Employee Engagement and Energy Information Software Supporting Carbon Neutrality

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ABSTRACT

This paper documents electricity savings that were achieved through employee engagement measures and use of an energy information system (EIS) at the 150,000 ft^2 Jack Davis Building located in Victoria, British Columbia, Canada. The paper compares results against those of a University of California Berkeley case study. It also summarizes some of the literature on energy information systems and community-based social marketing (CBSM).

We found that CBSM is an effective means to achieve energy savings through employee engagement. During a week-long campaign, one group of occupants at the Jack Davis Building was able to reduce lighting energy consumption by 12%.

We identified a number of key factors that contribute to the success of employee engagement efforts. In particular, a pre-existing culture of conservation and use of multiple CBSM tools are particularly important. Energy information systems that provide real-time feedback to building occupants were found to enhance the effectiveness of social marketing efforts. Repeated prompting is particularly effective when combined with real-time feedback through an EIS that shows the energy savings directly resulting from employee action.

In summary, employee engagement is an effective means to achieve energy savings, and energy information systems are an important tool for successful employee engagement.

Introduction – Employee Engagement for Energy Conservation

Employee engagement involves communicating with and empowering building occupants to encourage them to conserve energy. This paper investigates the effectiveness of employee engagement measures and energy information systems as tools to reduce energy consumption in commercial and institutional buildings. This paper documents electricity savings that were achieved through employee engagement measures and an energy information system at the 150,000 ft^2 Jack Davis Building located in Victoria, British Columbia, Canada.

The employee engagement initiative examined in this paper was based on community-based social marketing (CBSM) theory. An energy information system (EIS) served as the key engagement tool, providing real-time energy monitoring, visualization and feedback to building occupants.

An overview of CBSM methodology is presented below along with a review of relevant literature examining the efficacy of the approach in the context of employee engagement aimed at energy savings. A literature review was also conducted pertaining to the effectiveness of real-time energy monitoring and visualization tools in encouraging energy saving behaviors.

Community Based Social Marketing

CBSM is based on the theory that "initiatives to affect behavior change are most effective when they are carried out at a community level, and involve direct contact with people." (McKenzie-Mohr and Smith 1999, x). Traditionally, campaigns to change behavior have focused on raising awareness using one-way communication;[1] however there is substantial evidence that raising awareness alone does not lead to changes in behavior (Ibid., 9).

Describing the CBSM approach, McKenzie-Mohr and Smith (1999) explain that to change behavior, one must identify and communicate the benefits of a chosen behavior, remove the barriers to adopting that behavior, develop a strategy to change the behavior, pilot the strategy, and evaluate the strategy once it has been implemented across a community. (Ibid., 150)

Important tools used in CBSM methodology include (McKenzie-Mohr, 2009, 18-59):

- **Commitment** – individuals are more likely to follow through with an action if they sign a pledge or make a public commitment to do so
- **Prompts** – visual reminders are placed in a location where the undesired action occurs and in close proximity of where the desired action should take place
- **Norms** – if individuals observe members of their community acting a certain way, they are more likely to do the same
- **Communication** – messaging is targeted to the chosen audience; it is vivid, concrete, and personalized
- **Incentives** – use incentives to reward desirable behavior; delivering incentives at the location where the activity occurs increases the likelihood that employees will continue the desired behavior

A key method to ensure that employees sustain desired behaviors is providing timely feedback on the effects of their actions. (Ibid., 47) Energy information systems can track consumption and display results immediately in a way that resonates with a variety of audiences. Coupling appropriate energy visualization techniques with real-time monitoring can enhance employee engagement efforts by providing prompts, illustrating norms, and customizing communications.

Energy Monitoring, Information Systems and Feedback

Granderson et.al. (2009a) defines an EIS as performance monitoring software, data acquisition hardware, and communication systems used to store, analyze and display building energy data. Within an EIS, time series data from meters, sensors, and external data streams are used to perform analyses such as baselining, benchmarking, anomaly detection, and energy intensity tracking (Ibid., 4).

Fischer (2008) researched how improved feedback to building occupants about electricity consumption may provide a tool for customers to better control their consumption and ultimately save energy, analyzing which kind of feedback is most successful (p. 79). Feedback includes energy consumption, as well as its costs and environmental impacts. Energy savings have been demonstrated from the use of feedback with usual savings ranging from 5 to 12% (Ibid., 87).

