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Evaluating a Social Media Application for Conserving Energy and Improving Operations in Commercial Buildings

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1. ABSTRACT

Compared to the wealth of studies on residential energy behavior, studies on the energy attitudes and behaviors of commercial building occupants have been few. However, occupants exert significant control and influence over energy use in commercial buildings, and it has been estimated that 20% to 50% of total building energy use is controlled or impacted by occupants. This study explores 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 to understand the perspectives of typical office building occupants. The key findings presented are: 1) the influence of 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 rewards, and (5) the implications of using social media for improving communications between building occupants and operators.

Findings suggest that highly individualized energy information, at the level or individual workstations or offices, offers benefits for engaging and informing individuals about their energy use, and that the cost of energy is viewed as 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. Overall the study found considerable potential for using social media to engage commercial building occupants in energy conservation, and to improve communications between occupants and building management. The paper concludes with recommendations for the design of energy feedback systems including those with social media characteristics.

2. BACKGROUND

In both business and academic circles there is a growing interest in better understanding how to influence human behavior to reduce energy use in the built environment. As energy conserving technologies make building systems more efficient, the portion of energy use attributable to occupants increases, and some of the most cost-effective energy efficiency gains may now be made by changing the behavior of energy users (Sullivan and Sullivan 2009). In spite of notable successes, engaging residential energy customers and commercial building stakeholders to consider energy issues and energy related behaviors remains an ongoing challenge.

2.1 Previous research on energy feedback, behavior, and interface design

A body of research spanning close to four decades shows the potential for incentivizing energy saving in residential settings using a variety of interventions such as financial incentives, energy feedback, and social influencers such as social norms and commitments. Noteworthy meta-analyses of energy conservation pilot programs have found that household energy feedback can produce substantial energy savings that is generally persistent during the time that the feedback is available. Direct energy feedback from a meter or display monitor was found to provide savings in the range of 5-15% (Darby, 2006). A meta-analysis of 57 studies found savings of 4-12%, with the greatest savings resulting when direct or real-time feedback was provided, and when such feedback was more specific to the end use (Ehrhardt-Martinez et al. 2010). Most of the energy savings appear to result from simple behavioral changes such as turning off lights and equipment, and less from investments in energy efficient products.

A more recent meta-analysis from 2012 includes additional pilots of real-time energy feedback that displayed energy consumption and cost through in-home displays, web interfaces, and pre-payment meters, in the U.S., U.K., and Ireland, showing savings of 0 - 19.5%, with an average savings of 3.8% (Foster and Mazur-Stommen 2012). While the average savings was found to be modest, the researchers were encouraged by a small set of households that saved over 25%, a group they call 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 pilots resulted from effective design and content of the systems, the reliability of the devices, the level of users' engagement, and the degree to which learning and habit forming are influenced by the system (Foster and Mazur-Stommen 2012).

Tailoring energy information to the cybernetically sensitive and others is becoming more possible through the proliferation of web-based feedback systems enabled by the adoption of advanced metering technologies, commonly referred to as "smart meters." Many utilities, acting under state and federal mandates, have deployed energy information programs by providing consumers with individual energy feedback. It has been estimated that as many as half of all residential customers will have smart meters by 2020 (Karlin 2012).

The visual design and usability of energy feedback systems are important considerations that until recently have gotten little attention in the research literature. Few studies have looked at the specific design of energy feedback interfaces, and there is a significant gap between environmental psychology feedback literature — with large subject samples that provide statistically significant results — and human-computer interaction (HCI) studies that generally rely on smaller subject groups and providing more qualitative findings (Froehlich et al. 2012).

A review of residential demand-response and technology pilots launched by a California utility noted that participants found the energy feedback and curtailment devices difficult to use, and reported that there is "substantial room for improvement in the user interfaces of these devices" and that "devices that are difficult to use are less likely to be used." (Moran and Foster 2012). The paper suggested that vendors need to meet current standards for usability, and that larger-scale purchasers of such products request usability reports. In addition, the authors suggest that tailoring information according to the level of awareness or involvement of the energy users is helpful in keeping their interest.

Foster and Mazur-Stommen 2012 found that people had preferences for certain types of information displayed, and that "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."

2.2 Energy and occupant behavior in commercial buildings

Compared to the wealth of studies on residential energy behavior, studies on the energy attitudes and behavior of commercial building occupants until recently have been few. A prevailing belief has been that in commercial buildings occupants do not have a major influence on energy use, and that energy efficiency programs will be most successful if aimed at facility managers and operators. However, occupants affect energy consumption by controlling office equipment such as computers, copiers, and printers; controlling overhead or task lights; and in some cases through control of the thermal environment via thermostats, personal fans and heaters, shades, and/or operable windows.

As commercial buildings become more energy efficient through improved envelope and system technologies, and building teams striving for net-zero goals, the percentage of building energy subject to influence by occupant behavior increases. Anecdotal examples show that occupant and manager behaviors are difficult to predict, and in some cases may prevent buildings from meeting net-zero or ultra-low energy targets (*Centerline* 2008). Furthermore, simulation software tools are of little help in predicting or modeling the effects of occupant behavior (Fabi et al. 2011).

The amount of energy under occupants' control is significant. Recent studies found that plug loads represent over 20% of commercial building energy use in California (Moorefield et al. 2011) and offer a great potential for energy savings by powering down computers at night and weekends, and by turning off printers and speakers that are left on continuously but infrequently used (Mercier and Moorefield 2011). Large commercial building energy databases show that plug loads make up over 30% of the total electricity use (CEUS 2006, CBECS 2003).

However, recent studies further reveal that plug loads may be much higher in certain buildings; for example, an energy dashboard installed in a research building (non-laboratory) revealed that 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). Energy data collected by Lucid, a maker of energy dashboards for commercial buildings, included three large office buildings in which plug loads represent over 50% of total electricity use (Murray 2011).

A study of energy efficiency programs in five commercial buildings in North America found savings of 4% for a behavior-only program, to 75% for a comprehensive program in which behavior change was one part. The study outlines strategies for successful behavior programs such as the inclusion of five key engagement techniques: feedback, benign peer pressure, competition, rewards, and reference to appropriate social norms (Bin 2012). Bin uses the term “green work styles” to describe attitudes and behavior favorable to conserving energy at work, and cites actions such as turning off lights, monitors, copiers, and other equipment, and using energy-saving computer settings.

An energy efficiency concept developed at MIT proposed the use of community-action based models to address non-financial barriers with a three-part approach on energy feedback, community engagement, and motivation of individuals. The approach suggests the use of a pledge and tracking system, providing social recognition and rewards, and leveraging social networks to induce energy conserving behaviors (Alschuler et al. 2011).

Prompts represent another approach to encouraging energy saving behavior in the workplace. Researchers found that simple and inexpensive measures, such as sending a calendar reminder encouraging employees to turn off equipment at night and on weekends, reduced desktop computer energy use by an average of six percent (Mercier and Moorefield 2011).

2.3 Social influences on environmental behavior

Using social networks and peer influences to impact energy behavior shows significant promise. Past research suggests that social networks are more likely than other channels of communication to way to inform people of innovations. (Darley and Benninger 1981). While energy feedback may be useful, research suggests that feedback alone is not sufficient to maximize savings, and that additional methods combined with feedback are likely to provide better results. This can be done by tailoring information, making the information vivid, and by using social approaches that include making goals and commitments, using social comparisons and norms, and engaging occupants in small, actionable steps (Ehrhardt-Martinez et al. 2010).

Descriptive norms inform us about what is typically done in a given situation, and have been shown to be more effective in changing environmentally responsive behavior than an appeal focused solely on environmental protection (Goldstein et al. 2008). Descriptive norms in the form of neighbors’ energy consumption have shown to produce average household energy savings of two percent, and when combined with prompts can mitigate the potential “boomerang effect” in households that already use low amounts of energy (Allcott 2011). (The boomerang effect describes the potential for low energy users to increase their consumption when they learn that they are more energy efficient than their

peers.) Injunctive messages — those that convey social approval or disapproval — have also been shown to eliminate the boomerang effect (Schultz et al. 2008).

