Geophysical Research Abstracts
Vol. 21, EGU2019-8841-2, 2019
EGU General Assembly 2019

Improved energy-water modelling for hydropower capacity expansion planning under climate change: a case study in the Zambezi River Basin

Maria Giulia Pelosi (1), Luca Monaco (2), Angelo Carlino (1), Andrea Castelletti (1,3)

(1) Politecnico di Milano, Dept. Electronics, Informatics and Bioengineering, Milano, Italy , (2) University of Turin, Dept. Physics, Turin, Italy, (3) Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland

High economic and population growth in Africa is expected to lead to an expansion of the manufacturing and industrial sectors, increasing the energy consumption (EIA, 2018). These factors are triggering investment for further exploitation of hydropower potential on major African rivers. Indeed, for many Sub-Saharan Africa countries, energy security is dependent on hydropower generation which will be affected by future water availability and spatio-temporal variability. Conversely, water and food security might be negatively affected by the development of large hydropower schemes potentially altering existing flow patterns. Therefore, up-to-date modelling tools describing the water-energy nexus are required to plan infrastructure expansion.

Based on the Open Source Energy Modelling SYStem (OSeMOSYS) framework and on The Electricity Model Base for Africa (TEMBA), which provides data for the African continent over the period 2010-2050, this work contributes a new improved energy-water modelling scheme. This is done by using the so-called OSeMOSYS-Hydro model, which has been proved using historical data to be more effective and accurate in predicting the hydropower production than the original one. It explicitly models the river and its tributaries as they flow into the reservoirs accounting more accurately for all the physical and operational constraints. OSeMOSYS-Hydro is used to explore alternative hydropower dam portfolios in the Zambezi River Basin, according to the World Bank documentation, under different scenarios. Downscaling of hydroclimatic variables deriving from RCP 2.6, 4.5 and 8.5 simulations, is used to provide three future inflows scenarios using HBV hydrological models. This analysis employs Southern African Power Pool energy demand projections available in the TEMBA dataset.

Nevertheless, finding the optimal configuration and operating strategy of this complex water-energy system is computationally demanding. Therefore, a rolling horizon approach is applied, periodically updating input data information at each simulation. Therefore, rather than solving a complex problem over its entire time horizon, an approximated solution is obtained by optimizing subsequent smaller planning intervals and putting an overlap on two adjacent ones. Rolling horizon scheme parameters are identified via cross-correlation analysis of the output variables of rolling horizon and entire horizon solutions.

Results show that construction of new infrastructure and its timing are dependent on future scenarios of water availability and demand and some of them will drive the energy system in under stress conditions. Furthermore, OSeMOSYS-Hydro and a Water Resources Optimization Model (WROM) are coupled via soft integration to introduce multiple objectives. Conficts and tradeoffs among the least cost objective of the energy system and other social and environmental objectives are now made explicit in order to support system-wide planning strategies.