[1] Communication from management or a marketing team to an audience, with no opportunity for the audience to respond.

Fischer's feedback "best cases", mainly from the residential sector, include the following components (Ibid., 97-102):

- Computerized feedback, offering multiple options to the user (e.g., consumption over various time periods, comparisons, environmental impact, cost and/or energy saving tips)
- Interactive elements that engage households through activities like self-feedback or self-meter reading
- Detailed, appliance specific energy usage breakdowns
- High frequency feedback (daily or more)
- Long term duration – contributing to habit formation and more persistent savings
- Presentation that is simple but not simplistic, not involving additional paper, and a combination of text, diagrams, and tables
- Feedback that links closely to consumption actions, giving consumers a sense of control
- Including electronic "smart" two-way metering, data procession and communication

Case Study: Centre for the Built Environment (CBE)

The CBE at the University of California Berkeley has undertaken research on promoting energy conservation by using "data visualization methods" to engage building occupants. This research was built upon several studies that examined how feedback can help occupants reduce energy consumption. While the majority of these studies have focused on homes the results are still of note, on average, they found that real-time energy feedback resulted in overall energy savings of 10-15% (Lehrer, 2009a, 3).

Information (feedback) on its own is insufficient to save energy. Professor David P. Wyon at the Technical University of Denmark noted that "insight, information, and influence" are all necessary to positively affect building performance and resource consumption (Lehrer, 2009b, 3). Furthermore, a study conducted at the Eindhoven University of Technology (Netherlands) found that a group of test subjects with energy feedback, but no energy saving goals, used the same energy as a control group who were given no feedback. Test subjects given feedback and energy saving goals saved on average approximately 20% (Ibid., 7). In summary, energy saving is enhanced when occupants understand the context of energy use patterns (insight), set goals, and are empowered to influence energy use.

In Professor Cris Benton's architecture class at the University of California Berkeley, "The Secret Life of Buildings", students used data visualizations to understand energy patterns and recommended fan schedule changes that reduced overall energy use by 27.5% in the Wurster Hall building. This had no apparent impact on occupants (Lehrer, 2009a, 8). The visualizations included representations of ventilation, daylighting and lighting effectiveness, night occupancy, plug load and water use (Nauman et al., 2009). During the visualization work, an online occupant comfort survey was completed to probe the impact of changes to lighting and ventilation services. In addition, two "right now" surveys with pushbuttons in an office space were conducted seeking input on space heating and noise levels (Ibid.).

The visualizations are designed to display trend data and allow for historical and normative comparisons. Users are then able to view data in terms of metrics that are the most relevant to their interests such as energy cost and carbon emission equivalents (Lehrer, 2009a, 4).

The literature provides specific points that could be incorporated into employee engagement campaigns, with respect to how energy information is communicated. Several of these features were included in the case study below.

Case Study: MEMPR

In 2008 the Province of British Columbia (BC) Ministry of Energy, Mines and Petroleum Resources (MEMPR) signed an agreement with BC Hydro, BC's largest electric utility, to reduce its internal electricity demand 20% by 2020 (9% by 2009). MEMPR, along with the rest of the BC Public Service, is also required to be carbon neutral by 2010. Employee engagement has been a key mechanism for achieving these targets. This was coupled with some modest technology and building retrofit measures with limited capital funds. As part of its agreement with BC Hydro, MEMPR employed a full time Strategic Energy Manager, who manages electricity and greenhouse gas reduction projects and leads employee engagement measures.

Since 2008, MEMPR has conducted a series of initiatives to engage employees and build a culture of conservation. These initiatives played a key role in setting a foundation for an energy conservation campaign (described later) by ensuring that employees understood the importance of energy conservation (i.e., had insight) and were receptive to taking action (i.e., had influence).

Three initiatives that played key roles in developing that culture include:

- **Launch of the MEMPR green team** – a team of 'green-minded' individuals meets monthly to identify opportunities to reduce MEMPR's environmental footprint. A launch event hosted by MEMPR's Deputy Minister was held at the Jack Davis Building in order to raise the profile and awareness of the Green Team, and of MEMPR's electricity and carbon targets.
- **Workstation tune ups** – MEMPR employees were asked to complete a series of tasks at their workstation that would reduce energy consumption. They were given a checklist that included items like "turn off your computer monitor at the end of the day," and "plug peripheral devices into a power bar". Initially, the Tune-Ups were conducted in person where a Green Team member would walk an employee through the various tasks, enabling relationship building and the identification of key barriers. Taking lessons learned based on those experiences, an on-line tool was developed that facilitated the involvement of a much wider audience. 60% of MEMPR employees completed the Workstation Tune Up.
- **Green pledge** – on the day of the Green Team launch, employees were asked to sign a 'green' action pledge that was posted in the lobby of the building. Several months after that, about 40 employees of one Division of MEMPR were asked to choose from one of three 'green' actions: 1) reduce travel emissions by 25% over the previous year, 2) organize 'green' meetings, or 3) influence at least one co-worker or stakeholder to make a 'sustainable choice' each month. Employees reported on their progress with a simple check-box that they completed the action or not. As of April 2010, on average 44% of staff were completing the monthly pledge survey, with 80% of respondents maintaining their pledge commitment.

A variety of CBSM tools were used in the implementation of these initiatives, including:

- **Commitments** – employees signing a pledge
- **Prompts** – "turn it off" stickers
- **Norms** – employees saw colleagues engaging in energy saving behaviors and followed their example
- **Communication** – key messages were communicated via email, Intranet, posters, and verbally by management
- **Incentives** – prizes were awarded at the Green Team Launch for the top 'green' business improvement suggestions, and for completing the Workstation Tune Up

Other key factors in making these initiatives a success were keeping the messaging simple and easy to understand, and engaging senior executive leadership.

These initiatives helped build a culture of conservation at MEMPR. Since its launch, Green Team membership has more than doubled: from 13 to 29 members. In addition, approximately 20% of employees actively participate in Green Team initiatives and are consistently coming forward with suggestions to save energy. Conservation goals have also been incorporated into Ministry strategic planning and processes. For example, one Division's "Balanced Scorecard" plan includes green pledges (as noted earlier) and the MEMPR-wide orientation process for new staff and moving offices includes a "Green Move Checklist" that highlights energy conservation actions.

With an established level of employee engagement at MEMPR, an obvious next step was to measure the energy-saving and financial benefits of the aforementioned actions. A government-wide tool called SMARTTOOL documented energy consumption and emissions for each month with a 3-4 month lag. The total electricity consumption was 1.8 GWh in 2007, versus 1.6 GWh in 2009, illustrating a 12% reduction that may be partly attributable to the employee engagement measures. In order to complement CBSM initiatives, an energy information system (EIS) was required to allow for real-time energy monitoring at an energy end-use level, and provide feedback to building operators and occupants. The implementation was completed ahead of a campaign to change behavior specific to lighting use in July 2009. For the campaign to be successful, employees needed to be aware of and trust the suggested actions from the Green Team, and execute the actions themselves. The Green Team felt that, with the level of engagement achieved through the aforementioned initiatives, the conditions were present for a successful campaign.

MEMPR Lighting Campaign

In March 2008, MEMPR completed a lighting retrofit on the 4th and 5th floors of the Jack Davis Building. An automated daylight dimming system was installed on the south side of the 4th floor, while 85 individual light switches were installed in all work spaces on the 5th floor, including offices and cubicles. Power meters were installed to monitor lighting electricity consumption on the 4th, 5th and 6th floors. Using the 6th floor as the baseline of typical, pre-retrofit conditions, so that comparisons could be made between electricity savings realized from automated features (on the 4th floor) with employee-controlled features (on the 5th floor).

To determine what effect employee behavior could have on lighting energy consumption, MEMPR ran a campaign targeting approximately 200 employees to reduce occupant lighting use during the last week of July 2009. The campaign involved:

- Determining the baseline lighting energy consumption and setting a 10% savings goal
- Developing targeted communication for each floor, detailing specific actions they could engage in to reduce lighting electricity consumption (i.e., prompts)
- Conducting an 'Earth Hour' style event on the 5th floor, encouraging employees to turn off the lights during lunch hour
- Profiling champions on different floors who exemplified conservation behaviour
- Providing feedback to staff on interim savings throughout the week
- Communicating the results at the end of the campaign.