2.4 Leveraging social media for behavior change

The rapid growth of social media has created new online destinations for people to engage in social dialogue and interaction, information exchange, and collaborate on a wide variety of topics. The development of a "culture of participation" describes a fundamental shift from a "consumer culture in which finished goods are consumed passively to a culture of participation" in which people are enabled through the use of "Web 2.0" tools to collaborate on personally meaningful activities (Fischer 2009). Social media are also being utilized to bring about significant social and political change. During the "Arab Spring" the world observed as social media tools were used to mobilize protests leading to the eventual overthrow of regimes in Tunisia, Egypt, Libya and Yemen. In Egypt the opposition movement was launched through use of a Facebook campaign that resulted in protests of tens of thousands of demonstrators (Stepanova 2011). Data collected via ubiquitous social media sources are also proving valuable for research, and have been shown to be useful in predicting the outcomes of future events and outperforming market-based predictors (Asur and Huberman 2010).

Social media tools are being increasingly used to drive behavior change for improving health and other desired social outcomes. The term *captology* coined by B.J. Fogg has been used to describe "computers as persuasive technology" (Fogg 2003) and supports the view that social media may drive behavior change by combining techniques of persuasion with the influential power of mass media (Fogg 2008). Fogg notes that many applications for Facebook have been created for the purpose of impacting behavior, whether for simply purchasing products or for engaging people in social or political activities.

Shared personal documents and information may be described as "social objects"– often in the form of photos, videos, and/or text – that can be viewed, linked to, and distributed by others (Bell 2008). A pilot study 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. Posting snapshots allowed users to ask "experts" to help interpret energy consumption, to suggest what was occurring, and to identify possible savings. The study included other social strategies, for example allowing people to compare their energy use to similar households, and resulted in overall energy savings of over 9%. The study also found that the level of engagement, as measured by the frequency of logging into the site, was correlated to energy savings. 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).

3. MOTIVATIONS, HYPOTHESES AND METHODS

The body of research that shows how social factors and energy feedback lead to energy savings in residences raises many interesting questions about how such approaches may be used in a workplace setting. The overarching objective of this study was to evaluate 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. A secondary objective was to understand the potential for using a social media platform to improve communications between occupants, facility managers, and building operators.

This research builds on previous studies conducted at UC Berkeley on visualizing information in commercial buildings, looking at the information needs and preferences of both occupants and building operators. Researchers found that a high percentage of workplace occupants report taking actions to conserve energy at work. They say that they would make greater efforts to save energy if they had information about the energy they use and its associated cost (Lehrer and Vasudev 2011). In addition, over 90% of commercial building professionals surveyed expressed a desire for a more systematic way of communicating with workplace occupants (Lehrer and Vasudev 2009). A shortcoming of current occupant-operator communications methods is that they primarily provide one-way communication from workplace occupants to building managers, so occupants have little or no feedback on whether their complaints are heard and/or acted upon. A social media platform offers a convenient way to provide two-way communications between operators, and to allow potentially useful peer-to-peer interactions among occupant peers.

The research team developed a simplified energy feedback prototype with social media features in order to test a number of research questions: (1) the influence of having more personalized energy information compared to zone or whole-building energy use; (2) the influence of normative information such as average energy use of other office colleagues, or selected individuals; (3) the potential effects of seeing and sharing personal energy use data with others in the workplace; (4) the potential effects of letting people set and share energy goals, and receiving reward “badges” for meeting such goals; and (5) the potential benefits of using a social media application for improving communications between with building occupants and operators.

3.1 Research Approach

The prototype was developed on a scale that would be suitable for a single building or corporate campus. The prototype was designed with two types of users in mind: (1) typical commercial building occupants, and (2) expert users such as building managers, building design professionals, or commissioning agents. The prototype was tested with subjects intended to represent these user groups: the study used 128 university students and staff subjects to represent the perspectives of typical office building occupants. In addition, one-on-one interviews were conducted with six expert users who interacted with the prototype, including commercial building energy managers, design professionals, and facility managers.

The project team designed the prototype using an iterative design process. Previous research found that web users viewed the “design and look” as the most important factor in determining the credibility of a website, followed by the navigation structure (Fogg et al. 2003). Therefore the research team endeavored to create a prototype with clear navigation and compelling visual design so that subjects would view the prototype as credible, and that the test experience would better approximate interaction with a real working application.

The team identified the key features to be studied, developed wireframe layouts for typical pages, and then fully rendered “comps” to mockup a functional web application. The prototype allowed 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 leading social media applications such as Facebook and LinkedIn.

The research team created 13 “clickable” pages using the Adobe Fireworks web prototyping tool and posted pages to the web. Simple navigation links allowed participants to browse pages on the site, and all pages were numbered so that they could be easily referenced in the questionnaires. The prototype may be viewed at http://www.cbe.berkeley.edu/prototype/

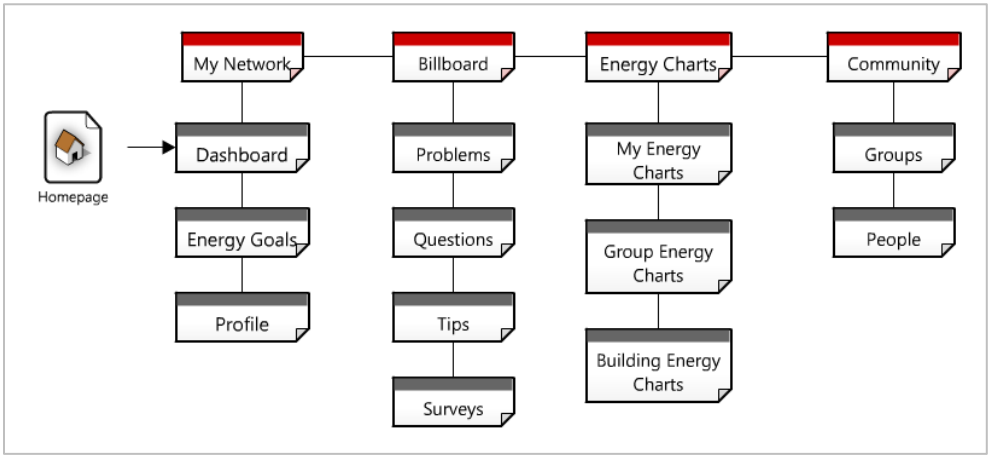

Figure 1. Site map for the social media prototype

The application prototype included four top-level sections: (1) my network, (2) billboard, (3) energy charts, and (4) community (Figure 1). The “my network” section included a dashboard landing page, and a goals feature that conceptually allowed 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. A site map of the prototype is shown in Figure 1.

A billboard section was provided to allow 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. A simplified occupant survey function —allowing managers to poll occupants regarding general or specific workplace questions — was also included in this section.

An energy charts section was included to display energy use at various scales, from the individual office or workstation, to floor by floor (represented as a competition) to whole-building energy performance. Various alternates of the energy pages were mocked-up in order to study participants’ preferences regarding energy information using various scales and metrics. These prototype features, and corresponding questions, were included as it is becoming increasingly possible to meter end-use energy consumption (e.g., lighting and plug loads) down to the level of individual offices or workspaces, and that costs for such devices are becoming competitive enough that leading companies are investing in

these products[1]. Finally, a community section was included, with a groups page that would allow people to work collaboratively on energy or building related activities.

3.2 Occupant test procedure

The prototype was tested with subjects at UC Berkeley's Experimental Social Science Laboratory (Xlab) using a classroom configuration shown in Figure 2. The Xlab staff recruited subjects by email to attend one of four test sessions lasting 1-1/2 hours. The test protocol included four steps. After signing in and signing consent forms, subjects completed a "pre-demo" online questionnaire with general questions about subjects' demographics and energy attitudes. Next, the research staff provided a ten-minute demonstration of the prototype to introduce the main features. The subjects were then given a hypothetical situation to consider when responding to the paper questionnaire, namely which their employer's management is encouraging people to use a new web-based application to conserve energy, and to help manage the operation of the building.

The subjects were then asked to review the features of the application and to respond to a paper questionnaire with multiple choice and ranking questions about specific aspects of the prototype. Finally, they were asked to answer an online "post-demo" questionnaire with questions about their experience viewing the prototype, focusing on the social aspects of the application. This questionnaire included open-ended questions about aspects of the prototype, including specific likes, dislikes, additional features that could be added, and general comments. The three questionnaires used in the test are included as appendices A, B, and C.

Figure 2. Xlab test setup.

