Reducing Carbon Emission in Multi-Building Commercial Facilities – A Co-optimization Approach

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Buildings are significant energy consumers. According to the Energy Information Administration (EIA), buildings consume about 75% of the total electricity generated in the United States and account for 39% of carbon emissions. As such, any sustainable pathway to a zero-emissions future will need to pay close attention to emissions reductions in buildings. An interesting sub-category of buildings is the multi-building commercial facility with different buildings within a defined geographical area, operated by the same entity, serving different purposes, and containing varying equipment types. Typical examples of multi-building commercial facilities include school campuses, e-commerce fulfillment centers, shopping complexes and data centers.

While most existing building management approaches focus on minimizing energy consumption and emissions for each building separately, a better strategy will capture complementary building operations and equipment usage patterns across the different buildings within a single framework to yield additional emissions reduction and energy savings. Such improved strategies are referred to as co-optimization strategies. In this work, a co-optimization strategy was developed and simulated to examine the additional carbon emissions reduction and corresponding comfort impacts that can be realized by considering all buildings in a multi-building facility within a single optimization framework instead of treating each building separately.

The co-optimization strategy was formulated as a Mixed Integer Quadratic Programming (MIQP) mathematical problem and implemented using the Python programming language. The strategy was tested with a hypothetical e-commerce fulfillment facility consisting of two office buildings and a warehouse. Each building in the facility includes heating, ventilation, and air-conditioning (HVAC) equipment, electric water heaters, solar photovoltaic (PV) systems, batteries, and electric vehicle (EV) charging stations. Also, different daily (weekdays and weekends) and seasonal (summer and winter) building and equipment operation patterns were considered. A Python-based building simulation toolbox developed by the research team was used to run all simulations.

Preliminary results show that the co-optimization strategy produced at least an additional 5% reduction in carbon emissions under different daily and seasonal operating conditions with minimal impacts on the comfort of each building's occupants. Subsequently, the initial results will be extrapolated to estimate annual additional emission reductions from using the co-optimization strategy and the corresponding financial and environmental implications.