J. ENVIRONMENTAL SYSTEMS, Vol. 20(2) 111-127, 1990-91

"MAYBE SOMEBODY FORGOT TO TURN THE CHILLER ON": ENERGY INFORMATION AND BEHAVIOR IN SMALL BUSINESSES

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ABSTRACT

Behavioral issues affecting energy use in small commercial buildings are explored. Interviews with energy decision makers reveal poor information on energy consumption and energy-using equipment. One striking example is that not one of the managers asked was aware that they paid a demand (kW) charge, even though this charge represented, on average, 43 percent of their electricity bills. Graphical feedback was developed to improve user information related to energy use. This graphical feedback was experimentally presented to a subset of store managers and their reactions were evaluated in open-ended interviews. The experiment compared different time periods of feedback and found that the preferred time period was a function of the user's job responsibilities. For example a store manager preferred daily feedback, since it provided information on equipment operation, which was her responsibility. In contrast, a store owner preferred monthly feedback so he could compare energy costs with other costs, which were billed on a monthly basis. Respondents saw both dollars and kWh as useful, but usually preferred dollars. Demand charges were not well understood, and were difficult to communicate even with our graphical methods. Respondents saw inter-store comparisons as valuable, but potentially misleading due to variations in the levels of service and comfort provided across different stores. It is argued that improved information is a necessary but not sufficient response to energy inefficiency in small commercial buildings.

Energy use in small commercial buildings–stores, restaurants, doctor's offices, and other similar structures–accounts for over one-quarter of total commercial building energy use [1]. These buildings have a large potential for energy efficiency

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doi: 10.2190/FRTW-T45H-CBD9-VCDU
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improvements [2], yet have received relatively little attention from building energy researchers. Programs to encourage efficiency in these buildings are typically extensions of those used in residential buildings–such as audits, rebates, and loans–yet little is known about how energy-related decisions are made in these buildings, or how these decisions can be improved.

Here we use interviews with small businesses to explore how energy decisions are made, and then evaluate graphical feedback as a method for improving them. The first part of our study uses open-ended interviews to explore small business energy decisions, and finds a set of factors affecting energy use which are different from those found in the residential sector, yet equally problematic. The second phase of our study addresses this information problem through the use of feedback. We devise experimental graphical feedback of energy consumption and evaluate it as a method of rectifying the information barrier to energy efficiency.

BACKGROUND

Although investments in building energy efficiency are often cost-effective (meaning that the financial rate of return on these investments is high), these investments often are not made. Reasons for this apparent market failure are complex; and include high perceived uncertainty, separation of costs and benefits, inappropriate pricing of energy, and poor information. Policies to address problems include information programs, such as audits and feedback; financial incentives, such as higher energy prices or rebates for purchasing efficient equipment; and regulations, such as appliance energy efficiency standards.

Both information and financial incentives are attempts to influence the behavior of individuals in buildings. Rebates, for example, are incentives to buy a more efficient energy-using device. Audits are intended to provide information on costs and savings of specific retrofits. The effectiveness of these programs, however, hinges on an understanding of how individuals make energy-related decisions. For example, audits are of little interest to a store owner who rents space and does not pay energy bills. Basic information on energy costs, responsibilities, and perceptions is needed for effective program design.

Here we use the case study approach to enhance our understanding of energy information and behavior in small commercial buildings. Our case study shopping center is located in central New Jersey, approximately 60 miles (100 km) from New York City. We will call it the "Jersey Mall." There are fifty-two businesses at the Jersey Mall. Three of the businesses are large anchor stores (two supermarkets and a department store), and the remaining forty-nine businesses are a diverse mix, including banks, a health club, restaurants, video rentals, and a dentist. About 35 percent of the businesses are members of chains, with an on-site manager. Energy-using equipment at the Mall includes space conditioning (heating, cooling, ventilation), lighting, and process loads (refrigeration, cooking, etc.). Space heating units are mostly natural-gas fueled forced air systems, although the large department store has an oil-burning furnace and several small stores have supplemental electric heat. All fifty-two businesses are served by electric space cooling systems. Both lighting and process equipment varies by business. Restaurants and the laundromat use natural gas for cooking, drying, and water heating; and several businesses (supermarkets, restaurants) use electricity for freezing and refrigeration.

