## Title
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## Publication Date
2014-08-01

Peer reviewed

# A Usability Study of a Social Media Prototype for Building Energy Feedback and Operations

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## ABSTRACT

This study explored the potential for using a web-based social network to promote energy awareness and influence energy-conserving behavior in the workplace. The research team developed a social media application prototype and conducted usability testing with 128 subjects as proxies for typical office building occupants. The key findings presented are: 1) the influence of highly personalized energy information; (2) the influence of normative energy information; (3) the potential for sharing personal energy goals and energy data; (4) the effects of incentives such as self-selected goals or reward "badges," and (5) the implications of using social media for improving communications between building occupants and operators.

Findings suggest that highly personalized energy information, at the level of individual workstations or offices, offers benefits for engaging and informing people about their energy use. The cost of energy was found to be the most useful energy metric, a finding supported by previous research. Social aspects of sharing energy use information and personal energy goals were also viewed favorably by the usability test participants. Although a laboratory study may not account for the many complexities of the workplace context, results show considerable promise for using social media to engage commercial building occupants in energy conservation, and to improve communications between occupants and building management around issues related to building operations. The findings conclude with recommendations for the design of energy feedback interfaces, and for incorporating social media characteristics into such systems.

## Introduction

Among business and academic circles there is a growing interest in influencing human behavior to reduce energy use and improve sustainable outcomes, and in documenting the range of effects resulting from behavior modification approaches and programs. As energy technologies make building systems more efficient, the energy use attributable to occupants becomes more significant, and in some cases may offer the greatest conservation opportunities (Sullivan and Sullivan 2009). However these "non-technical" energy solutions of behavior and culture change in the workplace are not well understood, and have not been sufficiently explored in research nor leveraged in policy (Moezzi and Janda 2014). In spite of a handful of notable successes, engaging commercial building occupants and operators in order to reduce energy consumption remains an ongoing challenge.

### Previous Research on Energy Feedback and Behavior

A body of research spanning four decades shows the potential for incentivizing energy savings in residential settings using a variety of interventions such as financial incentives, energy feedback, and social influencers such as social norms and commitments. Much of this research has focused on residential buildings, potentially undervaluing the opportunity to save energy in commercial properties (Moezzi and Janda 2014), however some residential studies provide insight into approaches that might be adapted for commercial buildings. For example, a review was conducted of large-scale residential pilots of real-time energy feedback that displayed energy consumption and costs via in-home displays, web interfaces, and pre-payment meters. The pilots found savings from zero to19.5%, with an average savings of 3.8% (Foster and Mazur-Stommen 2012). While the average savings is modest, the researchers were encouraged by a subset of participants who saved over 25%, the *cybernetically sensitive*, who respond readily to energy feedback, either by being predisposed to such feedback, or due to some new type of learning, habit, or motivation that resulted from the energy feedback. The study found no "one-size-fits-all" solution but rather that effective feedback results from effective design and content, the reliability of the devices, the level of users' engagement, and the degree to which learning and habit forming are influenced by the system.

Few energy feedback studies have evaluated the specific design of feedback interfaces, and there is a significant gap between environmental psychology feedback literature based on larger subject samples, and human-computer interaction (HCI) studies that generally rely on smaller subject groups and more qualitative approaches (Froehlich et al. 2012). However one study suggests that tailoring information according to the level of awareness or involvement of the energy users is helpful in keeping their interest, and "devices that are difficult to use are less likely to be used, particularly given the high expectations today's consumers have for the usability and engagement of electronic devices," (Moran, Forster and Gettig 2012). Research has also found that people preferred for certain types of information displays: "the cost of electricity was recalled most easily and seen as most relevant, followed by electricity consumption, and in some cases the 'traffic light' feature providing an environmental clue of usage" (Foster and Mazur-Stommen 2012). Such findings begin to drill down into the specifics of interface design and user experience in ways that are useful to the developers of energy information services.

