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Complementarity between Combined Heat and Power systems, solar PV and hydropower at a district level: Application to the North Eastern Alps

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Combined Heat and Power systems (CHP) produce heat and electricity simultaneously. Their resulting high efficiency makes them more attractive from the energy managers' perspective, than other conventional thermal systems. Although heat is a by-product of the electricity generation process, system operators usually operate CHP systems to satisfy heat demand. Electricity generation from CHP is thus driven by the heat demand, which follows the variability of seasonal temperature, and thus is not always correlated with the fluctuation of electricity demand. Consequently, from the perspective of the electricity grid operator, CHP systems can be seen as a non-controllable energy source similar to other renewable energy sources such as solar, wind or hydro. In this study, we investigate how 'non-controllable' electricity generation from CHP systems combines with 'non-controllable' electricity generation from solar photovoltaic panels and run-of-the river (RoR) hydropower at a district level. Only these three energy sources are considered within a 100 % renewable mix scenario (i.e. generation equals demand over the studied period, i.e. 15 years). Energy mixes with different shares of CHP, solar and RoR are evaluated regarding their contribution to total energy supply and their capacity to reduce generation variability. This analysis is carried out over an ensemble of seventeen catchments in North Eastern Italy located in various climate conditions ranging from high elevation and snow dominated head-water catchments to rain-fed and wet basins at lower elevations. Results show that energy mixes that include CHP systems, in the systems with photovoltaics and RoR have higher demand satisfaction and lower variability of the residual load. The use of electricity from CHP also decreases significantly the number of days with extreme low generation. Results also show that including CHP into the energy mix modifies the optimal share between solar and RoR power generation. Results are consistent across all hydro-climatic regimes.