The goal of the campaign was to reduce energy consumption for lighting on these three floors by 10% as compared to the average seasonal weekly consumption. It targeted savings over and above those from the technological measures installed in 2008, thus aiming to isolate the effects of employee engagement from the lighting retrofits. Key messages for daytime lighting use included asking staff to turn off boardroom lights when not in use and asking 5th floor employees to turn off their lights every time they left their desk. Key messages for after-hours lighting on the 4th and 6th floors included suggesting the use of task lamps instead of turning on the whole bank of overhead lights. Pulse Energy software was used to track lighting electrical demand on a minute by minute basis and provide employees with visual feedback on lighting energy consumption through a "Dashboard". This enabled participating staff to see the impact of their actions on a real-time basis. The Dashboard also allowed the campaign team to identify key opportunities for energy savings and determine which modes of communication were most effective at influencing employee behavior.

Use of CBSM Tools

In order to promote energy conservation, the team utilized a number of CBSM tools.

Communication and feedback. The communication used was vivid, concrete, and targeted to the audience. Brightly colored charts displaying goals and tracking progress were placed in the lobby of the building. Specific actions were clearly communicated to staff (i.e. turn off boardroom lights, use task lamps after hours) through emails and on the Ministry's intranet site. Given that each floor has different lighting controls the communication clearly separated key actions for the 4th, 5th, and 6th floors. The end-use monitoring on each floor, coupled with the Pulse Energy Dashboard made communication interactive by allowing employees to see the impact of their actions. Feedback on energy savings was reported throughout the week and results were presented at the end of the campaign by email, on the Intranet, and on posters in the lobby. The Dashboard allowed the campaign team to share both graphical and statistical results with staff in a way that was easy for employees to understand. The Pulse Energy software also provides a real-time prediction of the typical energy use based on current conditions, enabling the campaign team to quickly identify energy savings each day.[2]

[2] The Pulse™ Typical Curve analyzes a variety of variables that have an impact on energy consumption in a building and then predicts what would typically be used given current conditions.

Prompts. An 'Earth Hour' style event was conducted on the Wednesday of the campaign week. An email was sent to all 5th floor occupants just before lunch, asking them to turn off their lights if they were going to leave their desk for lunch and included an image of the Pulse Energy Dashboard showing lighting energy use for the 5th floor that morning. Feedback was also used to reinforce the message of the email prompt; on Wednesday afternoon the campaign team sent a follow up email highlighting the savings generated during the lunch hour.

In addition, email reminders were sent to all floors twice during the campaign; the emails included key actions for each specific floor and updates on energy saving progress.

Empowering champions. The campaign team highlighted the efforts of proactive campaign participants. 'Energy champions' were profiled on the Ministry Intranet, as well as at staff meetings with the aim of influencing other employees. There were three notable energy champions who took the initiative to turn out lights and suggest other opportunities to save energy during the campaign. One employee was able to convince her coworkers to turn off their zone of overhead lights during the day (note: this was a south-facing zone with light shelves to enhance day lighting). In response, that zone kept their lights off periodically throughout the week.

Norms and persistence of savings. The campaign team sought to establish new norms for energy conserving behaviors that would persist after the campaign. The behaviors promoted during the campaign have two characteristics that are advantageous for the establishment of norms. They can be repeated daily, encouraging the formation of new behavioural patterns. In addition they are publicly visible; those taking action send a passive message to their colleagues.

While outside of the scope of the campaign, the Pulse Energy software could be a powerful tool for demonstrating and reinforcing norms, provided employees view it on a regular basis. For example, if a norm is established that people turn off their lights at lunch, this will be evident on the Dashboard. This visual reminder may influence those who don't initially practice the behaviour to follow the norm set by their colleagues. This assumes that the information is specific to the behaviour being sought, requiring sub-metering of individual end-uses.

Analysis: Additional Savings from Employee Engagement

Daytime energy consumption during the campaign week was compared to the average value for weeks during the summers of 2008 and 2009. The analysis was limited to daytime energy consumption as the evening energy consumption varies significantly with fluctuations in the number of employees working outside of regular working hours.[3] In addition, time periods exhibiting clearly anomalous energy consumption were excluded from the analysis and adjustments were made to account for the effect of statutory holidays. Table 1 shows the energy savings observed during the MEMPR Lighting Campaign.

[3] In particular, after-hours use of the office was significantly higher than normal during the campaign week.

Table 1. Campaign Savings Results

	Energy Savings	Savings are Statistically Significant[4]	Deviation from Average Weekly Value
5th Floor (Occupant Switches)	12.0%	Yes	2.31 σ
4th Floor (Daylight Dimming)	12.6%	Inconclusive[5]	1.55 σ
6th Floor (No lighting measures)	2.4%	No	1.11 σ

Statistically significant reductions in energy consumption were observed on the 5th floor, where occupants have direct control of the lighting for their individual work areas. A 12% reduction in energy consumption, equating to 2.31 standard deviations, was observed in comparison with the average weekly value.