3.3 Energy expert test procedure

To evaluate the potential benefits and barriers of such an application from the perspective of building professionals, we conducted one-on-one interviews with expert users. The objective of this work was to understand whether building managers see potential benefits from using such an application to communicate with building occupants, track and respond to complaints, and survey occupants about buildings management issues. Via email the research team invited building industry professionals to participate in the study, and those selected for the study included facility managers, an energy consultant, and an architect.

Interviews were conducted in person, or remotely using desktop sharing utility, and lasted for about 60 minutes. The interviews followed a semi-structured format, participants were walked through the various features of the application and were asked to reflect on its overall usefulness and user-experience.

[1] Personal correspondence with industry contacts at Adobe Systems and Lucid, May 2012.

4. RESULTS FROM BUILDING OCCUPANT STUDY

The prototype was used in the Xlab study to study the research questions described above. Below we describe the subject sample, and summarize results.

4.1 Demographics, social media use, and environmental attitudes of study participants

This section briefly summarizes the results of the pre-demo questionnaire. The 128 subjects were comprised of 80% undergraduate students, 11% administrative staff, 7% graduate students, and 2% other. The age distribution reflected the Xlab's campus recruitment pool: 24% under age 20, 69% ages 20-29, and 8% age 30 or older. Asked about office experience, 41% of subjects reported having one year or less of office experience, 39% had 1-3 years, and 20% had 4 years or more. As may be expected of such a subject sample, the survey found that 99% of the subjects use social media sites, that 8% report using them on an hourly basis, and 71% use them 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% feel that it is their "duty as a socially conscious person" to conserve. Regarding their own home energy use, 84% reported that they were "fairly familiar with utility costs" or had a "general idea about them," and 66% reported that they were already taking measures to reduce their household energy use.

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 for employees in sectors such as technology and new media that have a large percentage of educated younger workers (for example, Facebook, Google, Yahoo!). Such progressive companies may be more likely to adopt energy-savings programs, and more likely to be early adopters of energy feedback and social media tools for company purposes.

Previous research also provides evidence that younger people have been found to be linked to higher energy savings due to energy feedback (Foster Mazur-Strommen 2012). Considering the test subjects' familiarity with social media and their generally pro-environmental attitudes, the research team believes that such a subject pool may provide useful insight about the social aspects and energy features of the prototype.

4.2 Test results regarding granularity of energy information

To investigate the influence of varying granularity of energy displays from whole building, to zones within the building (in this case floor-by-floor), to the level of individual offices or workspaces, subjects were asked to rate these alternatives in terms of their interest and usefulness. The displays showed power trends for a week, energy used and/or cost saved (Figures 2-5). Similar to many pages on the site, the page displays other users 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 ranking of the usefulness of the three energy displays increased with the level of granularity, with individual level displays getting the highest score, as shown in the chart in Figure 5. Subjects showed the most interest in their personal energy use, which informs the first of our five research questions. The personalized energy feature was also frequently cited as a favorite aspect of the application, as summarized in the summary of "liked" features (Table 1) and shown in the examples below:

> *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.*

Figure 2. Whole building power total and by major end use

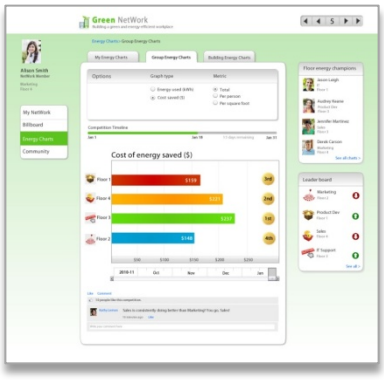

Figure 3. Energy use shown by floor level (energy competition)

Figure 4. Individual energy use

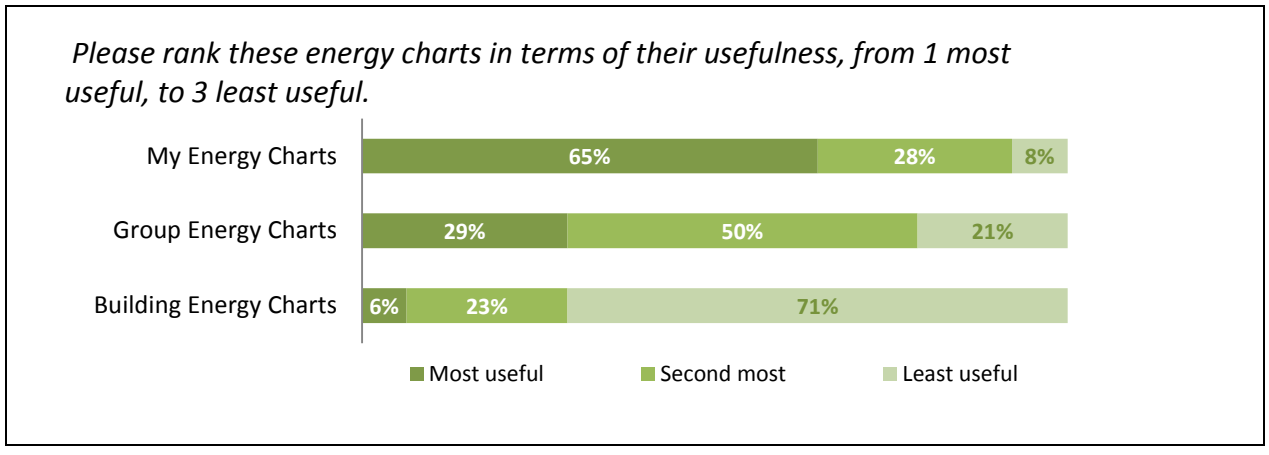

Figure 5. Ranking of usefulness of energy granularity

4.3 Test results regarding energy metric alternatives

Behavior change literature suggests that people are more likely to respond to informational cues if the information is made "vivid" to the audience. As energy use is all but invisible to building occupants, a goal of this study was to identify which types of energy metrics would be considered the most relevant, interesting or useful to potential users of an energy feedback application. Subjects were asked to evaluate four energy metrics that represented energy use at the level of a single occupant. The displays each represented daily energy use for one week, including the weekly total, represented 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 prototypes represented 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.

The responses show that subjects found the cost metric display to be the most interesting and useful, the power (watts) and total energy (kWh) to less so, and the light-bulb equivalent display to be the least interesting and useful. This stated preference for cost as an indicator for energy use is consistent with other recent research (Foster and Mazur-Stommen 2012) and was preferred in spite of the relatively low total cost of energy displayed. The results of a ranking question are shown in Figure 6. The conventional energy metrics (watts and kWh) were found to be of lesser interest and usefulness to subjects. Although the "light-bulb equivalent" was intended to show energy use using a familiar object, in fact this was viewed as the least interesting and valuable of the three energy metrics.

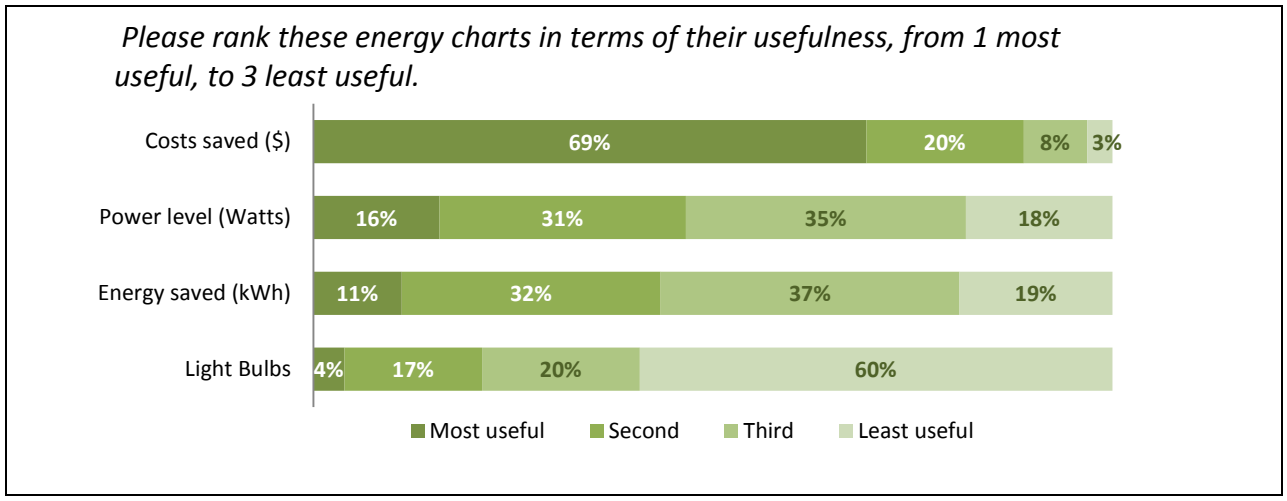

Figure 6. Ranking of usefulness of energy display

The comments in the closing questionnaire showed the cost metric to be one of the prototype features most liked by subjects, and provides insight as to why this 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.*

Seeing the energy use in terms of Kilowatts kind of held my interest a little less I think because it's not a form of measurement that I am familiar with, as currency, like dollars, is much more familiar and is maybe more attractive for a social media type of thing like this.