## Occupant Behavior in Commercial Buildings

Understanding behavior change in commercial buildings is far more complex than in residential properties, due to the range of building types, the diversity of stakeholders, organizational practices, and commercial lease structures (Axon et al. 2014). However additional research in this area is needed, as the amount of energy use under occupants' control in commercial buildings is significant. Past studies found that plug loads represent over 20% of commercial building energy use in California (Moorefield, Frazer, and Bendt 2011) and showed a great potential for energy savings by powering down computers at night and weekends, and turning off imaging equipment and speakers that are left on continuously but infrequently used (Mercier and Moorefield 2011). Other research has shown plug loads to be even higher in some buildings, for example in a research building (non-laboratory) where miscellaneous plug loads made up approximately 60% of the total building energy use, more than the peak value of HVAC and lighting combined (Marini et al. 2011).

The term "green work styles" has been coined to describe attitudes and behavior favorable to conserving energy at work, including actions such as turning off lights, monitors, copiers, and other equipment, and using energy saving computer settings (Bin 2012). Prompts are another useful approach to encouraging energy saving behavior. A study conducted by the New Buildings Institute found that the "easiest and least expensive behavioral measures, such as sending an Outlook calendar reminder encouraging employees to turn off equipment at night and on weekends, reduced desktop computer electricity use by 6% on average" (Mercier and Moorefield 2011).

### Social Influence

Using social networks and peer influences to impact energy behavior shows great promise. Past research suggests that social networks are more likely to inform people of innovations than are other channels of communication (Darley and Beniger 1981). While energy feedback may be useful, research suggests that feedback alone is not sufficient, and that inclusion of other methods is likely to improve results. This can be done by tailoring information, making the information 'vivid' (e.g., using clear imagery and memorable narratives), and by using social approaches including goals and commitments, comparisons and norms, and by engaging occupants in small, actionable steps (Ehrhardt-Martinez, Donnelly, and Laitener 2010). An energy efficiency concept developed at MIT proposes inducing energy conserving behaviors using a pledge and tracking system, providing social recognition and rewards, and leveraging social networks (Alschuler, Donnelly, and Michaels 2001).

Some have further suggested that commercial building energy must be addressed using a framework of "building communities," and that inherent in this effort is the need to promote collaboration between owners and occupants (Axon et al. 2014).

### Social Media and Behavior Change

Social media tools are being increasingly used to drive behavior change for improving health and other desired social outcomes (Tscheligi and Reitberger 2007). The term "captology" was coined to describe "computers as persuasive technology," (Fogg 2003) and social media applications have been cited as a valuable behavior and culture change method combining the potential of "interpersonal persuasion with the reach of mass media" (Fogg 2008).

The act of sharing personal information with others creates a "social object" in that the object – a photo, video, or chart – becomes something that can be viewed, linked to, and shared by others (Bell 2009). A pilot for a residential energy feedback program allowed users to create social objects by saving "snapshots" of their energy consumption charts and posting them to a virtual community bulletin board for discussion and for help identifying possible savings. The pilot allowed people to compare their energy use to similar households, and resulted in energy savings of over 9%. Between 10% and 25% of users shared their own energy information or posted a comment to an energy expert forum, and 35% to 55% viewed social content. A group of highly engaged users took frequent "snapshots" of their energy charts to document the energy use patterns in their homes (MacLaury et al. 2012).

## Hypotheses and Methods

This study explores the potential benefits of using a web-based social network, integrated into the workplace environment, to promote energy awareness and positively influence energy-conserving behavior of typical office workers. This builds on previous research by the authors showing that many workplace occupants report taking actions to conserve energy at work, and that they would make more of an effort to do so if they had information about the amount and associated cost of energy they use (Lehrer and Vasudev 2011). A related study found that 90% of energy professionals surveyed showed interest in a more systematic way of communicating with the workplace occupants (Lehrer and Vasudev 2010). A shortcoming of current occupant-operator communication methods is that they primarily provide one-way communication from occupants to building managers, so occupants have no information on whether their complaints are heard and/or acted upon. A social media platform potentially offers convenient two-way communications between operators and occupants, and peer-to-peer interactions among occupants related to building energy, comfort and/or problems.

