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INSTRUCTIONS FOR EXTENDED ABSTRACTS

Chance-constrained capacity planning and scheduling optimization for cooling-dominated integrated energy systems with integrated distributed photovoltaic considering source-load uncertainties

Summary

This paper proposed a bi-layer multi-objective chance-constrained programming framework for the optimal sizing and dispatch of a cooling-dominated IES with integrated solar photovoltaic (PV). The outer layer employed a multi-objective genetic algorithm to optimize the initial equipment capacities, targeting the minimization of the annualized total cost (ATC) and the maximization of the PV penetration ratio. Based on the capacities identified, the inner layer then determined the optimal scheduling strategy to minimize operational costs via mixed-integer linear programming (MILP). An office district in Zhejiang, China characterized by prolonged summers and massive cooling demands was adopted as a real-word case study to test the effectiveness of proposed framework. To determine the optimal trade-off between economic and low-carbon objectives, the entropy-weight based on TOPSIS method was subsequently applied to select the best compromise optimum from the Pareto fronts. The results demonstrated that the compromise optimal design featured the integration of a cold energy storage system in the IES, which allowed an annualized total cost of $232,020 and a PV penetration ratio of 19.00%. It featured storage capacities, comprising 916 kWh of cold energy storage (CES) and 146 kWh of electrical energy storage. Compared with the baseline scenario without cold energy storage, this system reduced annualized costs by 1.6% while achieving a comparable level of renewable energy integration using fewer than half the PV panels (i.e. 916 versus 1989).

Keywords: C*hance-constrained programming, Cold energy storage, Penetration ratio, Annualized total cost*

1. Introduction

With the clock ticking toward global carbon neutrality, integrating renewable generation into the design of integrated energy systems (IESs) has become significant and of great necessity for sustainable building complexes. However, the dual uncertainties of renewable output and load demands, exacerbated by stochastic weather change and stochastic occupant behaviors, often lead to severe mismatches between system sizing and actual operational performance. To address the system operation issue caused by the uncertainties, a large number of researchers have studied various handling methods recently, including stochastic optimization (Xue et al., 2025)(Yu et al., 2019)(Wang et al., 2020), robust optimization (Fan et al., 2023)(Li et al., 2024)(Wang et al., 2020) and data-driven methods, etc.

Existing optimization research on integrated energy systems (IES) under uncertainties typically combines two-stage frameworks, chance constraints, and multi-objective decision tools to balance cost, emissions, and robustness. While cold energy storage (CES) is known to enhance operational flexibility by decoupling supply and demand, its specific benefits in cooling-dominated IES lack systematic evaluation. Specifically, quantifying CES flexibility within a bi-layer, multi-objective chance-constrained framework remains underexplored. This paper introduces a framework to co-optimize IES sizing and dispatch. Validated through a subtropical case study, the proposed CES-integrated approach demonstrates significant advantages in fulfilling both economic and decarbonization targets.

2. Methodology

The overall framework of the proposed design strategy is illustrated in Fig.1. It consists of three main stage: Data Preprocessing, System modeling, and Two-layer Optimization.

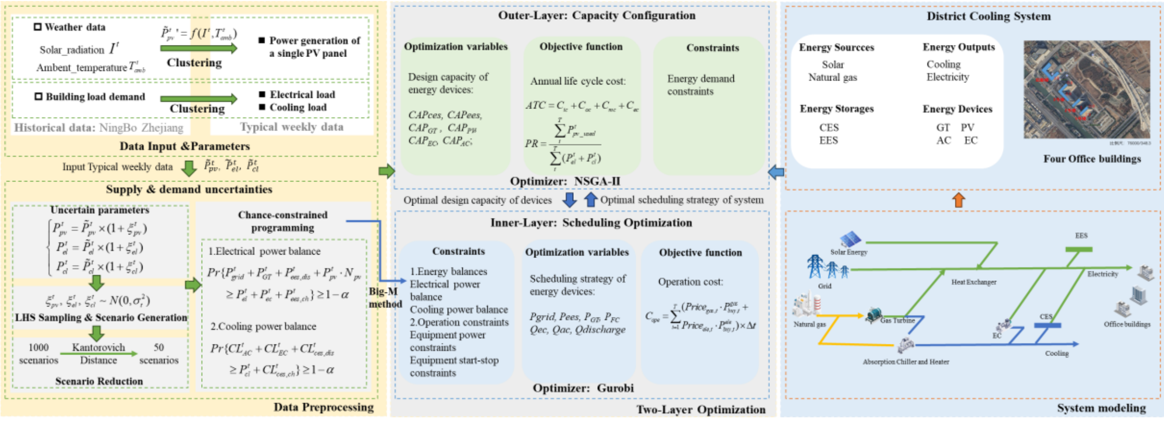

Fig.1 Framework of the proposed optimization strategy.

3. Conclusion

The results demonstrated that the compromise optimal design featured the integration of a cold energy storage system in the IES, which allowed an annualized total cost of $232,020 and a PV penetration ratio of 19.00%. It featured storage capacities, comprising 916 kWh of cold energy storage (CES) and 146 kWh of electrical energy storage. Compared with the baseline scenario without cold energy storage, this system reduced annualized costs by 1.6% while achieving a comparable level of renewable energy integration using fewer than half the PV panels (i.e. 916 versus 1989). The findings indicated that the integration of CES can upgrade the flexibility of IESs, contributing to significant cost reductions together with high-ratio penetration renewable energy. The highly flexible quantitative decision-making tool developed in this study can facilitate the design and establishment of low-carbon building areas.

4. References

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