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.

4.4 Preferences and attitudes regarding normative energy information

Subjects were asked to consider energy displays showing their personal energy use compared with various types of normative references. The energy display shown was a one-week bar chart, with a weekly total shown in terms of the cost of energy (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 use; (3) personal energy use compared to an individual that could be selected by the user.

The participants showed a strong preference for comparison to the average user, with 79% of subjects ranking this at the most useful option, and 13% ranking it as the second most useful (Figure 7). The comparison to a user-selected individual was ranked as most useful by 17% of subjects. A comparison to an average user is the most meaningful from a statistical standpoint, and the subjects seemed to understand this intuitively. However the ability to compare one's energy to peers may be useful for engaging individuals who are not interested in energy data in itself, but who might enjoy the gaming aspect of a friendly competition among peers. In general, the energy chart features were viewed favorably by almost all test subjects, with 98% responding "strongly agree" or "agree" that the energy chart features of the prototype would be useful in saving energy.

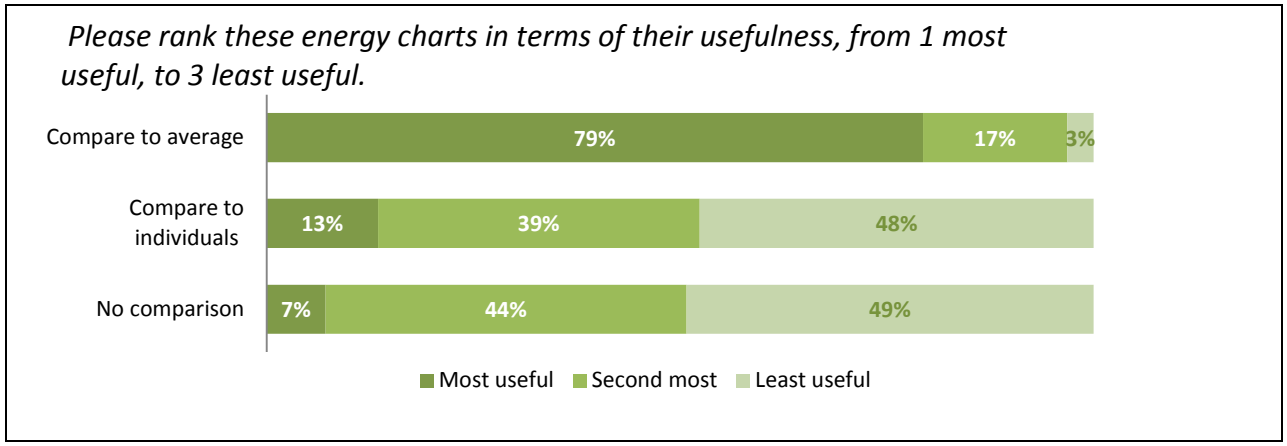

Figure 7. Ranking of usefulness of normative energy information

A number of responses to open-ended questions reveal participants' sentiments regarding comparisons to the average users and selected individuals:

I also like how the user can compare his or her energy usage to that of everyone else's (average). If my usage was higher than the average, looking at the charts will make me realize that and I would make a more conscious effort to conserve energy.

[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.)

I like the comparison features that let you see your personal energy consumption compared to the average. Even breaking it down by floor or department is helpful because it keeps others motivated to conform to other energy saving groups.

4.5 Findings regarding sharing personal energy information

After subjects reviewed the three options for normative energy information, they were asked additional questions about the social aspects of this feature — whether they 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. (In the short demonstration provided by the research staff, it was explained that users could opt-in to sharing their energy charts with others in their workplace.)

The results from these questions are shown in Figure 8. Two-thirds of the subjects (66%) responded "strongly agree" or "agree" that they would share their energy charts with others. Responses were similarly positive 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 suggest that the social media aspects of such an application would be effective for engaging building occupants and increasing interest in their personal energy use.

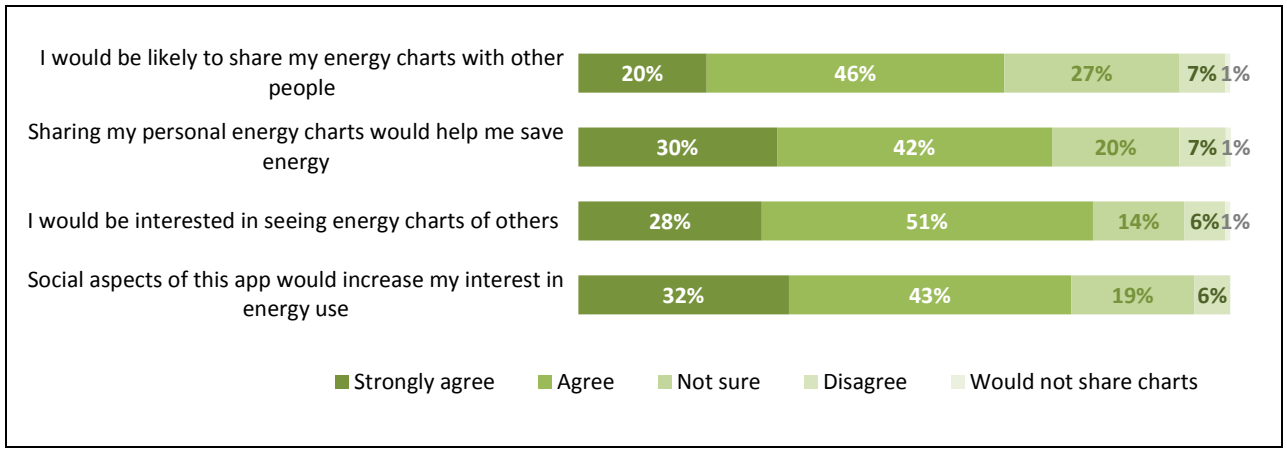

Figure 8. Likert scale questions regarding sharing energy information

Younger individuals tend to be more comfortable sharing information via the web, and this is reflected in the percentage of positive responses from these participants. Comments on sharing personal energy goals were generally positive, as in these examples:

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

I also like how the user can compare his or her energy usage to that of everyone else's. If my usage was higher than the average, looking at the charts will make me realize that and I would make a more conscious effort to conserve energy

However other comments about sharing personal energy information include concerns that would need to be considered in the design of such an application. For example, some comments included concerns about the use of energy charts by peers or management to view patterns of occupancy, that peers might be judgmental of others who used more energy, and/or that this may contribute to a "less friendly" work environment. Also, as people may have different equipment needs, some participants expressed the opinion that such comparisons are not fair, and that might cause them to opt-out of sharing or using the application:

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.

Sometimes, people may not want others knowing everything about them such as energy use. I can just imagine people going, "Wow, that person is such an energy pig," behind other people's backs.

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.

In the design recommendations at the end of this report, the authors suggest to potential energy feedback developers that the intended uses of personal energy use be made explicit, for example, that such information will not be used for monitoring employees' schedules, hours in the office, or equipment use.

4.6 Results regarding setting and sharing energy goals

The prototype included an "energy goals" feature that allows users to select individual goals, to report their progress towards these goals, and to see other people who have selected the same goals (Figure 9). 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% "strongly agree" or "agree"), and that they would be interested in seeing the energy goals of others (80% "strongly agree" or "agree"). Responses to energy goals questions are shown in Figure 11. The energy goals were cited frequently in the open-ended questions regarding favorite features of the prototype.

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.

