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Co-Design of Microgrids with Renewable Integration: A Modular Julia-based Tool and Applications

The integration of renewable energy sources in our energy systems is a global objective to mitigate global warming by reducing CO2 emissions, especially when replacing fossil fuels. International agencies consistently highlight the importance of increasing renewable energy penetration to reduce temperature increases over the coming decades. In the context of smart microgrids, Distributed Energy Systems (DES) allow the local integration of renewable energy sources, enabling both on-site generation and consumption. However, co-designing their sizing (types and quantity of units) and operation (optimal use of production, conversion, and storage units over time) is challenging for several reasons. The problem is inherently bi-level, with long time horizons (decades), fine temporal granularity (hourly or less to capture renewable dynamics), and significant uncertainties (stemming from environmental and modeling aspects).

Despite these complexities, this problem has been studied for a long time, evolving with the introduction of new elements, such as non-dispatchable energy sources and advanced storage technologies. However it has been and still is common to perform multiple simplifications in order to build an Energy System Optimization Model (ESOM).

To address these challenges, we introduce our modular julia-based tool devoted to the co-design of microgrids. It allows flexible customization of key elements, such as microgrid architecture, input data, component models, and optimization techniques.

This poster provides an overview of the general problem, highlights the features of our julia-based tool, and presents case studies using it. These include a multi-energy network for Toulouse Blagnac airport, a study on the impact of modeling simplifications on decision-making criteria, an in depth study on modeling and integration into microgrids of second-life batteries, and the co-design of an electric vehicle charging station.

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