The prototype was designed to investigate a number of specific research questions: (1) the influence of having more personalized energy information compared to area or whole building energy patterns; (2) the influence of normative information such as the average energy use of other occupants, or user-selected individuals; (3) the potential effects of sharing personal energy goals and energy use data with others; (4) the effects of giving people incentives such as self-selected goals or reward "badges" for meeting personal energy-related goals, and (5) the implications of using social media for improving communications between building occupants and operators.

## Research Approach

The research team developed a prototype social media application, and tested it with university students and staff as proxies for the perspectives of typical office building occupants. The prototype as tested allows people to track their own energy-related activities, to share this information, and to view and react to peers' activities, using interface conventions that are familiar to users of popular social media applications such as Facebook and LinkedIn.

Figure 1. Energy goals page

Figure 2. Energy use shown by floor

Figure 3. Individual energy use

The application prototype includes four top-level sections; (1) my network; (2) billboard; (3) energy charts; and (4) community. The "my network" section includes a dashboard landing page, and a goals page that allows users to set personal energy-related goals, to monitor progress towards these goals, to share this information, and to view and react to peers' activities. Sample prototype screens are shown in Figures 1-3.

A "billboard" section allows occupants to report problems, questions, and energy tips. This feature was designed to resemble typical social media concepts, allowing users to "join," "like," or "comment" on posts, including building managers who can respond to them.

An "energy charts" section was created to show building energy use at various levels of granularity, from the individual office or workstation, to floor by floor (shown as a competition) to whole building energy performance. Multiple versions of the energy pages were mocked up in order to test hypotheses related to displays of energy information with various levels of granularity and metrics.

Finally, a "community" section was included, with a "groups" page that would allow people to interact or work collaboratively on energy or building related activities.

### Test Procedure

The study was conducted at UC Berkeley's Experimental Social Science Laboratory (Xlab). Subjects first answered a "pre-demo" online questionnaire with general questions about demographics and energy attitudes. Next, the research staff provided a ten-minute demonstration of the prototype to introduce the features and explain the purpose of each. The subjects were then asked to review the features of the application while responding to a paper questionnaire with multiple choice and ranking questions about specific features of the prototype. Finally, they responded to an online "post-demo" questionnaire with questions about their experience viewing the prototype, with a focus on the sharing and social aspects.

## Results and Discussion

The study included 128 subjects comprised of 80% undergraduate students, 11% administrative staff, 7% graduate students, and 2% "other." As may be expected of a youthful subject group, 99% of the participants use social media sites, and with some frequency: 8% use the sites on an hourly basis, and 71% several times a day.

The subject pool was largely a pro-environmental group. A large number of subjects feel that environmental issues are important to them personally (42% "very important," and 48% "somewhat important"), and that it's important for individuals to reduce their impact on the environment (68% "very important," and 27% "somewhat important"). Asked to express their thoughts about energy conservation, 35% responded that "energy conservation is good for the environment," and 45% agree that it is their "duty as a socially conscious person" to conserve.

The authors acknowledge limitations to this study. Although a laboratory study may not account for the many complexities of a real workplace environment, the findings provide insight for the development of a workplace social media tool, and this preliminary study would be well served by testing in the field as a next step. With subjects that consist of generally pro-environmental university students, the results may not be representative of the full range of North American office workers. However, the sample may be a reasonable representation of employees in sectors such as technology, marketing and new media that have a large percentage of educated younger workers. Previous research also provides evidence that younger people have been found to be linked to higher energy savings due to energy feedback (Foster and Mazur-Strommen 2012), so such an application might be useful for younger employees.

### Display of Personalized Energy use and Energy Metrics

To investigate the influence of varying granularity of energy displays from whole building, to areas within the building (in this case floor by floor), to the level of individual offices or workspaces, subjects were asked to respond to these alternatives in terms of their interest and usefulness. Like most of the pages on the site, a column on the right side of the page showed other people that have shared information on the site.

