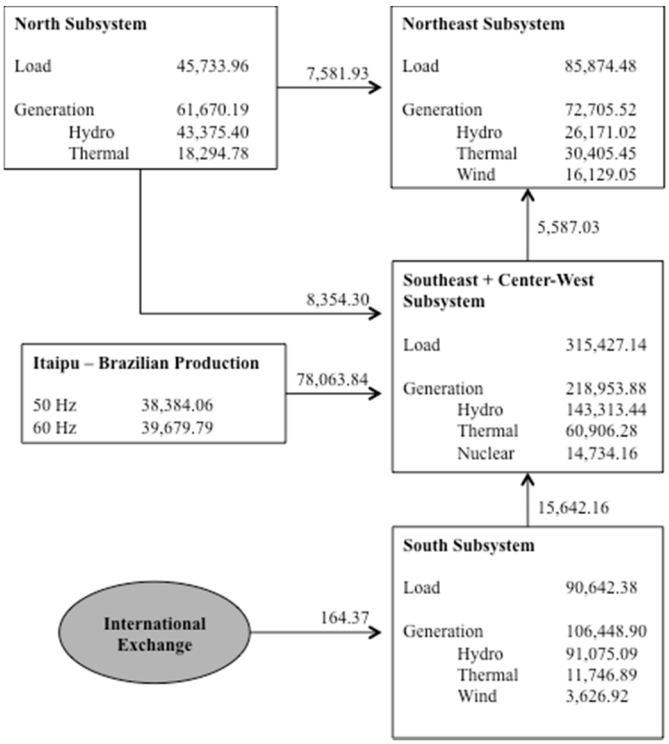

Figure 1. Energy Exchange between each Subsystem in the BIS.

Although there are large hydroelectric plants being constructed in the North Subsystem, new hydroelectric plants are run-of-the-river dams intended to reduce flooded area and prevent environmental damages. This reduces the amount of energy the system can store, and makes electricity generation

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