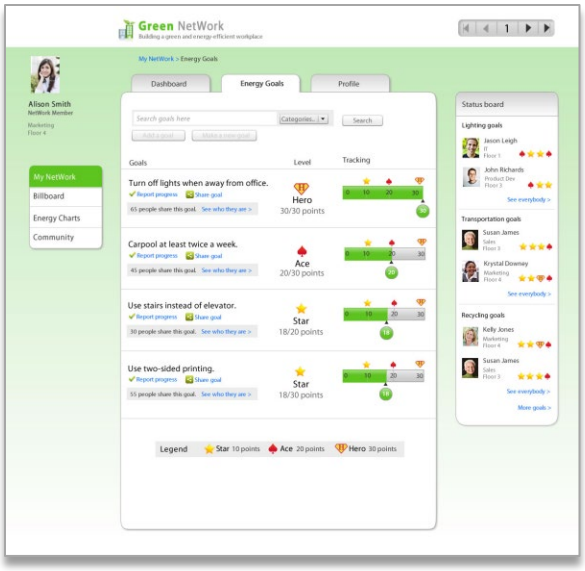

Figure 9. Energy goals feature

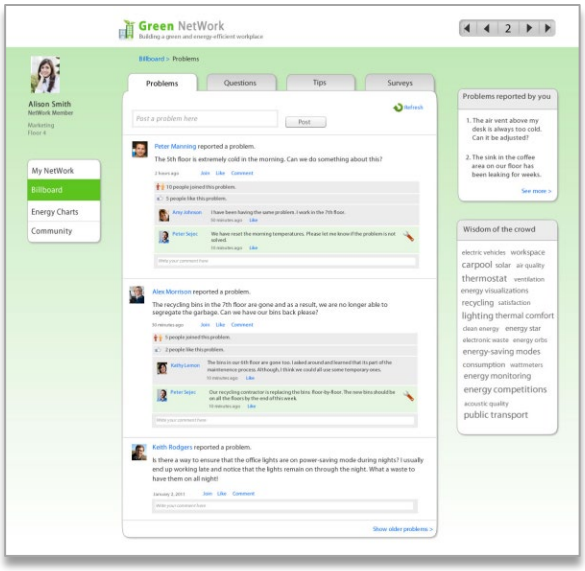

Figure 10. Billboard feature

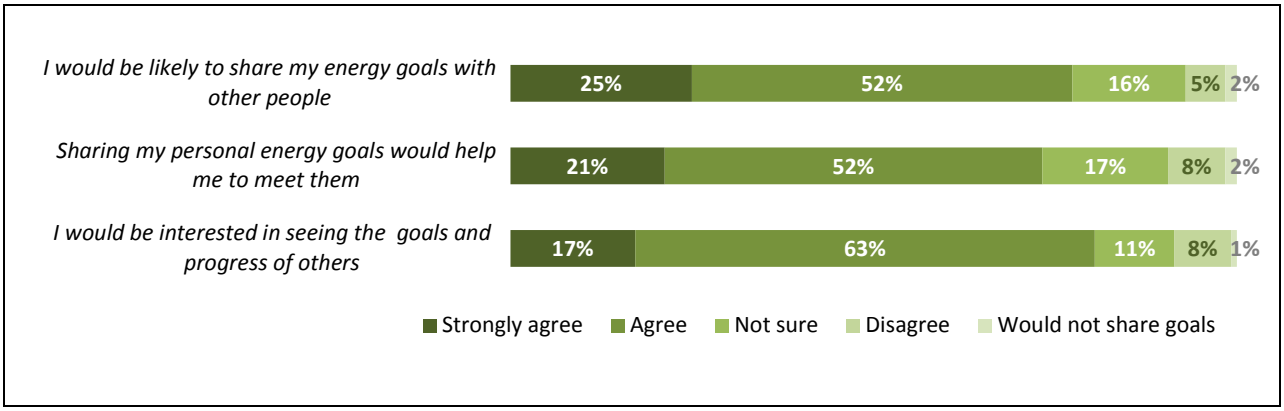

Figure 11. Responses to Likert scale questions regarding energy goals

4.7 Use of the prototype for communicating with building operators and occupants

A billboard feature allows 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 (Figure 10). Study participants responded favorably to this feature, with most all indicating that the billboard feature would be generally useful in the workplace, with 95% responding "very useful" or "somewhat useful". Participants indicated that they would be likely to use the application to report a problem (96% "strongly agree" or "agree") and to ask a question (79% "strongly agree" or "agree") as shown in Figure 12. Many also reported that they would be more likely to use the application than by phone or e-mail, to report a problem (77% "strongly agree" or "agree"). Over half reported that they would be likely to use the application to post an energy tip (58% "strongly agree" or "agree").

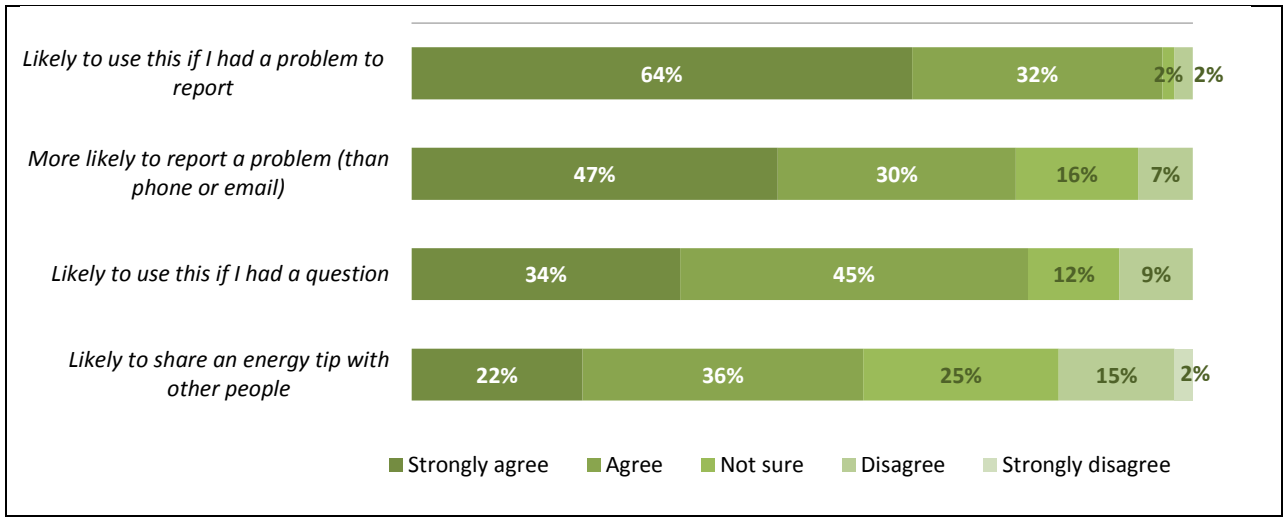

Figure 12. Responses to Likert scale questions regarding billboard feature

Subjects responded that they would be comfortable using a web-based application to report problems or pose questions to facility managers. Compared to making service requests by phone or e-mail, the web app would provide additional benefits by 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--its 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.*
>
> *Also, I think a board for technical problems with the building is a good idea; currently you call maintenance and try to figure out if they know about your problem, here you can just post it, search if anyone else has the same issue, and maintenance could respond to the board.*
>
> *The Problems page is a very good idea to foster open communication between people and management regarding problems in the workplace.*

4.8 Results of closing questionnaire

After viewing the prototype and completing the paper questionnaire, subjects were asked to complete a closing questionnaire with open-ended questions about the website, and were asked about aspects of the prototype that they liked, things they disliked, features that could be added to improve the application, and general comments. Many the questions inquired about participants' sentiments regarding the social aspects of the application.

4.8.1 Comments about most liked features

In response to the first open-ended question, participants expressed what they most liked about this application. Aspects of the energy charts and billboard features were the most frequently cited features in these responses. The most frequently cited features include viewing/sharing individual energy use (46 like comments), comparing one's personal energy use to the average (45 comments) and being able to report problems and view those reported by others (43 comments). The responses were binned by the research team into generalized categories and summarized in Table 1, below.