The subjects expressed interest in the energy displays of all three levels of granularity, with a slight preference for the floor and individual levels. However, their rating of the usefulness of the three energy displays increased strongly with the level of granularity, with individual level displays getting the highest score. This is shown in responses to the usefulness Likert scale question and also to the ranking question shown in Figure 4. Subjects showed the most interest in their personal energy use, which informs our first research question (the effect of highly personalized energy information). The personalized energy feature was also cited frequently as a favorite feature in subjects' responses to open-ended questions. This finding is consistent with a recommendation frequently cited in behavior change literature, to make information 'vivid' to the audience. Several of the participant comments illustrate the findings:

*Energy charts clearly show the cost of energy that I used. It also compares with average energy usage which gave me more realization of how much I am using.*

*I like that you can monitor your own energy use and so you know how effective you are being in your efforts at using less energy.*

*I like the visualization of my own energy consumption and also having an idea of the cost.*

A secondary goal of the study was to learn what energy metrics would be considered to be most relevant and/or useful. Subjects were also asked to evaluate and compare four types of energy displays, in each case the prototype showed individual energy use. The four displays each represented historical energy use for one week, including the weekly total, as shown by four metrics: (1) power in watts, represented by a time series chart; (2) a bar chart showing energy used in kWh; (3) a bar chart showing energy used in "light bulb equivalent" (the number of 25-watt bulbs in use for one hour); and (4) a bar chart showing the cost of energy used. The displays were designed to represent values that might be realistic in an office setting, for example, the weekly cost for energy to the individual workspace was shown as $1.43. Subjects were asked to rate how useful and interesting these charts were, and also to rank them from most to least useful.

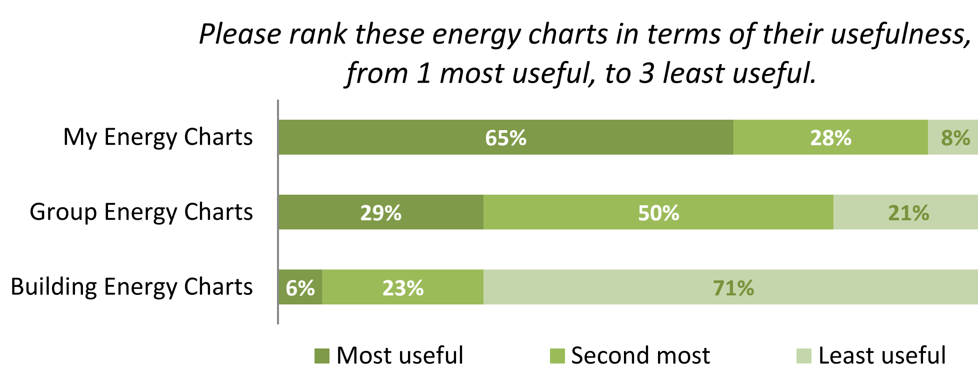


Figure 4. Ranking of usefulness of energy granularity.

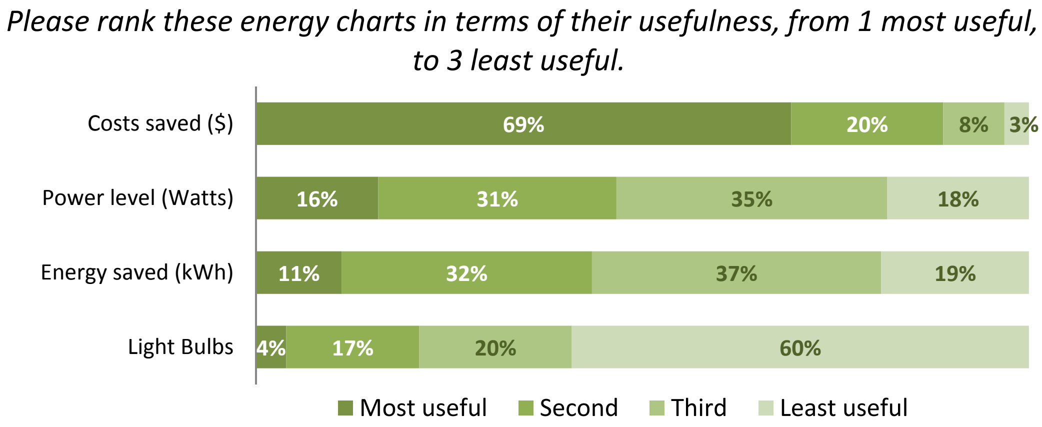


Figure 5. Ranking of usefulness of type of energy visualization.