Results for the 4th floor are inconclusive due to the fact that weekly energy consumption in summer 2009 was 13.3% higher than the previous year. Based on the combined 2008/2009 weekly average, a 12.6% reduction in energy consumption was observed on the 4th floor during the week of the campaign. If compared to the summer of 2009 an 18.1% reduction in energy consumption was observed on the 4th floor during the week of the campaign, 4.52 standard deviations below the average weekly value for that time period.

No statistically significant energy savings were observed on the 6th floor.

Analysis of Results

The results indicate that employee engagement targeting behavioral changes can deliver measurable reduction in energy consumption, over and above technological measures (e.g., installing light switches and dimmable ballasts with photo sensors).

There is a clear correlation between the ability of building occupants to take individual actions that save energy and the level of savings observed during the campaign. On the 5th floor occupants have direct control over the lighting in their individual work area and have few barriers preventing action.

In comparison, occupants on the sixth floor do not have direct control over the lighting. Four circuits control the lighting for the main office area where most work stations are located and consensus agreement from other staff would be required to turn off any of the lighting.

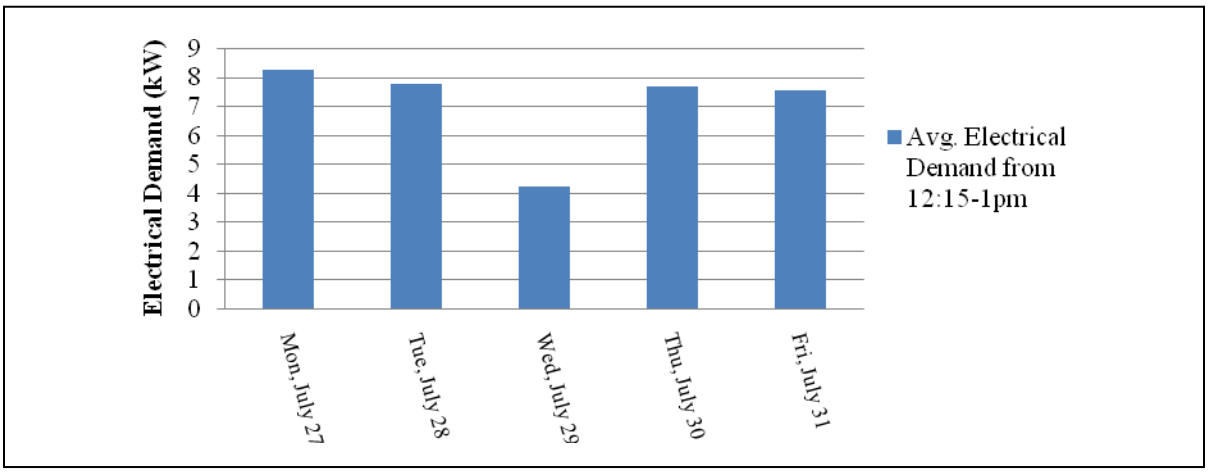
While occupants in the section of the 4th floor with the daylight dimming system do not have individual control of their lighting, they constitute a group of people working within the same Division, which includes the Energy Efficiency Branch. This group of people was highly engaged in the campaign, as the campaign coordinator is a member of this group and a number of staff members work on issues that relate to energy conservation.

Response to prompting for 5th floor occupants. The email prompt sent to 5th floor occupants on Wednesday had a clearly observable effect on occupant behavior. Over the period of 12:15-1pm, 5th floor lighting demand dropped to 4.25kW, half the typical value for the lunch time period during summer (approximately 8.5kW). Figure 1 shows the 5th floor, lunchtime lighting electrical demand for each day of the competition.

[4] Two standard deviations from the combined 2008/2009 seasonal weekly average is considered statistically significant.

[5] The summertime average weekly energy consumption on the 4th floor was 13.3% higher in 2009 than in 2008, making it difficult to draw clear conclusions about savings on the 4th floor.

Figure 1. 5th Floor Lunchtime Electrical Demand



It is interesting to note that while Thursday and Friday results were better than the days prior to the email prompt, the success from Wednesday did not persist in a significant manner. This illustrates that a single prompt was not sufficient to create a long term change in behavior. The campaign did not include an explicit effort to establish new norms, but a fall 2010 campaign will attempt to do so.