The study participants provided many positive comments on the application's potential to increase environmental awareness in the workplace, 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.*

Summary of most commonly cited "liked" features		**Number of comments**
Energy Charts	Viewing, sharing individual energy use	46
	Viewing the energy consumption floor by floor	22
	Other energy charts comments	18
	Seeing personal energy use and cost saved ($)	
	Compare to average cost	45
	Compare to individuals	32
	Other energy use comments	16
	Energy charts: Total "like" comments	**183**
Billboard	Reporting problems and seeing others' complaints	43
	Giving or getting some tips	16
	Asking and answering questions	12
	Other billboard comments	8
	Billboard: Total "like" comments	**82**
Other "likes" comments	Friendly competition	22
	Setting and sharing my energy goals	15
	Interacting with others/social aspect of the website	12
	Clean visual design	8
	Familiarity with other social website	7
	Increase awareness about environment/energy efficiency	6
	Total other "like" comments	**80**

Table 1. Most common responses to question about "liked" features

4.8.2 Comments about disliked features

In the second open-ended question, the participants were asked to note features or aspects of the application they disliked. The most frequently cited disliked features or aspects of the application are summarized in Table 2.

Summary of most commonly cited "disliked" comments		Number of comments
Social media aspect	***Sharing my personal information and energy use***	
	Unfriendly working environment	10
	Other sharing comments	9
	Unfair aspects of energy comparison	
	Different devices used	5
	Other unfairness comments	4
	Social media aspect of the website: Total "dislike" comments	**32**
Posting problems	The effectiveness of posting problems	5
	Other posting comments	8
	Posting problems: Total "dislike" comments	**16**
Other "dislikes" comments	Lacks a strong incentive to save energy	14
	Groups feature	11
	Too much information, overwhelming tracking	9
	Survey feature	6
	Difficult to use the website, and/or find information	5
	Total other "dislike" comments	**49**

Table 2. Most common responses to question about “disliked” features

A number of participants expressed concern that the social aspects of the application could contribute to an unfavorable work environment, and/or make unfair comparisons due to varying equipment needs or work schedules, as noted previously (32 dislike comments). Several subjects noted that more explicit messages about saving energy would be beneficial, and that energy feedback alone would not be a sufficient incentive to induce behavior change (14 dislike comments).

The groups feature drew a number of dislike comments, as participants did not think such a feature would be beneficial. While many thought the billboard feature would be a useful platform for interacting, some negative comments questioned this feature in terms its effectiveness, including the concern for the “potential to create, long, endless threads,” and that seeing the minutia of building related problems would not be valuable and could be tiresome to read through.

4.8.3 Comments about features to add

Finally, the open ended questions asked people for ideas for additional features they would find useful for such an application, and general comments. The responses were highly varied and are summarized in Table 3.

Some participants suggested embedding the application into other social media applications that people already used, and/or make it available on mobile devices. Suggestions included other ways to engage users, such as “more features or applications that reward [the user] for visiting”, ranking the “best commenter”, the “most visited” feature, the “most improved” energy use, or informing people via emails or alerts about a new features.

Summary of features to add comments	Numbers of comments
More educational information about the energy issue	28
More details about one's energy consumption	18
Influence on energy behavior	17
Additional billboard features	10
Extend the social media aspect	10
More options for the "comparison" feature	9
Privacy details settings	6
The website and the user	5
Involvement of the company	5
Total "additional features" comments	**108**
General comments related to additional features	
Explain how simple conservative gestures are effective	10
Financial reward or other prizes	13
Feature to check if a problem has already been posted or resolved	6
Ability to pinpoint which device is the most energy-consuming	5
Application for existing social websites or smart phones	5

Table 3. Comments for additional features

4.9. Summary of occupant usability findings

The Xlab study provided detailed feedback on the prototype, and insights into to the five study questions, which we summarize below:

1. Participants showed a clear preference for more personalized energy feedback, ranking individual energy use first, group or floor energy second, and whole-building energy use third. A display of energy costs was the preferred display format in comparison to conventional energy metrics (kW or kWh) or an energy approximation (in this case, an equivalent number of light bulbs). In responses to open-ended questions, viewing and sharing individual energy use was the most frequently cited beneficial aspect of the prototype.
2. Test participants were interested in normative information and preferred to compare personal energy use to an average user in the building, and this was confirmed in ranking and open-ended question formats. Subjects felt that such information would be valuable for helping them to save energy, and many felt that friendly competition among peers would be useful in an effort to save.
3. Participants responded favorably to a feature for setting, sharing, and tracking personal energy use via an energy charting feature. Responses were generally positive about sharing energy goals and energy use, however a subset of subjects expressed concerns about privacy, how such energy data might be viewed or used, and/or unfair comparisons between users with different equipment needs.

4. Test subjects also responded favorably to an energy goals feature, with 70-80% indicating interest in setting and sharing personal goals, seeing the energy goals of others, and using this feature to help them save energy.
5. Finally, participants were positive about features that allowed reporting of problems, and getting feedback from facility managers about problems, with 96% indicating that they would use such a feature, and 77% saying they would be more likely to use this feature compared to reporting a problem by phone or e-mail. Concerns were raised about the possibility that long and/or irrelevant comment threads might result.

In the final section of this report, the authors provide recommendations for potential developers of energy feedback systems, based on these findings.

5. RESULTS OF ENERGY PROFESSIONALS STUDY

The fifth research question focused on the potential benefits of using social media for improving communications between building occupants and operators. The research team conducted one-on-one interviews with six commercial building experts who would provide a range of perspectives. The objective of this work was to understand how professionals see potential benefits and barriers from using such an application to communicate with building occupants, track and respond to complaints, and survey occupants about buildings management issues. The study participants included:

- A project manager in an energy consulting firm
- An architect in a firm that designs a large number of green and LEED-certified projects
- Facility managers for a single building or multiple buildings on a university campus

Interviews were conducted in person or remotely, using a desktop sharing utility, and lasted approximately 60 minutes, following a semi-structured format. The participants were walked through the various features of the application and were asked to reflect on its overall usefulness and user-experience. Research staff noted subject responses during the interview, and the comments were aggregated by feature or content of the subjects' comments. Comments from the six participants are noted by designations P1-P6.

5.1 Detailed findings from energy professionals study

The interview subjects found the billboard and surveys features to be most interesting of those presented, with the billboard seen as a convenient way to report energy-related problems. Subjects (P2, P3, P4, P6) noted that by design, the billboard ensures that the occupants' concerns capture the attention of more people in the building, thereby overcoming some shortcomings of traditional complaint systems, including response time and lack of acknowledgment that the problem has been received (P3, P4). In cases in which a problem cannot be addressed due to technical or other limitations, the billboard affords a platform for the manager to communicate this to the occupants effectively (P6).

From a building operations perspective, the problem reporting functionality helps a building manager get a sense of where most of the problems in the building are, plan corrective operations and gauge

people's reactions to it (P3, P4). One participant (P3) called the billboard a great platform to post maintenance and other operations-related announcements.

The social components of the application were viewed as useful by both the building managers and the occupants. To the building manager, the number of people that "join" a problem indicates its severity. To an occupant, it may be oddly reassuring that he or she is not the only one inconvenienced by the problem. One participant (P2) noted that while traditional social network terminologies such as "like" build on people's existing knowledge and thus are easily understandable, they might not necessarily be applicable to this scenario and suggested a rethinking of these terms, "*While terms such as 'like' and 'join' are popular and people might understand them better, it is strange that someone might 'like' a problem. 'Agree' or 'strongly agree' might more appropriate*."

Even while most of the participants felt that this public problem-reporting space would make the occupants more aware of energy-related issues in the building and therefore view it favorably, one participant (P1) was wary of its 'social-ness.' "*Some people might be reluctant to post problems they are uncomfortable talking about. They want to keep a low profile. Others, on the other hand, are just more social. This might give a skewed representation of the building's energy climate.*"

Participants also noted a few useful additions to the billboard. One such addition is the ability to filter the problems by priority or date (P2, P5). A search function would also be beneficial particularly when the billboard is tied to a database of documented problems and recommended solutions (P5).

The survey feature was viewed favorably by the energy experts (P2) as well as the building managers (P3, P5, P6). This was seen as a very useful tool particularly to the building manager because its helps them to quantitatively measure occupants' comfort levels (P3, P5). Further, it allows the manager to assess occupants' responses to changes in building controls such as lighting, heat, etc. (P3). Additional useful features would be options to run multiple surveys at the same time, and analytics that track differentials and performance improvements over time (P4, P5).

