Matching energy supply and demand in buildings

January 31 2024, by Patricia DeLacey

Connor Flynn, an energy engineer with the Energy Management team, helps Aditya Keskar, a master's student in electrical and computer engineering, retrieve data from a campus building's HVAC system in a related research project. Credit: Dan Newman, University of Michigan

As power grids evolve to incorporate new variable renewable energy sources and adapt to growing peak electricity demands, balancing the grid—scheduling appropriate electricity supply to match demand—will become increasingly challenging.

The consumer's ability to shift electricity consumption to times when demand is lower or track consumption with the availability of renewable energy sources, known as demand response, is one approach to help maintain grid reliability and reduce electricity costs. Commercial buildings, which account for 37% of all electrical load in the United States, offer an opportunity to implement impactful demand response strategies.

"Commercial buildings provide an enormous grid balancing resource, but this resource has only been partially tapped. There is significant potential to increase commercial building demand response programs and load-side participation in electricity markets to support renewables integration, reliability and resilience," explained Johanna Mathieu, an associate professor of electrical engineering and computer science at the University of Michigan.

Mathieu and a team of researchers have presented a new open dataset in an accepted manuscript appearing in the *Journal of Dynamic Systems, Measurement, and Control*. The dataset will help researchers and practitioners better understand the role commercial buildings can play in balancing the grid.

Heating, ventilating and air conditioning (HVAC) systems are an ideal flexible load to target for demand response improvement as they account for almost half of commercial buildings' power consumption. Further, commercial buildings' high thermal inertia allows HVAC system power consumption to be altered for a short period of time before building temperatures noticeably change.

Proper grid balancing is best achieved with closed-loop control, incorporating feedback from the system, to achieve accurate power tracking. Current building automation systems—used to control and monitor variables like HVAC systems, lighting, plumbing, elevators, etc.—do not typically collect power measurements from HVAC system components. Whole-building electric meters usually measure power every 15 minutes, which is too infrequent for grid balancing, and do not provide a clear picture of HVAC system dynamics and responses.

To improve the availability of real-world demand response data, the research team developed the Sub-metered HVAC Implemented for Demand Response (SHIFDR) dataset. This massive dataset includes HVAC system component power measurements collected over five years from 14 University of Michigan campus buildings during typical operation and demand response events.

The dataset includes:

- Sub-metered fan power data at a one minute resolution
- Associated whole-building electric load data at a five minute resolution
- Building automation system data at a five minute resolution

"Open datasets are an important tool for researchers and practitioners alike. While past experimental work has generated lots of data, most of it is not openly available. There are a few open datasets like the Building Data Genome Project, but this doesn't include electricity submetering data or data from demand response events," said Mathieu.

Using the SHIFDR dataset, the researchers conducted a case study where they compared measured fan power data with fan power estimates generated from building automation system data and models. The estimates did not match the sub-metered fan power data during demand response events, indicating fan sub-metering is necessary for modeling and desirable for closed-loop control.

"We hope that the SHIFDR dataset can help researchers better understand the true potential of using buildings to benefit the power grid, fully reflecting the idiosyncratic nature of real world building operations," said co-author Jeremiah Johnson, associate professor at North Carolina State University.

The research team hopes this large, open dataset will encourage future researchers to combine building control and power systems research to reduce energy waste, improve building flexibility and maintain grid reliability.

Additional co-authors include: Austin Lin and Ian Hiskens of the University of Michigan; Shunbo Lei of the Chinese University of Hong Kong, Shenzhen; and Aditya Keskar of the North Carolina Utilities Commission.

More information: Austin J. Lin et al, The Sub-Metered HVAC Implemented for Demand Response Dataset, *Journal of Dynamic Systems, Measurement, and Control* (2023). DOI: 10.1115/1.4064348

Provided by University of Michigan College of Engineering