5D: Spotlight on Efficiency in Schools and Hospitals
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Evaluation Methods to Avoid Undercounting Savings in Behavior Programs

How much of the energy savings from behavioral programs is undercounted in a typical program evaluation, and should we be using a different approach to measure savings? Energy savings constitute a critical metric in the evaluation of behavioral programs. This presentation looks at how measurement decisions affect evaluation results and puts forward recommendations on best practices for more accurately calculating savings. The purpose of this work was to use hourly electric data to develop estimates of the energy savings generated by a school based behavior program that relied on the actions of a variety of actors (including teachers, children, and facilities staff) to reduce energy consumption. The study considered the following set of questions: How might traditional energy savings analysis methods be leveraged and should they be modified? Was a measureable amount of energy saved? How much confidence do we have in the measured savings? Do the savings persist over time? The evaluation resulted in the development of an innovative approach to analysis and a set of best practices for accurately representing behavior-based savings. More specifically, the pre minus post evaluation used a weather normalized approach to study the energy impacts of behavior change actions in a middle school over the period of a few months. In order to fairly represent program impacts when actors were not physically present, such as evenings and weekends, we divided the analysis into several periods, such as daytime/nighttime, and weekday/weekend periods, ensuring that each period had consistent energy use profiles. We also performed three sensitivity studies in order to estimate error bounds on the calculated savings. The study found that different approaches to analysis resulted in different savings estimates depending on which schedule periods were specified and which sub-metered loads were included. Specifically, higher savings with lower uncertainty resulted from more accurate assumptions about the specific program actions taken and the relevant hours of operations. Our high level findings revealed three important insights: (1) it is difficult to fairly represent the energy impacts of behavioral programs without direct knowledge of which program actions are being taken and which types of loads are being targeted; (2) measuring the energy savings associated with particular actions and loads can be successfully addressed by dividing the analysis into meaningful time periods such as day/night, and weekday/weekend; and (3) in this case study, energy savings proved to be sensitive to the direct influence of program implementers, suggesting that the savings from behaviors did not persist beyond the planned program actions. The evaluation methods discussed here are broadly applicable for behavioral programs across commercial buildings with hourly billing data (such as from smart meters). These findings should be further tested and reflected in program design and evaluation protocols and in policies governing monitoring of behavioral program outcomes.

Laurel Kruke, Pierce Energy Planning
Opportunities for Measuring Behavior Programs with K-12 Schools

Behavior change is difficult to achieve, and even more difficult to measure. There are many program strategies that successfully encourage behavior change in K-12 schools: for example, programs that encourage awareness and energy education, incentive programs based on observed behaviors, and competition-based programs. Each has its own merits, and can be successful at anecdotally changing behavior and making a school and its occupants more energy conscious and efficient. However, it is very difficult to show measured energy savings that directly correlate with behavior change. One way to measure savings is through technology and data management software. This can be a great engagement tool, allowing users to track their energy usage over time. Tracking monthly energy usage and expenditures increases overall awareness and can influence behavior implementation. Users can compare their monthly usage totals from one year to the next, and see any increases or savings they may have achieved. However, a challenge with this strategy is that if any mechanical improvement was made to a school (in addition to the energy behavior program implementation), this data does not directly measure behavior change impacts. Another strategy used to measure behavior change involves self-reporting through surveys about energy attitudes and behaviors, both in and outside of school. Conducting surveys with those who participate in professional development workshops and energy trainings, and then surveying them again three months after the workshop, can indicate how much was retained from the training, and whether they put that information into action. A challenge is that self-reporting can result in misleading information because the subject may overestimate their behavior change, and/or report what they think the researcher may want to hear. A third method to measuring behavior change is to utilize devices that measure the energy use specifically for a space and give information about the exact use of that room. This data can measure how energy is used in a particular instance. The challenge with this type of measurement is that it may be difficult and expensive to scale up for larger projects. The opportunity here is valuable when it can easily be used in larger-scale settings. This presentation will present examples of these measurement strategies, and discuss the challenges and opportunities for each in more detail.