The electricity rate schedule faced by these small businesses has two components–a consumption charge and a demand charge. The consumption rate is approximately $0.06/kWh, based on total electricity consumption; and the demand rate is approximately $10/peak kW, based on the maximum electricity demanded at any one time in the month. Many utilities charge commercial customers for demand to account for the utility's additional expenses in meeting peak-load requirements.[1] On average, 43 percent of the electricity bill for businesses at the Jersey Mall is due to the demand charge.

EXPLORATORY INTERVIEWS

Here we briefly summarize results from a series of interviews conducted with managers of the individual businesses. The interview results are described in more detail elsewhere [3].

On-site interviews were conducted with small businesses at the Jersey Mall from November 1987 through March 1988. These interviews were exploratory in nature, and were intended to uncover energy-related problems and issues as seen by the businesses. Interviews were conducted with forty of the fifty-two businesses at the case study shopping center. The interviews were conducted with the owner or manager of each business, and typically lasted 15-20 minutes. The style of the interviews was, in part, ethnographic. An ethnographic interview can be seen as a guided conversation, which allows the interviewee to influence the agenda of the interview. These exploratory interviews uncovered several previously undocumented issues. The single most striking finding was the poor quality of energy-related information available to the businesses. Here we summarize the information problem in several distinct areas–energy-using equipment, energy costs and bills, and energy efficiency.

Energy-Using Equipment

Small commercial energy users are poorly informed about their heating and cooling equipment–for example, 40 percent of those with natural gas space heating systems did not know their heating system used gas. When asked which appliances used a lot of energy, many respondents mentioned appliances that were

[1] The monthly demand charge, however, is determined by the most amount of electricity used in any 30-minute period in the month. Thus the businesses' peak consumption time may not correspond to the utility's peak demand period.

visible or noisy–such as dentist's drills and radios. Less visible or controllable appliances, such as refrigerators or air conditioners, were often ignored. This is consistent with research in the residential sector showing that consumers estimate an appliance's energy use partly by perceptual salience [4].

Energy Costs and Energy Bills

Approximately 35 percent of the stores are members of chains. These stores are usually operated by a salaried manager, and in all but one of these stores all bills, including rent and utility bills, are sent directly to the main headquarters. The store managers have no direct information about their energy use. These salaried managers usually said that the main headquarters monitored their bills and would notify them if a bill was much higher or lower than usual. However, only one manager could recall ever being notified about an electric bill, and this was due to a mistake made by main headquarters in reading the bill.

Sixty-five percent of the stores are owner-occupied. These owner-occupied stores all receive electric utility bills, yet many of them reported that they do not pay any attention to the bill. It generally goes directly to the bookkeeper or accountant. Only 42 percent of the stores reported that they actually looked at the bill. We asked one owner to show us his electric bill. When we remarked that it gave no information other than the amount due, he remarked that the "other stuff," meaning the bill inserts and the section of the bill providing consumption information, was thrown away when the bill was received.

Finally, of the approximately twenty tenant businesses asked, not one knew that they were charged for electricity demand (kW) as well as consumption (kWh). We asked this question in a variety of ways. At first we asked about "demand charges," but this resulted in a puzzled look. We then asked if their bill was different than the bill they got at home. A few tenant businesses knew that something was vaguely different about their bill, but not one of those asked knew how it differed.

Energy Efficiency

Two premises of energy efficiency generally accepted by analysts are that building occupant behavior will affect building energy use, and that an efficiency improvement does not require a decrease in comfort or amenity. Unfortunately these premises are not believed by small businesses in our case study. We asked small business people if they thought energy use was fixed or could be changed. Most made comments like, "There's nothing I can do about it." Small business people in our case study have a strong belief that energy use, and therefore energy costs, cannot be controlled. Any suggestions we made concerning reduced energy use were interpreted as requiring a corresponding reduction in comfort. For example, when we asked what could be done to reduce energy use, many respondents said that they could turn down the heat or turn off the lights, but that a cold, underlit store would discourage their customers. This is consistent with residential sector findings [4], in which users saw residential energy conservation primarily as behavioral curtailment rather than better management or more efficient equipment.