The role of real-time energy information during the campaign. The number of visitors to the Pulse Energy Dashboard spiked on Wednesday, coinciding with the email prompt sent to 5th floor occupants. The apparent relationship between the number of daily visitors to the Pulse Energy Dashboard and the reduction in energy consumption from normal daily values prompts further investigation during future campaigns. Figure 2 presents the daily energy savings and unique visits to the Pulse Energy Dashboard for the week of the campaign.

Reviewing Dashboard usage on an hour by hour basis provides insight about how campaign participants made use of the real-time energy information available via the Pulse Energy Dashboard.

Figure 3 presents the hourly Dashboard visits and the 5th floor lighting electrical demand for the last three days of the competition alongside the typical summertime load profile. On Wednesday and Thursday the majority of Dashboard visits occurred during or just after the lunch hour. This shows that occupants were using the Pulse Energy Dashboard to obtain real-time feedback about the energy savings resulting from their actions. On Friday the jump in Dashboard visits coincided with the end of the campaign which indicates participants were again looking for results and feedback on their efforts.

In summary, real-time energy visualization can be an important tool for providing feedback to occupants. Based on the results from the campaign and the literature, it was concluded that such feedback can help improve the effectiveness of prompts by illustrating the energy savings resulting from a specific action in a timely fashion.

Figure 2. Daily Energy Savings and Unique Dashboard Visits

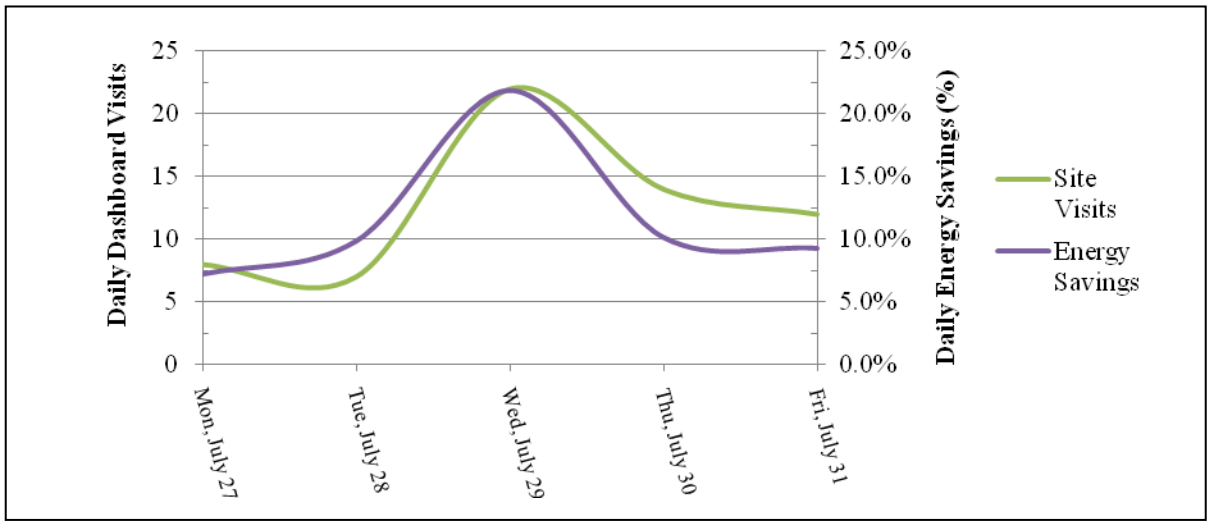
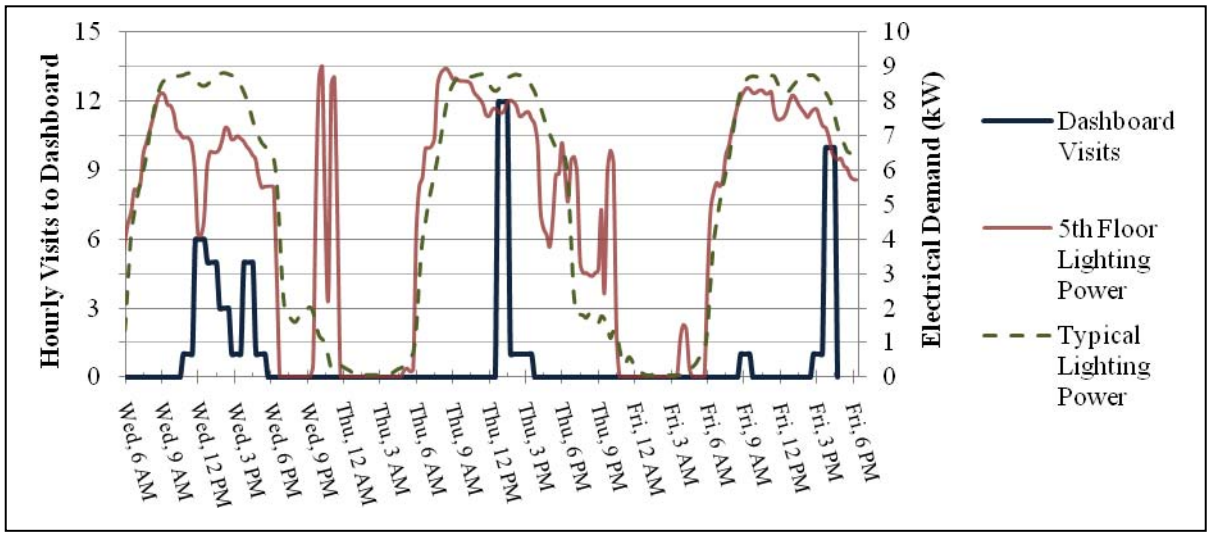


