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European transition to a low carbon electricity system using a mix of variable renewable energies: carbon saving trajectories as functions of production and storage capacity.

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Today, most of the produced energy is generated from fossil energy sources (i.e. coal, petroleum). As a result, the energy sector is still the main source of greenhouse gas in the atmosphere. For limiting greenhouse gas emission, a transition from fossil to renewable energy is required, increasing gradually the fraction energy coming from variable renewable energy (i.e. solar power, wind power and run-of-the river hydropower, hereafter denoted as VRE).

VRE penetration, i.e. the percentage of demand satisfied by variable renewables assuming no storage capacity, is hampered by their variable and un-controllable features. Many studies show that combining different VRE over space smoothes their variability and increases their global penetration by a better match of demand fluctuations. When the demand is not fully supplied by the VRE generation, backup generation is required from stored energy (mostly from dams) or fossil sources, the latter being associated with high greenhouse gas emission. Thus the VRE penetration is a direct indicator of carbon savings and basically depends on the VRE installed capacity, its mix features, and on the installed storage capacity.

In this study we analyze the European transition to a low carbon electricity system. Over a selection of representative regions we analyze carbon saving trajectories as functions of VRE production and storage capacities for different scenarios mixing one to three VRE with non-renewables. We show substantial differences between trajectories when the mix of sources is far from the local optimums, when the storage capacity evolves. We bring new elements of reflection about the effect of transport grid features from local independent systems to a European "copper plate".

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