Summary and Implications for Improved Energy Information

We have documented the poor quality of energy-related information supplied to small commercial users. Our impression is that information and decision quality here are actually worse than in the residential sector.[2] Improving this information, however, requires matching the information to the needs and interests of the recipients. Given small commercial users' relative lack of interest in energy, a complicated and difficult presentation of energy-related information will most likely be ignored. Research in the residential sector has shown that a simple report summarizing past consumption can increase user interest in energy consumption [5]. This method also has the advantage that the information presented is specific to the building–and as small commercial buildings are quite diverse, building-specific information is much more useful than generic recommendations. We designed several graphical energy reports and tested them on users, as described in the following section.

FIELD TESTS OF GRAPHICAL FEEDBACK

There are several ways that graphical feedback could address problems described in the previous section. As our interviews revealed, small businesses often feel that energy costs are fixed and independent of their behavior. If a graph of hourly electricity consumption showed, for example, that energy use was higher on the night they left the lights on, this would more clearly relate energy consumption to their behaviors. The belief that reduced energy use leads to discomfort might be disproven if it could be shown, using an inter-store comparison, that a neighboring store uses less energy even though that store is well-lit and comfortable. A monthly graph distinguishing demand and consumption charges may help users recognize and understand demand charges. As we discuss further in the conclusions, several delivery mechanisms are possible. Graphical feedback could be provided as part of an energy audit, it could be mailed to customers responding to a bill stuffer, or it could be automatically mailed to all commercial customers.

Some of the barriers to energy efficiency uncovered in our interviews, such as diffusion of responsibility, are not information or perceptual issues, and will not be solved by graphical feedback. However, feedback has the potential to improve

[2] This impression is based on the authors having interviewed in both sectors, and is not based on specific quantitative comparisons.

user information and is a necessary component of an overall energy efficiency program.

In this study, an information packet (Figures 1 through 5) with several different types of energy-related information is developed and presented to energy users, who are then interviewed to obtain data on their perceptions and interpretations of each type of information. We did not try to measure the long-term effects of information on behavior *per se*, but rather sought a qualitative understanding of the factors and processes involved when small commercial energy users perceive, analyze, and interpret energy-related information. This approach is valuable in exploratory studies, and in answering "why" questions about a phenomenon. However open-ended interviews are not intended to provide quantitative measurements of effects.

Existing Research

A recent review of the energy feedback literature found eleven studies reporting feedback which resulted in reduced energy use, and eight studies reporting no effects of feedback on energy use [6]. These studies use various formats to provide feedback, including continuous display monitors, written notes, and methods for individuals to monitor their own energy use. The feedback is given on an instantaneous, daily, weekly, or monthly basis. The diversity of approaches and methods used makes it difficult to reach an overall conclusion on the effectiveness of feedback as a conservation strategy.

Residential energy user's processes of analyzing and interpreting energy data has been explored [5, 7]. Like the current study, they evaluated several forms of information and used interviews to elicit processes of interpretation and analysis. Some respondents used the information to evaluate past retrofit actions. The authors point out an important difference between short- and long-term feedback. The short-term feedback used predominantly in other studies, such as continuous or daily, is appropriate for influencing energy-using behavior (turning off lights, setting back thermostats, etc.). Longer term feedback (such as monthly bills or an annual report) is more appropriate for evaluating retrofits or conservation investments. This distinction was incorporated into our graphical feedback, by presenting a range of feedback time periods (described below).

Methods

The field tests of graphical feedback discussed here are intended to improve understanding of the relationship between energy information, energy-using behavior, and energy consumption. This relationship is investigated through extensive interviews with energy users. An information packet, presenting feedback in several formats for different time periods, is prepared and given to energy users. Ethnographic interviewing methods, along with the use of some fixed questions, are then used to draw out the participants' perceptions and interpretations of the

Annual summary of energy use and comparison with other businesses.