The subjects found the display of energy cost to be the most interesting and useful, the power (watts) and total energy (kWh) less so, and the light bulb equivalent display to be the least interesting and useful. The preference for cost as an indicator for energy use is consistent with other recent research (Foster and Mazur-Stommen 2012). The results of the usefulness ranking question are shown in Figure 5. As money has a tangible quality and people show emotional responses to getting or saving money, it is not surprising that this metric would be seen as the most useful. This was true in spite of the relatively low total cost of energy displayed (in this case $1.43 for the week). The conventional energy metrics (watts and kWh) are unfamiliar to most people and were expected to be of lesser interest and usefulness to subjects. The "light bulb equivalent" was intended to provide an alternate way to display energy use using a familiar device, but in fact this was seen to be least interesting and valuable, as perhaps the idea was too much of an abstraction. The subjects' comments in the closing survey revealed the cost metric to be one of the features most liked, and helped to explain why the cost metric was preferred:

> *...most people (unless they are familiar with the watt and joules or technical terms like that) will not be concerned about pages like "watts used." I think people will be more concerned about the costs of energy and not the amount of energy spent.*
>
> *Cost is probably the biggest driver for someone to save energy and having this comparison between days increases one's awareness of his or her daily energy usage.*

Subjects were then asked to consider energy displays showing their personal energy consumption with various types of normative information. The energy display feature used a weekly bar chart, with a weekly total shown in terms of the cost of energy (which was found to be the most useful metric, as noted above.) Subjects were asked to evaluate and rank the following options: (1) no comparison; (2) personal energy use compared to the average user; (3) personal energy use compared to an individual selected by the user.

Results show a strong preference for comparison to the average user, as shown in Figure 6, with 79% of subjects ranking this at the most useful option, and 17% ranking it as the second most useful. The comparison to a selected individual was ranked as most useful by 13% of subjects. A comparison to an average user is the most meaningful from a statistical standpoint, and the subjects seemed to grasp the value of such a comparison. Having the ability to compare to selected individuals may be useful for engaging individuals who are not interested in energy conservation, but might enjoy using such a feature for friendly competition with workplace colleagues. Overall, almost all test subjects viewed the energy chart features favorably, with 98% responding "strongly agree" or "agree" that the energy chart features of the prototype would be useful in saving energy.

A number of responses to open-ended questions shed light on the sentiments regarding comparisons to the average users and individuals:

*[I liked] seeing my personal energy use as well as my office mates.*
*I liked the comparisons between individual energy use. It made it competitive and like a game, which is a good thing when it comes to energy conservation (a typically dull conversation topic.)*

However several comments were of the opinion that people might be judgmental of those who used more energy, that this may contribute to a less friendly work environment or that such comparisons are not fair due to varying equipment needs:

*I think a person versus person feature...could negatively and unfairly single some people out that may need to use more energy for their job than their co-workers.*
*I don't think we should "compete" to be the greener co-worker. I think it would raise negative atmosphere in the workplace between people who turn off light[s] and people who don't.*

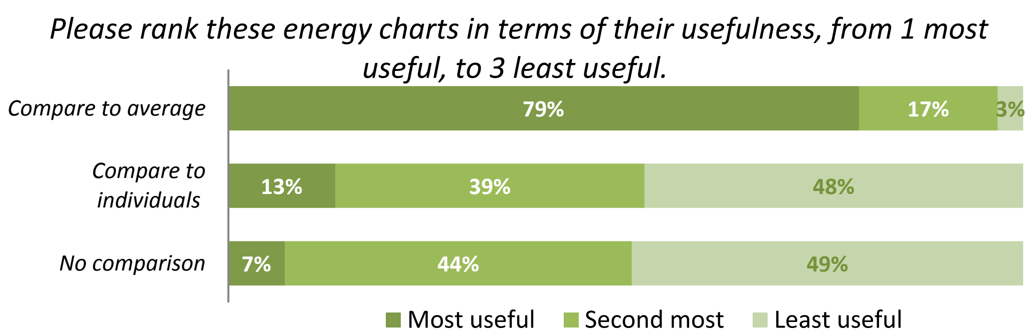


Figure 6. Ranking of usefulness of normative energy information.

