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TWO-STAGE, MULTI-OBJECTIVE OPTIMISATION FRAMEWORK FOR AN EFFICIENT PATHWAY TO DECARBONISE THE POWER SECTOR

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Abstract: The efficient and flexible design of renewable power plants is key to increase competitiveness of clean technologies and accomplish climate strategies. Hybrid renewable power plants, considering different renewable energy technologies, integrated with energy storage have the potential to provide sustainable, cost competitive and dispatchable energy. However, current renewable power plants are not dispatchable and deliver energy only when the renewable source is available. This results in large fluctuations and increasing cost of integration in the wider electricity system. Flexible design of renewable power plants with energy storage increase reliability and decrease integration cost of sustainable technologies. Nevertheless, the design of flexible, affordable and dispatchable power plants involves a thoughtful balance between technical and financial performance. Moreover, the design of renewable power plants has to handle a larger number of parameters compared with conventional power plants, and the integration of energy storage requires an operational strategy optimisation for every design. The model presented is developed as a two-stage multi-objective optimisation framework for a hybrid power plant. In order to exploit the synergies of hybrid power plants and to promote the best technologies to be chosen in the design, both design and operational optimisation objectives have to be linked. The first stage, i.e. the design optimisation, is performed by genetic algorithms and is focuses on the best definition of the capacities of every subsystem for a cost-competitive supply, handling the trade off between technical and financial performance. Then, as a nested second stage, a linear automated scalarisation method for multi-objective optimisation is performed in order to find the annual optimal hourly operation strategy. In this case, the objectives of the design optimisation include the levelised cost of electricity, investment and system flexibility. These are very closely related with the objectives of the operational optimisation, which include maximisation of the energy, minimisation of the mismatch between supply and demand, and minimisation of greenhouse gases emissions (in the case that a fossil fuelled unit is considered to give more flexibility to the system). Finally, by a post-optimisation sensitivity analysis, a set of optimal designs can be slightly modified to estimate benefits by increasing flexibility. Through the optimisation framework described it is possible to handle different energy generation and storage technologies to design a sustainable, cost competitive, flexible and dispatchable power plant. Besides, the post-optimisation analysis can handle other key performance indicators and provides more detailed information, improving the decision making.