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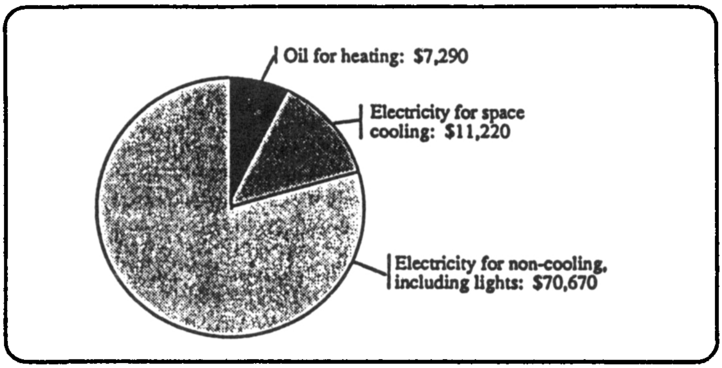
ENERGY REPORT FOR: DEPARTMENT STORE

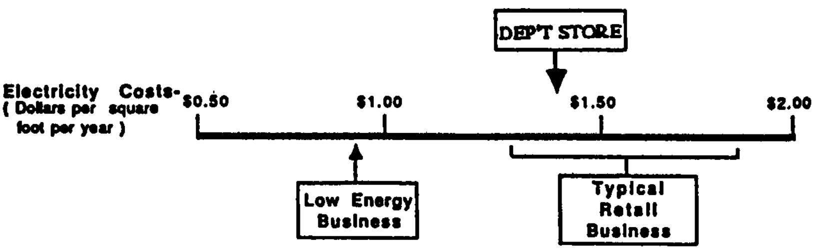
PART 1: Summary of Electricity Use

Total Energy Costs (Sept. 1987-August 1988): $89,180



Explanation: Oil deliveries, not consumption, are shown. "Electricity for space cooling" is estimated as the increase in electricity use and demand during hot weather months. The remainder is considered "non-cooling." Consumption is not weather-adjusted.

HOW DO YOU COMPARE?

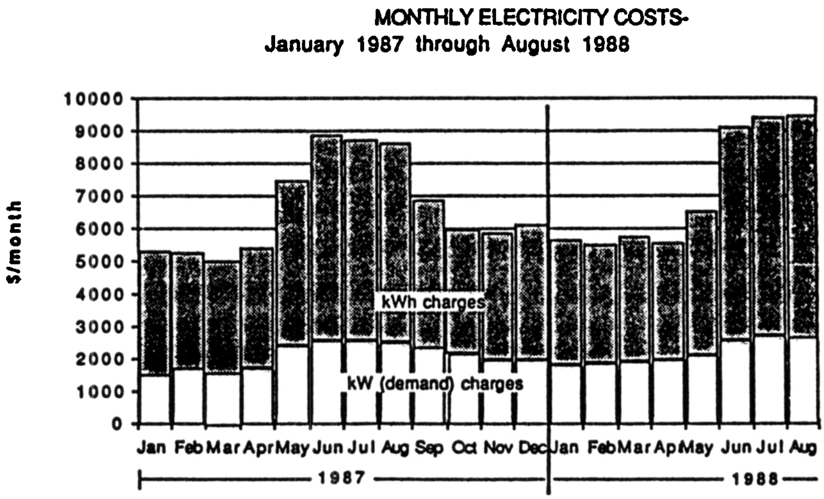


Explanation: "Typical retail business" is based on a small sample of businesses at the Shopping Center, and excludes grocery stores and restaurants. Range shown is one standard deviation. "Low energy business" is an average value for the lowest 10% of businesses in the sample.

Figure 1. Annual summary and comparison with other businesses, from graphical feedback sample packet.

ENERGY REPORT FOR: DEPARTMENT STORE

PART 2: Monthly Electricity Use



Months are from approximately 10th of month shown through 10th of following month. Data not weather-adjusted.

Annual Summary for 1987	
kWh	$53,500
kW (demand)	$25,000
Total	$78,500

Figure 2. Monthly consumption, from graphical feedback sample packet.

energy information. This section describes the subjects, the information packet, and the experimental procedure. More detailed information can be found elsewhere [8].

Four businesses at our case study shopping center–a large retail department store, a health club, a retail furniture store, and a stationery supply store–were selected for participation in the study. These four businesses reflect the variety of business types found at the Jersey Mall. At the large department store, a preliminary interview with the store manager identified four individuals as responsible for energy use and energy-using equipment at the store–the manager, the owner, Daily energy consumption.

