Decarbonizing the grid with flexible buildings

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Elvin Vindel, a Ph.D. student in civil and environmental engineering at Carnegie Mellon University, has led the creation of a model that can help cut emissions from buildings and improve the overall efficiency of the grid. The paper was co-authored by Vindel's advisors, Mario Bergés and Burcu Akinci, both professors of civil and environmental engineering.

In the U.S., buildings represent more than 70% of electricity consumption and a large portion of the carbon emitted by the energy sector. The sustainable integration of renewable energy in the electrical grid requires additional sources of operational flexibility. Renewable energy sources like wind and solar provide much cleaner energy than fossil fuels. However, the variability introduced by relying on natural processes for power generation will require a grid more adaptable to changes in the quantity of energy available. The Department of Energy (DOE) has recognized the potential in reimagining buildings as flexible assets through the implementation of technologies and innovations that will help increase efficiency and reduce carbon emissions.

The team's model for demand flexibility in heating, ventilation and air conditioning (HVAC) systems offers solutions in energy demand management for building managers and grid operators alike. Demand flexibility is the capacity of building to actively change its energy consumption—an important property that can help balance energy demands across the power grid.

Existing methods for estimating the flexibility of commercial buildings have focused on thermal flexibility while simplifying the response of the HVAC system. This approach often leads to low accuracy in flexibility predictions, which has so far limited the prospect of using buildings for grid services that improve reliability. Additionally, a fundamental challenge in developing more accurate models is to encompass the heterogeneity in the building population and in individual comfort preference.

The new model aims to define this flexibility as a property of the installed mechanical system by leveraging the data streams generated and stored in modern building automation systems. The proliferation of smart meters and sensors in over 60% of commercial buildings is providing these researchers more real-time data from HVAC systems than ever before. Their proposed model provides a more accurate demand flexibility prediction for drops in demand compared to existing approaches while supporting a scalable model acquisition process for widespread use in commercial buildings.

Better models for estimating demand flexibility suggest new ways that building managers and utility operators can coordinate to achieve mutually beneficial reductions in energy demand. If a building can provide the grid with a more accurate and timely picture of its demand flexibility, then grid managers can better balance and actuate energy demands while providing incentives to building managers who are able to lower their demand when needed. The team has already tested the model on simulations of three buildings under varied climates across the U.S. They're planning further testing on real-world HVAC systems starting this summer to validate the findings of this latest research.

Vindel, Bergés, and Akinci's work presents a means to actively control energy consumption in buildings and further integrate HVAC systems with the grid while respecting occupant needs and preferences. In anticipating the unique factors affecting renewable energy sources, they also present new possibilities for building managers and grid operators to cooperate in balancing energy demands and reducing consumption within a decarbonizing energy sector.

More information: Elvin Vindel et al, Demand flexibility potential model for multi-zone commercial buildings using internal HVAC system states, *Proceedings of the 8th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation* (2021). DOI: 10.1145/3486611.3486654