Energy Storage System (EES) siting and sizing

It is very important to consider the operation and scheduling of generation and storage units already at design phase to determine the most convenient combination (i.e. minimum objective function) of technology selection and size. This is especially true when dealing with selection, sizing and unit commitment of long-term, or seasonal, energy storage. Long-term storage systems have recently caught much attention due to their ability to compensate the seasonal intermittency of renewable energy sources. However, compensating renewable fluctuations at the seasonal scale is particularly challenging: on the one hand, a few systems, such as hydro storage, hydrogen storage and large thermal storage can be used to this purpose; on the other hand, the optimization problem is complicated due to the different periodicities of the involved operation cycles, i.e. from daily to yearly. This implies long time horizons with fine resolution which, in its turn, translates into very large optimization problems. Furthermore, such systems often require the integration of different energy carriers, e.g. electricity, heat and hydrogen. Exploiting the interaction between different energy infrastructure, in the so-called multi-energy systems (MES), allows to improve the technical, economic and environmental performance of the overall system [1].

In this framework, including the unit commitment problem already at design phase implies taking into account the expected profiles of electricity and gas prices, weather conditions, and electricity and thermal demands along entire years. Moreover, the technical features of conversion and storage units should be accurately described. The resulting optimization problem can be described through a mixed integer nonlinear program (MINLP), which is often simplified in a mixed integer linear problem (MILP) due to the global optimality guarantees and the effectiveness of the available commercial solvers (e.g. CPLEX, Gurobi, Mosek, etc.). In this context, integer variables are generally implemented to describe the number of installed units for a given unit, whereas binary variables are typically used to describe the on/off status of a certain technology. Furthermore, decomposition approaches relying on meta-heuristic algorithms for unit selection and sizing have been proposed. A comprehensive review of MINLP, MILP and decomposition approaches for the design of MES including storage technologies has been carried out by [2]. However, independently of the implemented approach, significant model simplifications are required to maintain the tractability of the problem. Such simplifications include limiting the number of considered technologies, restricting technology installation to a subset of locations, analyzing entire years based on seasonal design days or weeks, or aggregating the hours of each day into a few periods.

References

[1] P. Mancarella, MES (multi-energy systems): An overview of concepts and evaluation models, Energy. 65 (2014) 1–17.

[2] C. Elsido, A. Bischi, P. Silva, E. Martelli, Two-stage MINLP algorithm for the optimal synthesis and design of networks of CHP units, Energy. 121 (2017) 403–426.

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