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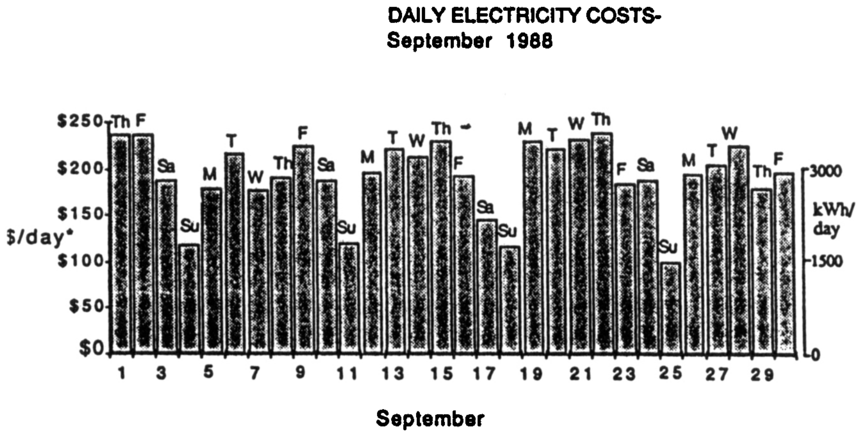
ENERGY REPORT FOR: DEPARTMENT STORE

PART 3: Daily Electricity Costs for Recent Month



*Excluding demand charges

Figure 3. Daily consumption, from graphical feedback sample packet.

and two building contractors. At the three smaller businesses, preliminary interviews identified the owner/manager as the primary decision maker. The furniture store was in the process of being sold, and both the old and new owner/managers were involved in energy-related decisions. Therefore, a total of eight individuals in four businesses were targeted for the extensive interviews.

Pulse-generating kilowatt-hour meters were installed and calibrated at the four stores to collect short-term electrical consumption data continuously. A data acquisition system collected and stored the data on disk. For long-term comparison, monthly consumption data for two years were obtained from the electric utility serving the four businesses.

Hourly energy consumption.

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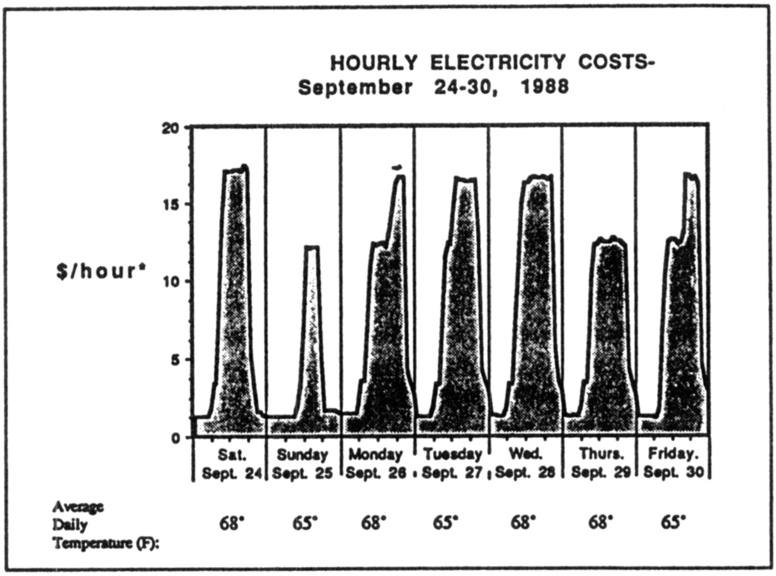
ENERGY REPORT FOR: DEPARTMENT STORE

PART 4: Hourly Electricity Costs



*Excluding demand charges

Figure 4. Hourly consumption, from graphical feedback sample packet.

The information packet is designed to meet several criteria–to show a range of time periods, separate demand from consumption information, and be as clear and informative as possible. Differences in energy-using equipment among the four participating businesses required minor modifications in the packet. The graphs include:

- an annual summary of energy use, and a comparison with other businesses (Figure 1);
- a plot of monthly electricity consumption for the most recent twenty months (Figure 2);

Hourly energy consumption using a three-dimensional representation.

