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Integrated water-energy modelling: a scenario-based analysis to support energy system transition policies in the EU.

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Climate change is expected to affect substantially future water availability and temperature across many watersheds in Europe potentially impacting hydropower generation and cooling efficiency of thermo-nuclear power plants. On the other hand, increasing Renewable Energy Sources (RES) penetration will substantially modify energy portfolios across Europe. As a consequence, prices will become more volatile, requiring more system flexibility. This study aims to explore the following key questions for supporting the definition and implementation of EU transition policies driving investments in the energy sector: 1) How climate change impacts on the hydrological system propagate to the energy system? 2) Can hydropower provide additional flexibility to a high RES-based energy system?

To answer these questions, we developed an integrated modelling approaches combining a conceptual hydrological model (HBV) and an energy system model (PRIMES-IEM). Based on daily air temperature and precipitation, HBV computes daily streamflow for each power plant. Water temperature is obtained from air temperature using an empirical formula. These two variables are used to define the constraints to the energy model PRIMES-IEM, a power market simulator of the European electricity markets.

Our analysis focuses on Iberian Peninsula and Danube region in 2040. Both regions' energy mix have a significant share of hydropower and rely significantly on thermo-nuclear power plants. In addition, both systems have already been under stress conditions due to heatwaves and droughts over the last years. On the climate side, we downscaled projected air temperature and precipitation projections for the RCP2.6 and RCP8.5 scenarios, covering the full range of possible climate futures from very low emission pathways to very high ones. On the energy side, we also consider two scenarios representative of the current system and of a future decarbonized system complying with European climate targets at 2030 and 2050. Despite some differences across the two regions, numerical results suggest some general trends: hot and dry climate futures significantly impact on the energy system because either increasing water temperature produces heavy stress due to thermonuclear generation curtailment or declining water availability limits hydropower generation forcing the energy system to shift to other technologies in order to maintain its reliability.