## Impacts of Sharing Energy Information

After subjects reviewed the three options for normative energy information, they were asked additional questions about this aspect of the prototype. In the demonstration provided by the research staff, it was explained that users could "opt-in" to sharing their energy charts with other people in the workplace. A series of questions asked whether people would share their energy information, whether they would be interested in seeing energy charts of others, and whether such sharing of information would be interesting and/or useful for saving energy. The results from these questions are shown in Figure 7. Two-thirds of the subjects (66%) responded "strongly agree" or "agree" that they would share their energy charts with others. Responses were similar for related questions, whether sharing information would be useful in saving energy (72% "strongly agree" or "agree"), subjects' interest in seeing energy charts of other people (79% "strongly agree" or "agree"), and whether the social aspects of the application would increase subjects interest in energy (79% "strongly agree" or "agree"). Overall the results indicate that such an application would likely be an effective tool for engaging building occupants and increasing interest in their personal energy use.

The results also show that the social aspects of the energy charts have potential to engage occupants and to assist those wishing to save energy. Younger people who have grown up with the web are generally comfortable with sharing information via the web, which is reflected in the percentage of positive responses from the college age test subjects. Participants' remarks regarding the sharing of personal energy goals included positive comments such as:

> *I will be more likely to set higher goals to save energy if I knew people are tracking my usage through this application.*

However sharing personal energy information in a work situation brings up several considerations. Some people might be concerned that the energy charts could be used by peers or management to view patterns of occupancy, even if proven to be an unreliable measure. Also, as noted above, people may have different equipment needs (e.g., the number of computers, monitors or printers in a workspace, or shared devices) and some would feel that such a comparison is unfair, and might decide to opt out of sharing or using the application, as expressed by this subject:

> *I don't like the feature where other people could view how much energy I consume, and would likely not choose to share such information. For example, by looking at a co-worker's energy use I can become more judgmental about that person.*

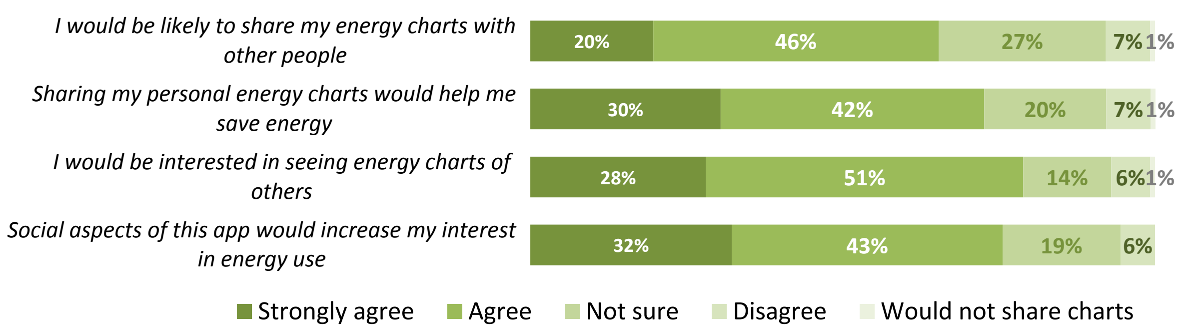


Figure 7. Responses to Likert scale questions regarding energy charts feature.

## Responses to Setting and Sharing Energy Goals

The prototype included an "energy goals" feature that allows users to select individual goals, to self-report their progress towards these goals, and to see other people who have selected the same goals. As represented in the prototype, users can obtain "badge" levels of "star," "ace," or "hero" by reaching designated point scores for each goal.

