Building Energy Audits for Residential or Commercial Buildings

The objective of this challenge is to develop technical solutions to expedite energy audits or develop a simplified, yet effective, energy audit methodology, by finding ways to reduce time and cost compared to current audit practices. In addition to proposing solutions, this challenge also asks teams to demonstrate the proposed energy audit solution on an existing building.

Background

Buildings, whether long-standing or recently constructed, have potential for energy improvements. Engineers uncover the energy improvement potential for these buildings through thorough inspection, survey of systems and review of past energy usage; a practice commonly referred to as an energy audit.

Energy audits are used in both the residential and the commercial building sectors. An energy audit is a process and inspection survey to understand the energy use of the building and to identify opportunities to improve energy efficiency while maintaining or improving occupants' comfort. In addition to this, energy audits can be used for energy efficient building certification (e.g. Home Energy Rating System Program [HERS], U.S. Green Building Council [USGBC] Leadership in Energy and Environmental Design [LEED]). The energy audit can range from a simple walk-through of the building to a detailed audit with onsite measurements, tests, and analysis of many, if not all, building systems. ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) provides industry with three standardized levels of energy audits where thorough on-site investigation is required as audit complexity increases.[1]

Simple energy audits (ASHRAE Level 1) include a review of utility bills, interviews with building staff, and a walk-through of the building. The purpose of this audit is to identify energy inefficiency and provide recommendations to building owners regarding operational adjustments or system upgrades with cost-effective energy efficiency measures (EEMs). For example, inefficient lightbulbs can be replaced with energy-efficient lightbulbs, such as LEDs. Simply replacing old filters of heating and cooling equipment can save energy by increasing filtration effectiveness and maintaining superior indoor air quality.[2] These recommendations are easily identified by a building walk-through and easily implemented by building owners or facility managers where immediate energy savings can be anticipated. Major problem areas can be uncovered by simple energy audits, but level 1 energy audits are often not sufficient for implementing more significant measures and in that case, more detailed energy audits are recommended. Also, the lack of granularity of utility bills reduces the potential for diagnostics and other data processing techniques. In addition, many buildings today are equipped with a vast array of sensors that could provide more meaningful analyses and insight into a building's operation. Wireless sensors and data acquisition also offers new potential for improving our ability to quickly and efficiently understand energy performance of an existing building. More detailed energy audits (ASHRAE Level 2 and Level 3) provide a comprehensive understanding of the energy usage of building and enables advanced energy efficiency measures and future investment planning. By examining the condition of

[1] ASHRAE energy audit level 1 2 and 3- https://www.smartwatt.com/whats-difference-ashrae-level-1-2-3-audits/

[2] Do-it-Yourself Home Energy Audits- https://www.energy.gov/energysaver/home-energy-audits/do-it-yourself-home-energy-audits

building envelope and HVAC systems, and operations and maintenance procedures, a baseline for energy usage can be developed to evaluate the cost-effectiveness of pre-selected EEMs.[3] For example, a blower door test[4] or tracer gas test[5] can be performed to identify air leakage or determine the air tightness of the building. Insulation level of the building can be identified based on as-built drawing, while thermal bridging or insufficient insulation can be identified using an IR camera[6] together with a blower door test. Remote building energy audit services using new technologies such as advanced data mining techniques or machine learning are under active development.[7][8] These potential EEMs, which are identified through detailed energy audits, can be evaluated and prioritized using whole-building energy simulation tools (e.g., EnergyPlus, OpenStudio).

Detailed audits are more expensive and time consuming, and they require more detailed field data but can be necessary to plan an appropriate path forward. Because Level 2 and 3 audits are expensive, they are not performed often, especially for residential buildings, and so significant energy savings are left unrealized.

The Challenge

The JUMP into STEM competition is looking for technical solutions to expedite the audit process or develop a simplified but more effective audit method, by finding ways to reduce time and cost.

Possible solutions could be related to any required tasks in any of the three levels of energy audit (e.g. energy bill analysis, review mechanical and electrical system, building air tightness testing) and many aspects of building (e.g., building envelope, HVAC system, lighting system) to improve the current system for energy efficiency and occupants' comfort. In addition to proposing solutions, this challenge also asks the teams to test their proposed solution by conducting the energy audit at a local building. Engaging with a local building owner or homeowner can be a great way to identify improvements in the solution as well as identify EEMs for the owner or homeowner.

Solutions may address either residential or commercial buildings and should include the following:

- The proposed technical solution and how the solution will benefit or improve the audit process
- Site assessment including a virtual visit, virtual interviews of building staff if necessary (e.g., homeowner, facility managers, operations and management staff)
- Energy usage analysis (e.g., collect and analyze at least one year of utility data)
- The expected impact of the energy audit; examples of impact include energy saving potential using a whole building energy simulation tool (e.g., EnergyPlus, OpenStudio) or other relevant

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[3] A guide to energy audit - https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20956.pdf

[4] Blower door test - https://www.energy.gov/energysaver/blower-door-tests

[5] Tracer gas test - https://www.energy.gov/energysaver/pft-air-infiltration-measurement-technique

[6] Thermographic inspection - https://www.energy.gov/energysaver/thermographic-inspections

[7] Remote building energy audit - https://thedaily.case.edu/case-western-reserve-completes-license-option-with-spinout-company-edifice-analytics-inc/

[8] Remote building assessment - https://www.businesswire.com/news/home/20141211005115/en/FirstFuel%E2%80%99s-Remote-Building-Assessment-Named-Project-Year

methods to capture the scientific effects of the propose method, economic benefit, and indoor environment comfort

- Feedback on energy audit outcomes (e.g., a list of recommended EEMs, cost-benefit analysis) from the homeowner, local building staff, etc.)
- A technology-to-market plan for how to scale up this solution to make an impact on the building industry