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Assessing climate change impact on complementarity between solar and hydro power in areas affected by glacier shrinkage

Handriyanti Diah Puspitarini (1), Baptiste François (2), Davide Zoccatelli (1), Casey Brown (2), Jean-Dominique Creutin (3,4), Mattia Zaramella (1), and Marco Borga (1)

(1) Department of Land, Environment, Agriculture and Forestry, University of Padova, Legnaro, Italy, (2) Department of Civil and Environmental Engineering, University of Massachusetts Amherst, Amherst, Massachusetts, USA, (3) Université de Grenoble-Alpes, LTHE, 38041, Grenoble, France, (4) CNRS, LTHE, 38041, Grenoble, France

Variable Renewable Energy (VRE) sources such as wind, solar and runoff sources are variable in time and space, following their driving weather variables. In this work we aim to analyse optimal mixes of energy sources, i.e. mixes of sources which minimize the deviation between energy load and generation, for a region in the Upper Adige river basin (Eastern Italian Alps) affected by glacier shrinking. The study focuses on hydropower (run of the river - RoR) and solar energy, and analyses the current situation as well different climate change scenarios. Changes in glacier extent in response to climate warming and/or altered precipitation regimes have the potential to substantially alter the magnitude and timing, as well as the spatial variation of watershed-scale hydrologic fluxes. This may change the complementarity with solar power as well.

In this study, we analyse the climate change impact on complementarity between RoR and solar using the Decision Scaling approach (Brown et al. 2012). With this approach, the system vulnerability is separated from the climatic hazard that can come from any set of past or future climate conditions. It departs from conventional top-down impact studies because it explores the sensitivity of the system response to a plausible range of climate variations rather than its sensitivity to the time-varying outcome of individual GCM projections. It mainly relies on the development of Climate Response Functions that bring together i) the sensitivity of some system success and/or failure indicators to key external drivers (i.e. mean features of regional climate) and ii) the future values of these drivers as simulated from climate simulation chains.

The main VRE sources used in the study region are solar- and hydro-power (with an important fraction of run-of-the river hydropower). The considered indicator of success is the 'energy penetration' coefficient, defined as the long-run percentage of energy demand naturally met by the VRE on an hourly basis. Climate response functions, developed in a 2D climate change space (change in mean temperature and precipitation), are built from multiple hydro-climatic scenarios obtained by perturbing the observed weather time series with the change factor method, and considering given glacier storage states. Climate experiments are further used for assessing these change factors from different emission scenarios, climate models and future prediction lead times. Their positioning on the Climate Response Function allows discussing the risk/opportunities pertaining to changes in VRE penetration in the future. Results show i) the large impact of glacier shrinkage on the complementarity between solar and RoR energy sources and ii) that the impact is decreasing with time, with the main alterations to be expected in the coming 30 years.

Brown, C., Ghile, Y., Laverty, M., Li, K., (2012). Decision scaling: Linking bottom up vulnerability analysis with climate projections in the water sector. Water Resour Res 48. 515 doi:10.1029/2011WR011212