Signo Uddenberg, MKThink

Do I turn on the lights or not? Investigating room light signatures

Flipping on the light switch is an almost unconscious instinct for many when entering a room. For dark rooms, this action makes sense, as you need light to see. For day-lit rooms, it is difficult to know if additional light is needed. When in doubt, lights are turned on. As an unintended consequence of combining daylight and electric light, there could be glare or over-illumination problems adversely affecting occupant health. Furthermore, these lights typically remain on throughout the day consuming energy, as turning off lights when exiting a room is less of an ingrained behavior. One way to illuminate the behavior is to investigate the interaction between light use, daylight and occupancy. Thirty sensors were deployed in nine K-12 classrooms in a school in San Francisco, CA to assess their light use signatures in concert with daylight availability and class schedules. The objective was to first understand when lights were used and then to devise successful initiatives and programs that save energy and enhance indoor environmental quality of spaces. The classrooms were chosen as a representative sample accounting for differences in the amount of windows, class schedules and grade levels. Consistent to all classrooms were the types of light bulbs, fixtures and controls. Light state and light level sensors were deployed for three months in Fall 2016 to assemble light use patterns for each classroom. Results surprised facility staff and teachers. First, data showed that electric lights were on when daylight was sufficient 62-89% of the time. Turning these lights off could save an estimated 8-26% in lighting energy. Second, lights were routinely left on during school hours when no classes were scheduled. Third, night custodial staff left classroom lights on ~2hrs a night as a way of tracking their rotational cleaning progress. Responses to these results prompted school employees to brainstorm changes to occupant behavior and building operations. Low or no-cost solutions were quickly implemented such as providing custodial staff other options for progress indicators. An option in the cue included a Daylight Action Day email campaign to encourage daylight only classrooms on certain sunny days. Opportunities requiring larger investments include classroom light level indicators to convey real-time lighting quality by activity and improved lighting controls (e.g. photo-sensors, occupancy sensors, dimming, automatic shade control). This lighting classroom evaluation also sparked questions from school staff for future studies around the impact of window shades and proper light levels for the range of classroom activities (e.g. whiteboard learning, computer activities, art, music and reading).

Sarah Outcault, University of California, Davis

Teacher knows best? Balancing energy savings, air quality, and comfort in schools

California taxpayers have spent $2.5 billion on improving energy efficiency (and clean energy generation) in the State's schools. Much of the funds spent have paid for HVAC upgrades, but a new study by university researchers found that despite the new equipment, indoor air quality and teacher satisfaction are low. Researchers recruited 100 classrooms from 10 schools around the State, ranging from small rural districts to large urban districts, covering Northern and Southern California, and coastal as well as inland areas. Monitoring equipment was installed in each classroom for one month and gathered data on temperature and air quality. Teachers' experience with their new HVAC system was collected in an online survey. Merging the two sources of data allowed researchers to explore how occupants and their HVAC systems affect each other. Across participating schools, the level of autonomy granted to teachers over the system varied, to differing effect. Limiting thermostat control to a relatively conservative range of temperatures undoubtedly saved energy in schools which adopted that approach. But it also resulted in dissatisfaction and repeated complaints from teachers, as well as efforts to "trick the system" into providing more conditioning (for example, by covering the thermostat with a hot towel). At the other end of the spectrum, some schools give teachers complete autonomy over their classroom thermostat. In our study, the school that did this achieved higher rates of teacher satisfaction with temperature, but much lower indoor air quality, on average. This was because teachers were able to shut the system down completely, including the ventilation system which is designed to run continuously during the school day to address indoor air pollutants. Interestingly, although many teachers reported air quality-related complaints (e.g., the air being stuffy, stale, smelly, dusty), our study found that teachers' perception of indoor CO_2 levels was not reliable. This is a much more serious indoor air quality issue, as prolonged exposure to elevated CO_2 levels is associated with poor student performance and increased absence. The study found evidence of poor HVAC installation and commissioning that virtually ensured under-ventilation. Granting teachers autonomy over the system also appeared to result in them, at times, inadvertently disabling the ventilation system in an effort to achieve thermal comfort (or save energy). Striking the balance between autonomy, satisfaction, energy efficiency, and health is paramount to creating a sustainable HVAC system, one in which the human occupants and decision-makers are recognized as integral. There is a need to educate teachers on the vitally important role the HVAC system plays, emphasizing the oft-forgotten "V" in HVAC. There is also a need to establish controls protocols that ensure the delivery of adequate fresh air, even when they give teachers some degree of autonomy over comfort.