A number of the participants found energy goals useful (P2 - P6). One participant (P5) described the feature as a "*vehicle to help [an individual] participate in energy conservation*." Participants (P2, P5) noted that people are "*competitive by natur*e" and are "*more likely to do better, if there is someone watching over their shoulders.*" One participant (P1) however, was more skeptical. He pointed out that it's in some peoples' nature to "*be rebellious*" and "*not appear too goody-goody*." Further, participants (P2, P6) recommended exploring visualizing people's energy goals and how they relate to the leaders graphically, and provide a way to indicate the larger impact of goals in order to differentiate between them.

To most participants, the costs of providing individual energy feedback outweighed the benefits, from the perspective of the energy professionals. Participants (P1 - P5) indicated several reasons why individual energy displays were the least useful of the energy charts: (1) the information is too granular to be meaningful on the scale of the whole building, (2) it's difficult to measure energy use at this level of granularity, and (3) the difficulty of establishing individual accountability in a shared workplace. However, one participant (P6) was optimistic. He pointed out that the "*devices to measure personal*

energy use are increasingly becoming easy to use and deploy. As a result, obtaining personal energy use data will become easier in the future."

Participants believed that aggregate numbers of energy use including energy/dollars saved over an extended period of time and its relation to other statistics such as national averages are more likely to have an impact on the user than the information that they "*saved three cents over somebody else"* (P4, P6). The concept of comparing personal energy use with others in the building is, however, a "*fun thing to do"* and "*promotes friendly competition"* (P6). A majority of the participants agree that a useful metric would be an individual's carbon footprint (P1, P2, P4, P5, P6). Some suggested that a person's carbon footprint should comprise not only his or her activities at work, but all of her daily activities including travel to and from work, energy use at home and work-related travel (P1, P3, P4).

5.2 Summary of energy experts study

The generally positive feedback from energy professionals regarding the billboard for reporting and responding to comments, and the social aspects of the prototype application, show that such a system may provide benefits to commercial building operators and professionals. Providing two-way communication between operators and occupants was viewed as highly beneficial, and may help operators to triage and prioritize complaints, and to update occupants on complaint status, and to potentially alleviate occupants' frustrations when solutions to reported problems are not immediately available.

For building operations, the individual-scaled energy was seen as less useful than aggregated energy information, however some of the energy experts recognized the potential for driving behavior change offered by the more granular energy feedback. This finding stands in contrast to the occupants' preference for individual energy information and shows that information needs vary considerably between the two groups. This finding leads the research team to recommend distinct interfaces for these two commercial building stakeholder groups, as outlined below.

6. CONCLUSIONS

This study found considerable potential for using social media to engage commercial building occupants in energy conservation, and to improve communications between occupants and building management. Findings reveal that highly individualized energy information, at the level or individual workstations or offices, has potential benefits for engaging and informing individuals about their energy use; and that cost is considered the most vivid and tangible energy metric, something that is supported by other research.

Sharing energy information using social media tools appears to offer a means for increasing occupant engagement and interest in energy matters, as many subjects expressed interest in sharing energy goals and energy charts with others, and seeing that of peers. However an important caveat to this finding is the concern some test subjects expressed that public display of personalized energy information holds a risk of stigmatizing individuals that use more energy than the average user, which may contribute to ill feelings among peers, and may reduce the potential level of engagement by all participants.

6.1 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:

6.1.1. Provide energy information that is highly specific to the individual building occupant.

In this study participants showed an overwhelming preference for energy displays on the scale of the individual workspace. As this requires specialized hardware (smart plug strips, advanced lighting controls, etc.) and associated software with costs that are not negligible, this may only be feasible for highly motivated companies. (However the research team found numerous anecdotal examples of leading companies that have installed such systems, and costs are likely to come down as these are adopted and more product choices are available.) When providing individual energy feedback is not possible, zone or floor level energy information is preferable. If only whole building energy data is available, showing energy in terms of per person use use may be an alternative way to engage occupants.

6.1.2. 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 show 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 were continued. While a web interface can easily let users toggle between various energy metrics, and this provides the benefit of letting users explore and interact with data, this study found that cost is considered the relevant energy metric, which is consistent with other recent research.

6.1.3. 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" (when low-energy consuming individuals use more energy when they see that they are below average) displaying the energy use of an efficient energy use is a viable approach (as seen on some energy feedback systems such as home energy reports that provide comparison the energy use of top 20^{th} percentile in energy efficiency).

6.1.4. 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, for people who harbor such concerns. Alternately, competition could be shown by comparing individuals to their own personal baseline, and comparing and/or reward savings that individuals make over time.

6.1.5. Focus on positive aspects of energy comparisons, avoiding judgmental feedback.

For the reasons 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.

6.1.6. Be explicit about the use of energy information being solely for energy conservation

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

6.1.7. Allow occupants to collaborate with peers and have two-way communications with facility managers regarding building problems and repairs.

Both operators and energy experts found a billboard feature that allowed for reporting problems, seeing peers' problems, and operator responses, to be 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 (perhaps with branching radio-button selections, for example), 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.

6.1.8. Provide specific page views and features for energy professionals and facility managers

Energy professionals and facility managers showed less interest in the highly granular energy information, and more greater interest in whole-building energy, and in the ability to easily survey building occupants on building features and improvements, with the ability to track performance over time.

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APPENDIX A: PRE-DEMO QUESTIONNAIRE

Test Subject Identification Number _____

Test Subject Identification Icon _____

1. Which of the following best characterize what you do?
    - Undergraduate student
    - Graduate student
    - Research staff
    - Administrative staff
    - Faculty
    - Other (please specify) _____
2. Do you have experience working in an office type environment? (In a company, school, university, or other similar setting.)
    - Yes
    - No
3. If you answered yes to the question above, how many years of experience working in an office environment do you have?
    - Less than one year
    - 1-3 years
    - 4-5 years
    - Over 5 years
    - No office experience
4. What is your age?
    - Under 20
    - 20-29
    - 30-39
    - 40-39
    - 50-59
    - Over 60
5. What is your gender?
    - Male
    - Female
6. Do you regularly use social media sites such as Facebook, Twitter, MySpace, LinkedIn, Flickr, etc.?
    - Yes
    - No
7. If you answered yes to question 6, how many different social networks do you follow or participate in on a regular basis (viewing a few times per month)?

    _____

8. If you answered yes to question 6, how frequently do you view or participate in social network sites?
    - Hourly
    - Several times a day
    - Several times a week
    - Several times a month
    - Less than once a month
    - I don't use these sites
9. How important are environmental issues to you personally? (For example, energy use, air pollution, recycling, climate change, etc.)

    - Very important
    - Somewhat important
    - Neutral
    - Not that important
    - Not important at all
10. How important do you think it is for individual people to change their behavior to reduce their impact on the environment? (For example, turning off lights, saving water, recycling, etc.)

    - Very important
    - Somewhat important
    - Neutral
    - Not that important
    - Not important at all
11. Which of the following best expresses your thoughts about energy conservation?
    - I don't try to conserve energy.
    - I feel that better technology is the best solution to reduce energy use.
    - I feel energy conservation is good for the environment.
    - I feel it is my duty as a socially conscious person to conserve energy.
    - My friends/neighbors conserve energy, so I do too.
    - Other (please specify)
12. What do you know about the utility costs in your home? (For example. gas, electricity, and water.)
    - I am fairly familiar with the utility costs.
    - I have a general idea about them.
    - I do not know what the costs are.
    - Other (please specify)
13. Please indicate the response that best represents your current thinking about your household energy use.
    - I don't think much about it; it is what it is.
    - It is a hassle/too hard to try to change my energy consumption.
    - I don't know how to reduce my energy consumption.
    - The potential for cost savings is not worth the effort.
    - I am already taking measures to reduce energy consumption.
    - Other (please specify)

14. Any other comments about energy use and environment?

APPENDIX B: PROTOTYPE DEMO QUESTIONNAIRE

Test Subject Identification Number _____

Icon _____

For each question below, please circle the response that best represents your answer.

Example :

Response 1	Response 2	Response 3	Response 4	Response 5

View the prototype online at http://cbe.berkeley.edu/prototype

Scenario: As you consider the questions below, imagine that you are working in an office building, and the firm management is encouraging people to use a new website to help people to conserve energy, and to manage the operation of the building.

1. Please go to "**Energy Goals"** on page (1).

   This feature (page) allows you to select personal energy goals, and to track your progress with them. You can share this information with others (either with office acquaintances, or everyone) and to see the goals and progress of other people that have shared their information.