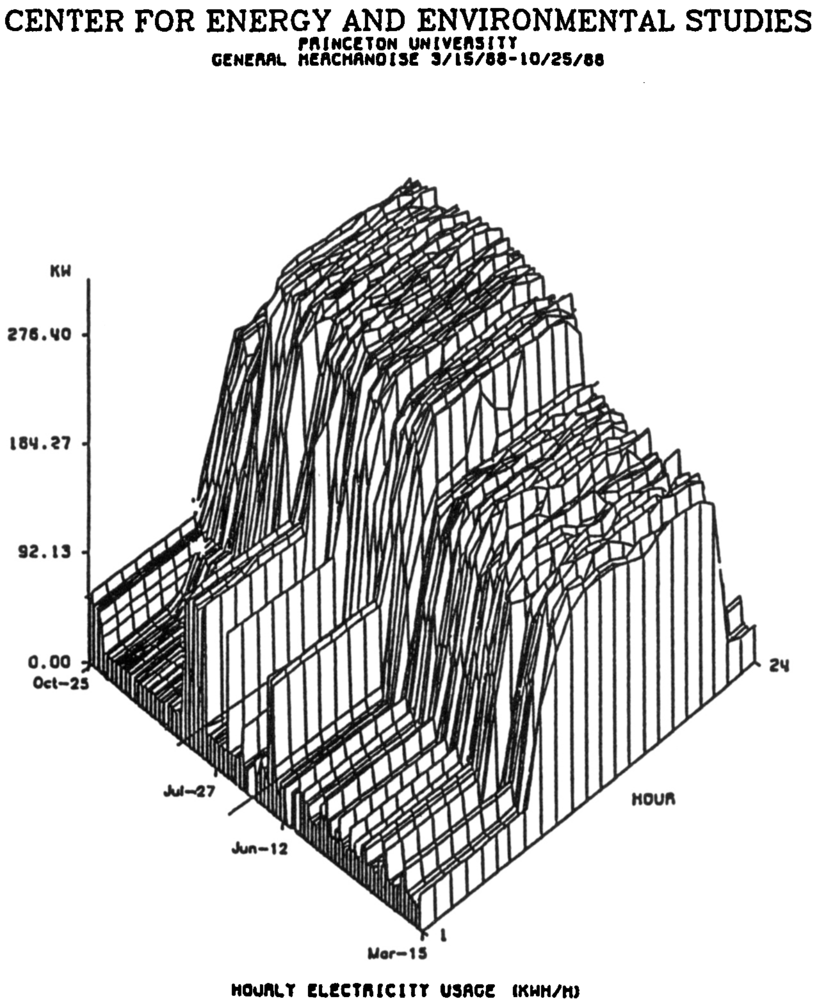


Figure 5. Hourly consumption over seven months in three-dimensional representation, from graphical feedback sample packet.

- a plot of daily electricity consumption for a recent month (Figure 3);
- a two-dimensional plot of hourly electricity consumption for a recent week (Figure 4); and
- a three-dimensional plot of hourly electricity consumption for several months (Figure 5).

Each person interviewed was presented with the information packet for his or her business. Each page was presented individually, and the person was encouraged to vocalize his or her interpretations and responses. The interviews were intentionally open-ended to allow for unanticipated responses. Each interview lasted approximately 45 minutes.

Results

The interview results are summarized in three areas–user conceptions and understandings of consumption units; user understandings of variables influencing energy use, including his or her own behavior, equipment operation, and exogenous variables such as weather; and user preferences for format and time period of feedback data.

Energy consumption units — The information packet used three basic units related to energy use–kWh, kW, and collars. The monthly plot divided energy costs into two components–kW charges and kWh charges. In addition, the daily plot showed daily energy consumption in both kWh and dollars. User comments and interpretations provided some insight into how individuals perceive and interpret energy units.

Our initial interviews at the Jersey Mall uncovered a lack of understanding related to demand charges. This finding was strengthened by our field tests of graphic feedback. When the eight users were shown the monthly plot with the kW charges, only one demonstrated any understanding of what this charge was due to. One participant (an independent contractor for the department store) commented, "KW demand . . . What's this KW demand?" The store manager said, "I don't understand demand–or how it affects costs. The average consumer cannot understand demand." One contractor demonstrated a partial understanding of demand charges, "This KW charge is probably a surcharge for equipment starting and stopping, and going over their demand limit." As suggested by the earlier interviews, these results indicate that users do not clearly understand demand charges. Furthermore, the comments by contractors indicate that energy-using equipment in these small commercial stores is selected and installed without regard for electric demand.