Subjects reacted favorably to this feature, with 81% of subjects responding "strongly agree" or "agree" that they would be likely to use such a feature. Subjects also felt that they would be likely to share their energy goals with others (77% "strongly agree" or "agree"), that sharing would help them to meet these goals (73%), and that they would be interested in seeing the energy goals of others (80%). Responses to energy goals questions are shown in Figure 8. The energy goals were cited frequently in the open-ended responses regarding favorite features of the prototype, as in these comments:

*The energy goals is [sic] also a great start to allow employees to be conscious of their energy usage.*
*I also enjoy that users would be able to set goals and have other people join those goals too. It really creates an environment of peer support.*
*I also like that you can set your own goals, because what may be a realistic energy-saving practice for one person might not be as feasible for another.*

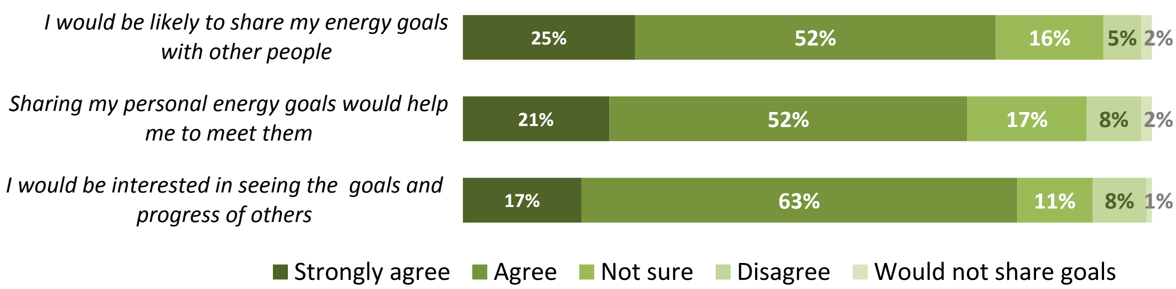


Figure 8. Responses to Likert scale questions regarding energy goals feature.

## Use of the Prototype for Communicating with Building Operators and Occupants

A "billboard" feature allowed people to report "problems," "questions," and "tips," using a format that is familiar to social media users, such as the "wall" feature of Facebook, allowing people to comment on posts by others, and view building managers' responses to service requests. The test subjects responded favorably to this feature, with mostly all indicating that the billboard feature would be generally useful in the workplace (95% responding "very useful" or "somewhat useful"). Subjects indicated that they would be more likely to use the application to report a problem (96% "strongly agree" or "agree") and to ask a question (79%). Many would be more likely to use the application to report a problem than the phone (77%). Slightly more than half reported that they would be likely to use the feature to post an energy tip (58% "strongly agree" or "agree"). Subjects responses show that many are comfortable using a web based tool to report problems or ask questions. Compared to making service requests by phone, the web tool would provide additional benefits for example allowing users to see the status of a request, and to see if peers have similar problems. Subjects commented on potential benefits from the collaborative nature of the application:

*I like how you can personally make complaints or ask questions on the site while also getting feedback from your colleagues—it's nice to know you are not the only one experiencing problems and that your complaints will not go unseen.*
*Being able to see other people's complaints about the building is useful because I can see whether my complaints about the building are shared by others.*
*I know people tend to complain about a problem at the office, but don't really know how to get it fixed... so if enough people are complaining in a constructive way, then I see potential for a faster response.*

However, a few subjects indicated through comments that they would not want to be bothered by the building-related concerns of other people, and would not use such a tool unless they had a problem to report. This leads to our recommendation below to provide filtering capabilities and/or personalized settings.

### Results of "Closing" Survey

After viewing the prototype and completing the paper survey, subjects were asked to take a closing survey that included multiple choice and open-ended questions about the prototype. Many subjects viewed the application and its social features favorably, for example:

> *I like the friendly, social aspects of the application that remind me about the connection between work and the environment. I also like that it makes me think about how our actions affect one another and the environment. It makes me think about saving energy in an easy straightforward way.*

However some participants expressed apprehension about the competitive aspect of energy comparisons and privacy concerns. This suggests that comparative or competitive aspects of energy feedback displays should be framed in positive terms and should avoid any approach that may be viewed negatively by individuals with such sensitivities.

The energy charts feature was the most frequently cited aspect of the prototype in the "like" comments (mentioned in 183 comments). For example, subjects cited the ability to visualize energy information and to "*figure out when [he is] using the most energy and see if [he] could cut back at those times"*

## Conclusions

This usability study illustrates the potential for using social media to engage commercial building occupants in energy conservation, and to improve communications between occupants and building management. The study found that highly personalized energy information, at the level or individual workstations or offices, offers potential benefits for engaging and informing people about their energy use; and that cost is considered the most vivid and tangible energy metric, a finding supported by previous research.

