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Summary:

The increasing penetration of renewable energy sources (RES) into the power system poses several challenges to the system operators for the safe and reliable operation of the system. For example, the high share of RES to the energy generation mix requires the provision of higher operational flexibility. The performance of annual studies using long-term unit commitment (UC) models is vital to evaluate the system reliability and efficiency under a variable RES generation. The UC problem optimizes the scheduling of generating units, such as single-cycle (SC) and combined-cycle (CC) units, in a power system to minimize the operational cost over a time horizon, considering physical and operating constraints. The UC is a mixed-integer programming (MIP) problem which is hard to solve, especially for long time horizons.

CC units have been widely used in power systems due to their advantages over SC units in terms of efficiency and flexibility. Specifically, CC units consist of multiple combustion turbines (CTs) and steam turbines (STs) where the waste gases from CTs are utilized by STs to increase their efficiency. The CC units are widely represented in optimization problems using the configuration-based model, where a configuration represents a specific set of committed CTs and STs. The usage of the configuration-based model into the UC formulation increases the problem complexity due to the different operating configurations and the transition constraints between the configurations.

This work integrates the CC units using the configuration-based model into a long-term UC model to enhance the accuracy of the resulting studies. To reduce the computational complexity due to the integration of the CC units, a simplified configuration-based model is used that decreases the number of configurations. Nevertheless, the simplified CC model still captures the efficient configurations to avoid the deterioration of the solution quality. The considered UC problem is formulated as an MILP program, which is intractable when a long-term horizon is considered. To make the problem tractable, a rolling horizon approach is proposed to generate a fast and high-quality solution to the long-term UC problem by splitting the original problem into smaller sequentially solved subproblems. The proposed method is applied to the power system of Cyprus and an annual study is performed to examine the impact of an increasing RES penetration on the system operating cost, CO_2 emissions, and the percentage of RES power curtailments. To the authors best knowledge, this is the first work that considers the different configurations of the CC units in a long-term UC model, enhancing the solution quality of the resulting studies.

Using the proposed method, we have developed a unique software tool for optimizing the unit commitment and economic load dispatch for the power system of Cyprus. It includes: (a) all technical and operational constraints of the installed conventional units, (b) all operational constraints of the power system of Cyprus, and (c) new technologies such as additional conventional units, energy storage systems, electric interconnections, and demand response mechanisms. Furthermore, the proposed software tool can be used for scheduling the daily operation of the power system, as well as for long-term planning. The proposed software tool is currently used by the Cyprus Transmission System Operator (TSO) and the Cyprus Energy Regulatory Authority (CERA) to carry out a significant portion of their tasks, serving as a powerful tool in achieving the national goals of the Republic of Cyprus in the areas of climate neutrality, energy efficiency, and renewable energy sources.