Users were asked their preferences for dollars versus kWh. Dollars were in general preferred, but energy units were also seen as of some value. The furniture store owner commented, "Dollars per day makes sense. Kilowatts . . . I don't know a kilowatt from a . . . well . . . whatever" (she was actually looking at a plot labeled kWh, not kW). She also used dollars to compare her business energy consumption to her consumption at home–"July (energy charges) are about four times what I pay at home." Similarly, the stationery store owner said, "Money makes more sense than the other figures. Most people do not know how to translate that [points to kWh scale] into something they can compare." The owner of the department store, who was considering several energy-related retrofits, said both units were useful–"We do financial budgeting in dollars, so dollars are better for the monthly and annual figures. However, from a project standpoint, we deal with kWh–the goal should be in kWh." These results suggest that dollars as energy units provide a useful way to compare energy to other business costs, but that there is some recognition that kWh can also be useful. This is consistent with other researcher's findings [5], which suggests that both units should be used in residential feedback.

One component of the annual section of the information packet gave energy use in units of dollars/ft^2. Users found this informative, but recognized that it could be misleading. Said one, "I don't know if you can compare us with the smaller stores." Similar comments included, "These low energy businesses–are they very cold or very dark? Maybe they're not open as long as we are," and "This comparison is based on businesses in the area. But what if the whole neighborhood is high?" Several users said that the comparison should be relative to similar businesses–"If this graph showed Fitness Centers–that would be interesting." Based on these reactions, one simple addition might be to provide comparisons with other stores with the same SIC code, rather than with other stores in the same physical location.

The use of prior beliefs as a cognitive reference point in comprehending the information was revealed by user comments on the end-use breakdown provided by the pie chart. Comments such as, "I spend a lot on lights . . . I expected that," and "That seems pretty low for just the chiller" suggest that energy feedback is initially checked against prior beliefs. Information that was strongly inconsistent with prior beliefs was viewed with suspicion–one user, viewing our daily consumption graph that showed large day-to-day variations, commented "Why isn't it constant? . . . This is totally ridiculous." By contrast, a user with minimal prior conceptions of the details of her energy use found the information difficult to comprehend–"I'm not getting much out of the (pie chart). I don't know anything about any of this stuff." These comments remind us that new information is never interpreted in a vacuum, and that a program using materials like our packet should provide some source of further explanation, such as a telephone contact or energy audit.

End uses were also compared–"Lights are the largest cost center," leading to conclusions on which end-uses were deserving of further attention–"I guess more efficient lights would have the biggest impact," and "The primary focus should be on . . . lighting." However, a contractor noted the need for some form of normalization–". . . (the graph) doesn't tell me whether or not the lights are efficient. The oil for heating–it's not against anything." These comments, we feel, accurately reflect some of the complexities of end-use comparisons.

Influencing Variables — One intention of this study was to see how users tie graphic information to their real world–that is, the connections made between the energy feedback data and their own behavior, their business operations, and other factors affecting energy use. Our graphs clearly provided new insight on their equipment and business operations, and the connections they made with energy use differed for the monthly, daily, and hourly graphs.

The monthly data were linked to the presence of space conditioning, as indicated by comments such as, "It's obvious that the cooling season makes it go up," and "The air conditioning causes a peak in May to September." Interestingly, users were uncomfortable when they did *not* see a summer increase in energy costs–"July and August electricity use is medium–I would expect it to be high. I wonder what happened," responded one user.

The daily plot was tied to business hours and to weather. Business hours were often mentioned first–"I guess these low days–we must be closed." "We aren't open as much on Sunday, and you can see that." Also mentioned in conjunction with variations in daily consumption was weather–"This Friday is higher than that Friday . . . must be weather." "There's also a variation week-to-week . . . it is probably weather influenced."

Unlike the monthly and daily plots, the hourly plot was closely connected to energy-using behavior. One respondent pointed to a low-consumption period and said, "Maybe somebody forgot to turn the chiller on, or maybe it wasn't working." She also tied the hourly data to her own work schedule, "It never reaches the peak on Thursday. I'm off Thursdays–what are they doing when I'm not here?" An owner/manager asked, "Why does it fluctuate so much? I never touch the thermostat . . . it must be the lights." A contractor pointed to an hourly fluctuation and noted, "Somebody screwed up here . . . things are staying on. What's this peak on Monday? Must be air conditioning."