   1.1. I would be likely to use this feature (page) to set one or more personal energy goals.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   1.2. If I used this feature, I would be likely to share one or more of my energy goals with other people in my office.

Strongly agree	Agree	Not sure	Disagree	Would not share goals

   1.3. Sharing my personal energy goals would help me to meet the goals I set for myself.

Strongly agree	Agree	Not sure	Disagree	Would not share goals

   1.4. I would be interested in seeing the personal energy goals and progress of other people (such as office acquaintances and others).

Strongly agree	Agree	Not sure	Disagree	Would not share goals

   1.5. In general, would the "Energy goals" features of the website be useful to you for saving energy?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

2. Please go to "**Billboard > Problems"** on page (2). This feature allows you to report a problem in your workplace, and allows the building manager to respond to it. It also allows you to ask questions related to your workplace, and to post energy saving tips.

   2.1. I would be likely to use this if I had a problem to report (for example, a problem about temperature in the office).

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   2.2. Having this tool would make me more likely to report a problem than if I had to call or use email to do so.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   2.3. I would be likely to use this if I had a question (for example, a question about operating lights or equipment in the office).

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   2.4. I would be likely to use this if I had an energy tip to share with other people (for example, an idea about how to put your computer in sleep mode).

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   2.5. Would you be interested in seeing the problems, questions and tips posted by other people?

Problems	**Questions**	**Tips**
Very interesting	Very interesting	Very interesting
Interesting	Interesting	Interesting
Not interesting	Not interesting	Not interesting
Not at all interesting	Not at all interesting	Not at all interesting
No opinion	No opinion	No opinion

   2.6. In general, would the "billboard" features of the website be useful to you in your workplace?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

3. Please navigate to **"Billboard >Surveys" on page (3)**. This would be used by the building manager to find out how satisfied people in the building are, and to report the results of these surveys.

   3.1. I would be likely to participate in a survey asking about the conditions in the workplace.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

   3.2. I would be likely to view the results of such a survey.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

3.3. Would you be interested in the survey feature of the website?

Very interested	Interested	Not interested	Not at all interested	No opinion

3.4. In general, how useful would the "survey" feature of this website be to you in your workplace?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

4. Please go to "**Energy Charts > Building Energy Charts"** on pages (4-6). This shows different views of energy use in the building.

Energy Charts > Building Energy Charts on page 4 shows the energy use of the entire building.
Energy Charts > Group Energy Charts on page 5 shows the energy use by floor.
Energy Charts >My Energy Charts on page 6 shows the energy use of your personal office or workspace.

Again using the scenario outlined above, how interesting would you find this information, and how useful would it be for helping you to keep track of your energy use?

4.1. Building Energy Charts on page 4 (entire building)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

4.2. Group Energy Charts on page 5 (energy use of your floor and that of others)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

4.3. My Energy Charts on page 6 (this shows the energy use of your personal office or workspace)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

4.4. Please rank these energy charts in terms of their usefulness, from 1 most useful, to 3 least useful.

Building Energy Charts, page 4	
Group Energy Charts, page 5	
My Energy Charts, page 6	

5. Please go to "**Energy Charts > My Energy Charts**" on pages (6-9).

Then review the following three pages:
Energy Charts > My Energy Charts > Power on page 6 (power use over time)
Energy Charts > My Energy Charts > Amount on page 7 (your energy use by amount)
Energy Charts > My Energy Charts > Light Bulbs on page 8 (your energy use by light bulb equivalents)
Energy Charts > My Energy Charts > Costs on page 9 (your energy use by cost)

Again using the scenario outlined above, how interesting would you find this information, and how helpful would it be for helping you to keep track of your energy use?

5.1. My Energy Charts > Power on page 6 (in watts over time)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

5.2. My Energy Charts > Amount on page 7 (in kilowatt-hours kWh)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

5.3. My Energy Charts > Light Bulbs on page 8 (light bulb equivalents)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful

Not at all interesting	Not at all useful
No opinion	No opinion

5.4. My Energy Charts > Cost on page 9 (in $)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

5.5. Please rank these energy charts in terms of their usefulness, from 1 most useful, to 4 least useful.

My Energy Charts > Power, on page 6	
My Energy Charts > Amount , on page 7	
My Energy Charts > Light Bulbs, on page 8	
My Energy Charts > Cost, on page 9	

6. Please go to "**Energy Charts > My Energy Charts"** on pages 9-11.

Then review the following three pages:
Energy Charts > My Energy Charts on page 9 (no comparison)
Energy Charts > My Energy Charts > Compare to average on page 10 (compare your energy use to the office average)
Energy Charts > My Energy Charts > Compare to individuals on page 11 (compare your energy use to individuals you select)

Again using the scenario outlined above, how interesting and useful would this information be to you?

6.1. *My Energy Charts* on page 9 (no comparison)

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

6.2. *My Energy Charts > Compare to average* on page 10

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

6.3. *My Energy Charts > Compare to individuals* on page 11

Interest	Usefulness
Very interesting	Very useful
Interesting	Somewhat useful
Not interesting	Not useful
Not at all interesting	Not at all useful
No opinion	No opinion

6.4. Please rank these energy charts in terms of their usefulness, from 1 most useful, to 3 least useful.

My Energy Charts (no comparison) on page 9	
My Energy Charts > Compare to average, on page 10	
My Energy Charts > Compare to individuals, page 11	

For the following questions, consider the energy charts with comparisons, pages 10-11

6.5. I would be likely to share my energy charts with other people in my office.

Strongly agree	Agree	Not sure	Disagree	Would not share charts

6.6. Sharing my personal energy charts would be useful for me in terms of saving energy.

Strongly agree	Agree	Not sure	Disagree	Would not share charts

6.7. I would be interested in seeing the personal energy charts of other people in the office.

Strongly agree	Agree	Not sure	Disagree	Would not share charts

6.8. The social aspects of the energy charts (sharing my energy use, seeing that of others) would increase my interest in energy use in my workplace.

Strongly agree	Agree	Not sure	Disagree	Would not share charts

6.9. In general, how useful would the "energy charts" features of the website be for saving energy?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

7. Please go to "**Groups"** on page 12.

This feature allows you create or join groups of people that are interested in saving energy at work, or helping operate the building in an effective way (for example, a group of people interested in buying EnergyStar computers for the firm).

7.1. I would be likely to use this feature to join a group.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

7.2. I would be likely to start a group.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

7.3. I would be interested in this feature of the website.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

7.4. In general, would the "groups" feature of this website be useful to you in the workplace?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

8. Please go to "**Dashboard" on page 13**.

This page is the "landing page" when you log on to the website, and gives you an overview of the various features of the site.

8.1. I would be likely to use this feature.

Strongly agree	Agree	Not sure	Disagree	Strongly disagree

8.2. In general, how useful would the "dashboard" feature of this website be to you in the workplace?

Very useful	Somewhat useful	Not useful	Not at all useful	No opinion

When you have completed this paper survey, please use the link on the laptop to go to the closing survey.

APPENDIX C: POST-DEMO QUESTIONNAIRE

Test Subject Identification Number _____

Test Subject Identification Icon _____

Header, all pages: Using the scenario we described earlier, please respond to the following questions:

1. If an application like this would be available to you at work, how likely would you be to use it ?
    - Very likely
    - Likely
    - Not sure
    - Not likely
    - Not at all likely
2. If an application like this would be available to you at work, how frequently do you think you would be to use it ?
    - Once a month or less
    - A few times a month
    - One or more time a week
    - Once a day or more
    - I do not think I would use this application
3. My experience seeing this prototype has made me more aware of energy use in an office environment.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree
4. Having such application in my workplace would create an incentive for me to save energy.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree
5. The social aspects of this application would increase my interest in energy use in my workplace.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree
6. Being able to share my personal energy goals and patterns with others would create an incentive for me to save energy.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree

7. The social aspects of the site would make me more likely to use such an application.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree
8. The social aspects of this application would increase my interest in the operations of the building in general.
    - Strongly agree
    - Agree
    - No opinion
    - Disagree
    - Strongly disagree
9. What features do you specifically like about the application?
10. What features do you specifically dislike about the application?
11. Please list any additional features that would be useful.
12. Additional comments.