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Enabling agency: trade-offs between regional and European design flexibility in renewable energy systems

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To fulfil the Paris agreement, European countries have set out decarbonisation targets for 2050 and to reach them plan to massively expand the deployment of renewable energy technologies. Within the European Union, the member states are responsible for mapping out national strategies that meet the overarching EU objectives, including those of the recent REPowerEU plan. At the same time, the European electricity network is highly integrated with many interdependencies such that national policy decisions already have cross borders effects.

We study trade-offs between design flexibility on a regional level and in the entire network, and whether decisions by some actors (i.e. countries, regions or the EU) can enable or restrict the choices of others. This is done using the open sector-coupled energy system optimisation model PyPSA-Eur-Sec at a high spatial and temporal resolution, aiming at carbon-neutral scenarios for 2050. We define design flexibility in the context of near-optimal feasible spaces --- using recent advances we are able to approximate the joint near-optimal feasible space for both a particular region and the rest of the system. By intersecting near-optimal spaces for different scenarios, we make this approach robust to uncertainties including weather variability and technology costs. For a number of selected regions in Europe, we thus look for both regional and European investment decisions which enable or restrict agency by enlarging or shrinking the space of solutions compatible with the decarbonisation targets for 2050.