Preferences–time and format — Our experimental graphs also used several different formats to present energy information for four time periods (annual, monthly, daily, and hourly). Following the presentation of all graphs, respondents were asked, "If you could keep only one of these forms, which would it be and why?" The results suggest that energy information is valued in the context of the specific responsibilities and interests of the user. A contractor preferred the monthly plot because, ". . . it reflects the kW demand, which I could do something about." A store manager, by contrast, preferred the daily plot because it provided information on equipment operation, which was her responsibility. The store owner preferred the monthly plot, as he ". . . could use it to verify the calculations of contractors." Another store owner also expressed a preference for monthly data as, "Most of my bills and expenses are monthly."

Preferences for types of graphs were also revealed in the interviews. Both the bar and pie charts were understood by most users, and no clear preference between these two formats was revealed. In spite of its increased use in the research community [9], the three-dimensional plot was universally disliked by the participants in this study, for example, "The way it's charted, I can't see what's going on. I don't think it's a good representation."

Users were asked what specifically they might do differently because of the information. Several comments suggest that the data would be used either to forecast or to evaluate the effects of conservation–"This (monthly) graph is good . . . especially if we make a change in something and want to see that effect." "If I could see (consumption) to the minute, I could tell if they're turning lights on too early." The information also served to build interest in energy conservation. "This is good information–what can I do to make this a low-energy business?," asked one owner of a new store at the end of the interview. He was making several retrofit decisions at the time, and his willingness to consider energy use in these decisions supports our point made earlier concerning the need to intervene at the time retrofits and remodels are being planned.

IMPLICATIONS AND CONCLUSIONS

Our exploratory interviews uncovered a severe lack of energy information for managers of small businesses. Appliance energy use was often estimated by noise and visibility. None of those asked was aware of demand charges, even though these charges constituted 43 percent of their bills. Users see energy use as unchangeable, and conservation as requiring discomfort and sacrifice.

Elsewhere, four directions for future programs to address these issues are suggested [3]. These are to recognize and exploit non-financial determinants of behavior, to target decision-makers, to intervene at time of remodeling, and to improve user information. In this article, we pursue these suggestions by experimentally evaluating the effects of improved information using graphical feedback techniques.

It was found that feedback is much more effective when matched to the user's area of responsibility. Specifically, contractors and others selecting, installing, and evaluating equipment can benefit most from annual or monthly data. Building operators and those responsible for equipment management find more value in shorter term data, which can be used to evaluate specific equipment control decisions. Both dollars and energy units should be used in providing energy feedback–dollars are more readily understood, and energy units provide a method of controlling for rate changes. Users recognize the need to normalize consumption when comparing different businesses, but they see normalizing by floor area as insufficient to allow credible interstore comparisons of consumption. Users correctly see interstore variations in hours of operation and amenity levels as making these comparisons difficult. Comparison of a business with others with the same SIC (Standard Industrial Classification) code would be a logical first step in producing a credible interstore comparison.

We are not arguing that merely supplying information will be sufficient to induce energy efficiency improvements. The issues discussed earlier, including a diffusion of responsibility for energy use and users' concern with nonfinancial factors, also act as barriers to energy efficiency. Nevertheless, the provision of carefully designed targeted information is a necessary component of an overall program to encourage cost-effective energy efficiency improvements.

Finally, one could interpret the information and motivation problems uncovered here as meaning that any decisions to increase energy efficiency should not rely on the users. An energy service company, for example, could be hired by the mall management to retrofit all businesses in the mall, bypassing the small business managers entirely. This could solve several of the investment decision problems, but we do not advocate it as an exclusive answer for several reasons. First, the users will still operate the equipment, and in the absence of improved information will continue to operate it without regard to energy use. Second, decisions on lights and business-specific equipment are made by the individual businesses, and these decisions cannot be made by energy service companies. Third, the businesses are paying energy costs in any case, and therefore have a right to know what they are paying for and what they could do to reduce their costs.

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