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RESEARCH BRIEF

Evaluating the Energy Efficiency Gap & Measuring Savings from Fault Detection and Diagnostics

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Data analytics will play a major role in advancing global energy efficiency and high performance building goals nationally and globally. As the fault detection and diagnostics industry emerges and unlocks numerous energy efficiency savings opportunities in buildings, it is crucial that we also advance our methodologies for evaluating these systems and quantifying the energy impact.

Energy efficiency programs account for 72% of global greenhouse gas abatement strategies (IEA), and utility spending on energy efficiency more than doubled in the United States from 2007 to 2011 (Cooper and Wood). With an increased focus on high performance, sustainable buildings in the United States and around the world, and as improvements in data analytics continue to develop, a new field of building fault detection and diagnostics (FDD) has emerged. FDD systems can continually monitor heating, ventilation, and air conditioning (HVAC) systems in buildings and identify numerous faults as they occur, rather than these faults going un-noticed for years or even decades and causing significant energy waste. For example, hot water and chilled water valves can fail after only a few years and cause energy waste, but these relatively small components of an HVAC system are often hidden above ceilings or in mechanical rooms and can easily go unnoticed without a closely monitored FDD system. However, there is very little research evaluating FDD systems in real buildings to identify the actual energy impact of these faults.

Through this research initiative, I tested a modeling approach using novel machine learning algorithms to estimate counterfactual energy usage in real buildings and calculate the energy efficiency savings associated with an existing FDD system. We took advantage of high-frequency 15-minute interval electricity, chilled water, and steam energy usage data over several years in four campus buildings. We then compare the accuracy of these models applied to brand-new data using three different machine learning modeling techniques, the Lasso Model, Ridge Regression, and an Elastic Net Model and numerous interacted variables, such as hour of the day, day of the week, month, time, temperature, and humidity.

Finally, I applied these models to 8 time periods in which the existing FDD system identified a fault, thus isolating the energy impact of the fault. With this approach, I found that each of the three modeling techniques outperformed the other two techniques in at least one of the models, indicating that there is likely a benefit from using three approaches in building energy modeling. Further, I found that the models are likely able to isolate the energy increase associated with these faults, with some models yielding a higher confidence level than others. In addition to the overall average increase in energy, the faults showed consistent results in the daily load profile shifts after the fault occurred.

This methodology could therefore be used in more buildings and with different types of FDD systems to better evaluate the benefits of FDD software across applications. By using this method more extensively, we can better inform policy that can in turn aim reduce the energy efficiency gap in commercial buildings. There are currently very few building code requirements that specify FDD systems, but this is likely to change as the FDD market rapidly expands. As building codes begin to specify FDD software, this research methodology could help regulators to identify how and which type of FDD applications should be required. Additionally, this methodology could be developed further to run alongside an FDD system to help identify and estimate the energy impact of faults as they occur in real time.

References

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About the Author

Danielle Dahan held the position of Research Assistant in the MIT Center for Energy Environmental Policy (CEEPR). Danielle graduated with a Masters of Science from MIT in Technology & Policy with a focus in energy efficiency in 2017. Danielle now serves as a Technical Service Program Manager at McKinstry focusing on energy efficiency, sustainable building operations, and data analytics.