Impacts of climate change on the Italian power system

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Relevance: The impacts on power systems' optimal generation mix due to climate change, accounting for the compound influence of cooling demand increases and supply-side vulnerabilities, is mostly disregarded by the literature, despite the growing empirical evidence on both demand [1, 2] and supplyside impacts [3, 4, 5, 6]. Understanding the resilience of power systems during extreme weather events such as heatwaves could help to avoid substantial additional costs, in the form of balancing services, load shedding or economic losses induced by power outages. In this work we couple forecasts of future airconditioning demand and power generation availability under extreme temperatures projections around 2030, and evaluate the additional generation capacity and dispatch mix required to ensure the correct operations of the Italian power system.

Methods: We combine existing and new empirical evidence to expand the understanding of power demand shocks and supply impairments under future climate change, with a focus on the implication of extreme temperatures on: i) air-conditioning demand; ii) thermal power outages; iii) hydro-power generation. Then, we evaluate the implications of i)-iii) with a power dispatch and capacity expansion model (based on Oemof: Open Energy MOdelling Framework [7]), providing simulations of how power systems can respond to climate change by adjusting the optimal power capacity mix and of the ability of different power system mixes (e.g. with varying shares of renewable generation and storage) to provide a reliable flow of power. Rather than relying on median temperature changes, we characterize the uncertainty around future climatic changes by assessing demand and supply impacts across over 130 climate simulations.

Results: We find that already by 2030 climate change would require an increase in the additional capacity installed, in order to compensate for the increase in cooling demand and the reductions in hydropower capacity. In the scenario with no constraints on the sectoral emissions, the additional capacity required increases only by 1 GW (≈4% of the baseline increase of 26 GW), since gas capacity accounts for most of the required generation. Under an emission cap that keeps Italy on track with the EU decarbonization goals, the additional capacity required reaches 6 GW under the median of the climate projections (≈10% of the baseline increase of 58 GW), and as much as 14 GW - 25 GW under the 75th95th quantiles of the climate projections. The mix of the additional capacity installed is composed of rooftop and utility-scale solar as well as storage, by around 65% and 35%, respectively. The impacts of extreme temperatures on thermal generation outages are non-negligible, but can be compensated almost entirely by the large spare capacity of the existing gas fleet. Additional costs reach around 120 million under the median of climate scenarios, and 500-1000 million in the 75th-95th quantiles.

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