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Improving the accuracy of LP storage models: a systematic approach using XPORTA.jl

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Energy storage systems have become a promising option to increase power system flexibility and harness larger shares of variable renewable energy. To get a full picture of their potential operation and benefits, a realistic representation of their characteristics is essential in power system models. Energy storage models require binary variables to correctly model reserves and to ensure that there is no simultaneous charging and discharging. Solving mixed-integer programming (MIP) problems such as these are computationally demanding, and can pose a significant impediment in large-scale models. A common practice is therefore to formulate them as linear programs (LP), thus allowing simultaneous charging and discharging, resulting in practically infeasible solutions. We propose a tight linear program (LP), i.e., convex hull, for describing the operation of storage including reserves in one time period, which guarantees that there is no better LP approximation to its mixed-integer program (MIP) counterpart. It is obtained by writing the two disjunctive sets of constraints for charging and discharging, and applying the Fourier-Motzkin elimination procedure to reduce the dimensionality of the problem back to the original. We implemented two case studies, as introduced by J.M. Arroyo et al. (2020) in On the Use of a Convex Model for Bulk Storage in MIP-Based Power System Operation and Planning, in Julia, which show that our proposed formulation indeed results in an integer solution, contrary to previous ideas in this field. By embedding the proposed LP formulation into large optimization problems, we expect that it helps to provide solutions equal to or very near to the exact integer feasible behavior of the storage; and when used in its integer form, it is expected to speed up MIP problems.

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