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Power electronics in hydro electric energy systems – A review

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ABSTRACT

Hydropower is a major energy source among the renewable energy sources. According to "BP Statistical Review of World Energy, June 2013", 16.34 percentage of global power generation acquire from hydropower. To attain efficient generation in hydro plant, extensive design with the up to date technology is mandatory. To make the generation more effective various technologies are adopted, among these the very effective one is power electronics (PE) technology. The paper has reviewed the challenges in how PE technology fits in as the solution for various hydroelectric energy systems (HEES). The PE technology is adapted efficiently in various parts of HEES like, grid integration, machine control, switching (pumping mode to generating mode and vice versa), power control, voltage and frequency control, power factor correction, etc., The advancement of PE technology diminishes the cost and space of the plant and enhances the power handling capability. The paper emergence the outstanding features of power electronics in various aspects that will extensively contribute to the development of HEES around the world. In addition, PE contribution satisfies the need of reliability, dynamic response, efficiency, protection, etc., in HEES.

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1. Introduction

According to the law of energy conservation, the hydroelectric energy systems are extracting electricity from water. Globally, 3673.1 Terawatt-hours of energy are consumed from hydropower in various countries as shown in Fig. 1. These hydroelectric energy systems are classified according to the accessibility of sources. The traditional hydroelectric plants are capable to produce power up to few GW. Small hydro plants are also available without dam or water storage. According to the plant rating, the small hydro plants are further classified into mini (rated up to 1000 kW), micro (rated up to 100 kW) and Pico (rated up to 5 kW). Pumped storage plant stores electrical energy in the form of potential energy by raising the water to the highest level and utilizes during demand period. This generated power is utilized by the consumers directly or once after synchronizing with the grid, which depends upon their location and rating. In the above process, the voltage and frequency should maintain constant and it can be achieved by controlling the generating machines through PE converters in various aspects like excitation control, dump load control, etc., In pumped storage plants, same machine is operated for both pumping and generation at variable speed to provide more efficiency. This effective operation of the machine can attain through PE converter adapted with different control technique. Hydroelectric generation enabled with the advanced power electronics and proper control strategies possess superior performance in their technical characteristics like voltage and frequency regulation, active and reactive power control, short circuit control, fault ride through, etc., [1]. Therefore, above all generation, conversion and transmission controls would fulfill only with the help of PE technology.

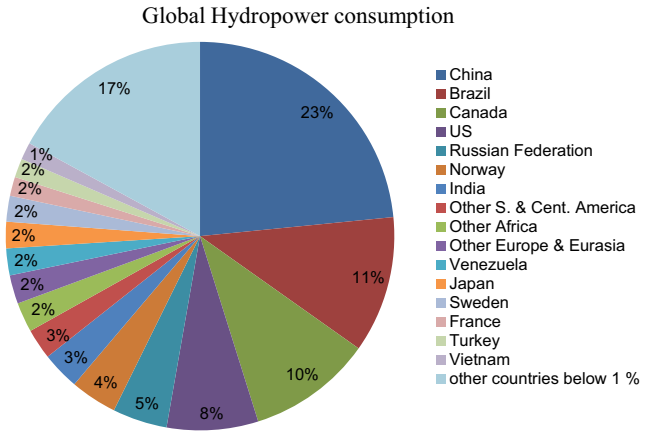

Fig. 1. Global hydropower consumption.
Source: BP Statistical Review of World Energy, June 2013.

The paper depicts the various aspects of power electronics technology in hydroelectric energy system as in Fig. 2. In **section 2** the PE in grid integration, in **section 3** the PE binds with machine control, in **section 4** PE for variable speed operation in both generation and pumping mode of operation, in **section 5** the PE in voltage and frequency control and in **section 6** future trends are described in detail. Finally, the paper concludes in **section 7**.

2. Grid Integration

The interconnection of two or more generating sources in the transmission network is known as grid integration. This balances the supply and demand at all the time and it should be executed

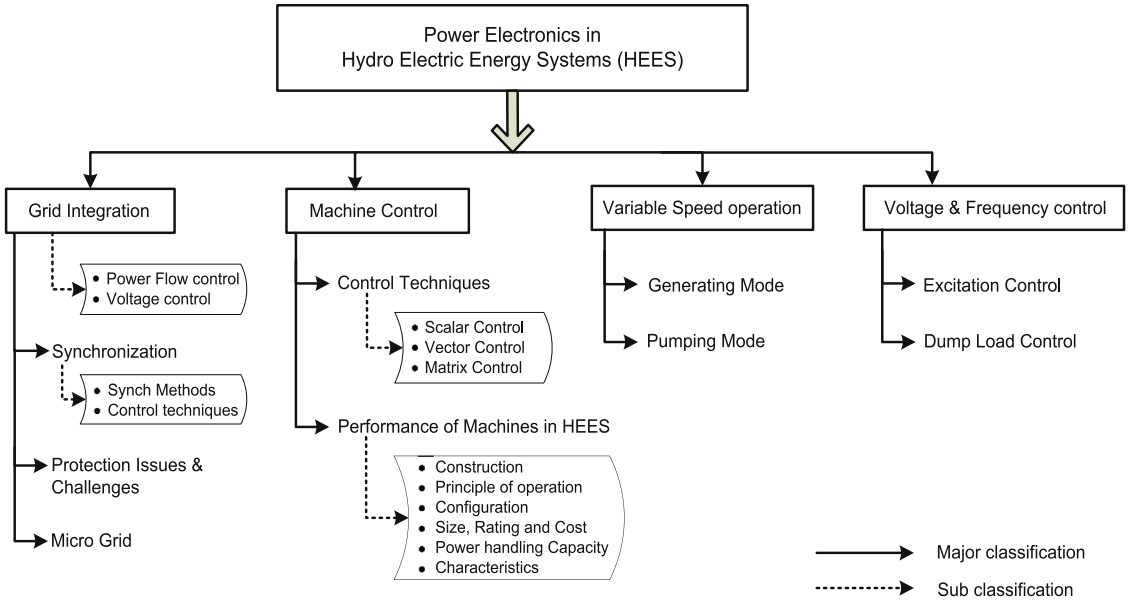

Fig. 2. Perception of the paper.