Figure 3. 5th Floor Electrical Demand and Hourly Dashboard Visits



Norms and persistence of savings. It appears that energy savings did not continue in a persistent manner following the campaign. The success of the Wednesday prompt for 5th floor occupants indicates that employees are willing to undertake new energy saving behaviors. However, drop off in savings on the following days without prompts highlights the fact that new behavioral patterns take time to form. Significant persistence of savings is likely to occur if prompts are used until participants become habituated to energy saving behaviors. As noted earlier, it is hypothesized that feedback with energy information systems could help reinforce norms by highlighting new behaviors (e.g., turning off lights at lunch) and nudging non-participants to take action.

Conclusions

This paper has illustrated how employee engagement measures, coupled with an energy information system, achieved electricity savings of 12%, over and above the impact of installing new energy efficiency technologies. This was achieved by 5th floor staff during a one week campaign in the Jack Davis Building.

The success of the campaign may have been influenced by the extensive community-based social marketing (CBSM) efforts of the Green Team and Strategic Energy Manager during the year before.

The results highlighted an important relationship between prompts and feedback – that information on its own may be insufficient to facilitate persistent action. The campaign could have been improved through the repeated use of prompts, supported by real-time feedback from an energy information system, to establish new norms.

Key conclusions from the MEMPR case study and the literature review include the following:

- The CBSM approach is an effective means of occupant engagement, provided that organizational goals and policy are consistent with the desired behaviors
- Some key factors for successful occupant engagement emerged from the lighting energy conservation campaign:
  - The success of the campaign was likely dependent on over a year of CBSM efforts by the Green Team that included commitments, prompts, norm formation, communication, incentives and barrier removal
  - Empowering individuals to act is highly important; energy savings had a strong relationship to the level of individual control of the lighting system
  - Information should be presented in a simple and vivid manner both electronically and on posters in highly frequented locations of the building
  - Email prompts can be highly effective when done in a timely manner and there are no significant barriers to taking action
  - Additional information and prompting may be more successful if provided at the location of actions (e.g. printed reminders near light switches)
  - Champions can play an important role in influencing the behavior of colleagues

- Energy information systems can play an important role in supporting occupant engagement efforts by:
  - Providing a simple and vivid presentation of energy information
  - Giving contextual information to help occupants understand energy-use patterns (i.e., historic and "typical" consumption)
  - Presenting information using units that are meaningful to occupants
  - Improving the effectiveness of CBSM tools such as prompts by providing timely and interactive feedback that highlights the energy savings due to a specific action
  - Helping to identify key opportunities for energy savings, allowing Energy Managers to focus campaign goals and messaging on specific actions and times
  - Providing detailed information to determine which employee engagement approaches are most effective

Future research will incorporate more of the feedback best practices from the literature into energy efficiency campaigns for the Jack Davis Building and other buildings. For example, targets will be displayed on a real-time basis in the energy information system, possibly inspiring further action to achieve the goal and establish new norms. In addition, the scope of efforts will be expanded to influence heating energy demand, such as encouraging employees to turn down thermostats to comfortable levels.

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