Future hydropower production in the Lower Zambezi under possible climate change influence

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ABSTRACT

Hydropower is the most important energy source in Mozambique and many other countries in southern Africa. Substantial hydropower development is planned for the Lower Zambezi for the next decades, with regional importance due to integration into the Southern African Power Pool. For such a long-term development, the possible impact of climate change on the future production is of essential interest. The objective of the presented study is to assess hydropower generation in the 21st century for a future hydropower development scenario under two climate scenarios. The two climate scenarios represent a future wetting climate and a future drying climate, both with considerable warming, and are based on bias-corrected data of two recent Global Climate Models. All hydro-meteorological input data are publicly available from an online decision support system, the Zambezi DSS. The future hydropower scenario considers the extension of the existing Cahora Bassa plant and three planned facilities downstream, Mphanda Nkuwa, Boroma and Lupata. Hydropower modelling for this cascade of reservoirs and hydropower plants is carried out with the HEC-ResSim model. Modelling results show a strong impact of precipitation projections on simulated future hydropower generation. With a wetting climate scenario, a marked increase of hydropower production of +11% for a near-future period (2021–2050) and +9% for a far-future period (2071–2100) are projected, as compared with simulation results for a historic reference scenario. In a drying climate, hydropower generation decreases by −6% (near future) and −13% (far future). The climate change impact is stronger for the large extended Cahora Bassa plant than for the smaller downstream facilities. The results show the importance of considering climate risk in technical design and financial assessment of hydropower projects in the region.

Keywords: Zambezi River, hydropower development, climate change, hydropower modelling, water resources

INTRODUCTION

Two of the world's largest reservoirs, Kariba reservoir and Cahora Bassa reservoir, are located along the Zambezi River. Energy supply in the region relies largely on hydropower production, providing over 70% of the energy generated in the countries of the Southern African Power Pool (excluding South Africa; SAPP, 2012). Cahora Bassa energy is invariably transmitted to South Africa almost entirely, and transnational energy transfer plays an increasing role within SAPP. With an expected growth in electricity demand of almost 40% until 2025 in the SAPP countries (SAPP, 2012), and a large remaining hydropower potential, hydropower development will continue to be one of the major resources of the Zambezi basin (World Bank, 2010a, Vol.3). Several hydropower projects are currently developed, planned and already partly under construction along the Zambezi and its tributaries (World Bank, 2010a, 2010b).

Changing climatic conditions, however, might impair the benefits of hydropower development. Future warmer temperatures will tend to decrease inflow due to higher land surface evapotranspiration and will increase reservoir evaporation. In addition, possible changes in precipitation patterns will affect runoff generation. Thus, climate change will impact hydropower, as it strongly depends on river discharge. According to Beilfuss (2012), the Intergovernmental Panel on Climate Change (IPCC) expects the Zambezi basin to suffer the worst potential effects of climate change among 11 major Africa basins. Analyses of the impact of climate change on the terrestrial water cycle and, in consequence, on hydropower generation, are therefore of great relevance for water management and, in general, economic development in the region.

As reviewed by Beilfuss (2012), several investigations into the interrelation between climate change and hydropower development in the Zambezi basin have been conducted. Already, initial studies based on early results from climate modelling point towards a high sensitivity of hydropower generation to possible changes in climatic conditions (Salewicz, 1996; Urbiztondo 1992; IPCC, 2001). The more recent sensitivity tests of SWRSD (2010) also show strong effects of assumed higher evaporation and lower precipitation on the inflow to the existing reservoirs.

Yamba et al. (2011) investigated the combined effects of climate change and increased water demand on existing reservoirs. However, few studies have applied the latest generation climate models to investigate the effects of a future climate on future hydropower generation, including newly planned facilities. In their extensive economic investigation of the state and future of the Zambezi basin, the World Bank (2010a) also analyses hydropower production and includes the planned extension of Cahora Bassa and one new project, Mphanda Nkuwa (an alternative spelling is Mepanda Uncua). The impact of increasing temperatures, however, is investigated only for scenarios with important irrigation development, which leads to stronger effects from increased evaporation. Projected trends in precipitation are not considered. Beck (2010) and Beck and Bernauer (2010) apply scenarios that

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