Sharing energy information using social media may provide considerable value, as many subjects expressed interest in sharing energy goals and charts with others, and seeing that of peers. However an important caveat to this finding is the concern expressed by some study participants that sharing personalized energy information holds a risk of stigmatizing individuals that use more energy than the average person, which may contribute to ill feelings among peers, and may reduce the potential level of engagement by all participants.

### Design Recommendations for Social Media Energy Feedback

Based on the results of this paper and related research, the authors offer the following design recommendations to potential developers and customers of social media technologies for energy feedback and building operations:

**Provide energy information that is specific to the individual building occupant.** Subjects showed an overwhelming preference for energy displays on the scale of the individual workspace. As this requires specialized hardware (smart plug strips, wireless lighting controls) and associated software with costs that are not negligible, this may only be feasible for highly motivated companies. However some notable companies are installing such systems at scale, and costs are likely to come down as these devices are more widely adopted. When providing individual energy feedback is not possible, zone or floor level energy information is the next best option. If only whole-building energy data is available, showing energy broken down in terms of per-person energy use may be an alternate way to engage occupants.

**Provide normative energy comparisons in terms of average energy use, and also show the energy use of an energy efficient user.** Subjects were most interested in comparing their energy use to the average user in the building. To avoid the "boomerang effect" (low-energy consuming individuals increasing energy use when they see that they are below average) providing the energy use of an efficient energy use is a useful approach. (This approach has been widely adopted in home energy reports that compare the customer against the most energy efficient 20$^{th}$ percentile).

**Allow users to share and view personal energy displays as "social objects," and to share and view energy saving goals.** Subjects showed a strong inclination to share their energy use charts and goals with others, and indicated that the social aspects of such sharing may be useful for engaging people in energy conservation. This capability should be an opt-in feature, as some subjects expressed concerns about privacy or competition. Having an option in which people can share their energy use anonymously may allow people to be engaged with a program while not being identified personally, if they harbor such concerns.

**Be explicit about the use of energy information being solely for energy conservation.** Due to subjects concerns about privacy and competition in the workplace, energy feedback programs should be explicit about using personal energy use information solely for energy conservation, and not for other purposes such as monitoring employee schedules.

**Focus on positive aspects of energy comparisons, avoiding judgmental feedback.** In response to the concerns noted above, energy use should be shown in positive terms such as energy saved compared to past use, potential for savings, etc. Obviously terms that reflect poorly on groups or individuals (e.g., energy hogs, wasting energy, etc.) should be avoided, and the program should explicitly recognize that energy use will necessarily vary greatly among individuals as a result of varying usage and equipment needs.

**Display energy information in terms of the cost of energy use as the default.** Subjects had a strong preference for seeing energy use data in terms of costs, in spite of the relatively low cost of electricity used by an individual (less than $2 per week per person in this study). In cases where energy use is low, it may be preferable to aggregate energy use in terms of weekly, monthly, or annual costs. For example, an energy display could show a user the yearly cost if the current power level was constant. A web interface can easily let users toggle between various energy metrics, and this provides the benefit of letting users explore, tailor, and interact with data.

**Allow occupants to collaborate and communicate with facility managers on building problems and repairs.** Subjects found a "billboard" feature valuable and indicated that they would use such a feature if it were available. However such a system should be designed so that users can easily search and also filter out irrelevant information. To avoid the possibility that such a system will increase the rate of complaints, the authors suggest using an intelligent complaint reporting approach, that inform users if a particular problem has already been reported. Such a feature would benefit by allowing facility managers to respond to complaints and to push announcements to building occupants via the application.

**Acknowledgements**

This study was funded by the California Energy Commission Public Interest Energy Research (PIER) Buildings Program under the "Advanced Integrated Systems Technology Development" CEC Contract 500-08-044. Sections of this paper are included in the final report appendix 2.3.2: "Evaluating a social media application for conserving energy and improving operations in commercial buildings," September, 2012, 37 pp.

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