Behavior and Potential Energy Savings in Business Establishments

Ken Tiedemann, Iris Sulyma, and Ron Sahota, BC Hydro
Jack Habart, Habart & Associates Consulting

ABSTRACT

Research on energy savings in businesses has been dominated by an engineering economics paradigm, in which economic agents adopt practices and technologies which are cost effective. This paper, together with its companion paper on behavior and energy savings in residential dwellings, challenges this paradigm and reports on a preliminary behavioral study done with business customers. Using data collected from an on-line survey of 279 business customers, we develop and apply a conditions, capacity and commitment model of behaviour, which argues that conservation and energy efficiency adoption depend on the customer's satisfaction with and level of concern around energy efficiency (conditions), the customer's ability to act to change or modify service levels (capacity), and customer's undertaking or implementation of energy efficient actions or practices (commitment).

The implementation of the model was based on a detailed survey that focused on several main business energy end uses, including indoor lighting, air conditioning, and space heating. For each end use area, respondents were asked a series of scaled questions dealing with their satisfaction with service levels for the end use (such as lighting levels or temperatures); their ability to modify or change service levels (such as local on/off switches or HVAC controls); and the extent to which they performed energy efficient actions or behaviors (three possible actions for each end use). The study found that task lighting, day lighting, use of natural ventilation, thermostat set back, and use of window blinds are the most promising areas for behavioral energy change in businesses.

Introduction

Research on energy conservation has been dominated by an engineering economics paradigm, in which economic agents adopt those technologies and practices which are cost effective. Some key references to this literature include Duke and Kammen, Golove and Eto, Horowitz and Haeri, Jaffe and Stavins and Joskow and Marron. Within this literature, analysis of energy savings opportunities typically proceeds by estimating net life cycle costs, and then assuming that the technologies and practices with the best life cycle costs will be adopted by economic agents, whether they are businesses or households. From a public policy perspective, the most effective policy initiative is one which most cost effectively promotes improvement in lighting, appliances, motor systems, HVAC systems and building shells. Demand side management programs have focused their attention on market barriers to the adoption of efficient technologies and developed instruments to overcome these barriers.

The rich behavioral literature on how customers actually make decisions on how they use energy has had, until recently, relatively little impact on energy efficiency policies. Some key references for this literature include California Energy Commission, Janda et al., Lutzenhiser, and Stern. This behavioral literature typically examines the actions of economic agents in specific and well-defined contexts with a view to understanding how and why they make decisions on energy use and on energy conservation behaviors. Interest in the behavioral literature began to increase both during and after the California energy crisis of 2000-2001, where the traditional hardware solutions to energy conservation were initially promoted. But the substantial energy demand reductions that were actually observed appeared to be, upon detailed examination, due primarily to conservation behaviors promoted by mass media and by social marketing. This suggests that it may be useful to try to more explicitly model the role of residential and business customers in securing conservation benefits, and to build a model that will help understand why some customers adopt energy efficient technologies while others do not adopt them.

It is worth noting that one initial basis for the behavioral analysis of energy efficiency was rooted in the theory of reasoned action of Fishbein and Ajzen, which argued that the best predictor of actual behaviour was behavioral intention. Intention to perform the behaviour was in turn determined by the individual's attitudes towards the behaviour and the subjective norms held by the individual. Subsequent developments by Ajzen led to the theory of planned behavior, which argued that behavioral intent depends on three factors: attitudes towards the behaviour; social norms; and perceived behavioral control

Method

Our paper presents a preliminary analysis of behavioral energy savings in the commercial sector. Our model both builds on and simplifies the models used by previous authors, and we argue that adoption of conservation and energy efficiency actions and practices has three main components. (1) Condition refers to the circumstances surrounding a customer's potential conservation actions, which include, in particular, the customer's satisfaction with the status quo. This satisfaction with the status quo could well have as its antecedents a mediation between attitudes and social norms, as in behavioral theories based on social psychology, but the mediation between attitudes and social norms is not necessary for this model. (2) Capacity refers to the customer's ability to act to undertake conservation actions, which may include both the presence of an enabling technology and the authority to act. This is essentially the same concept as perceived behavioral control and includes both the technical capacity to undertake a conservation action and the authority to undertake the action. (3) Commitment refers to the customer's acting to undertake an energy saving action or behavior, which may include the frequency with which an action is performed.

The careful reader will note that our model has performance of actions (commitment) rather than a measure of behavioral intent to perform the action as the dependent or the outcome variable. Although behavioral intent is important in many of the contexts studied by social psychologists, it may be, in our view, an unnecessary concept in examining energy conservation behavior. Rather than positing an intervening intention, we move directly to the effect of conditions and capacity on behavior, in other words, performing an action is a function of conditions and capacity.

The conditions-capacity-commitment model is applied here to three main business energy end use areas: indoor lighting; air conditioning; and space heating. Data was collected through a web-based, on-line survey of 279 business respondents. Survey development proceeded in several steps. First, published literature on behavioral energy savings was reviewed. This provided a number of useful insights, but the majority of papers reviewed focused almost completely on residential customers rather than business customers. Second, a workshop was held with program staff and external experts to review and define possible approaches and researchable questions. Third, a draft survey was developed, circulated among stakeholders and revised in response to comments received. Fourth, data was collected though a web-based, on-line survey of 279 business customers. Fifth, data was cleaned and a variety of cross tabulations were run in SPSS.

The survey included a wide range of energy related attitudes, conditions and behaviors as well as detailed information on the respondent's place of work. For each end use area, the respondents were asked a series of scaled questions dealing with their level of concern about the service level for the end use (such as lighting levels or temperatures); their ability to modify or change service levels; and the extent to which they performed energy efficient actions or behaviors.

This study examines four main issues. (1) Lighting Behavior. Understanding of appropriate lighting levels, ability to use lighting conservation actions (turn lights off, use day lighting, use task lighting) and frequency of use of lighting conservation actions. (2) Air Conditioning Behavior. Understanding of appropriate cooling levels, ability to use cooling conservation actions (open windows, close blinds, turn temperature up) and frequency of use of cooling conservation actions. (3) Heating Behavior. Understanding of appropriate heating levels, ability to use heating conservation actions (open blinds, turn down temperature, close the exterior doors) and frequency of use of heating conservation actions. (4) Aggregation Bias. Examine the loss of information if individual energy efficient actions are aggregated, by using Chi-squared tests of differences across the set of actions.

Indoor Lighting

Table 1 summarizes survey information on indoor lighting conditions, capacity, commitment and behavioral target. Respondents were first questioned about the appropriateness of lighting levels, that is they were asked whether lighting levels were too bright, too dim or about right. About 76% of respondents indicate that lighting conditions in their place of work were about right. Presumably these respondents have little reason to change their lighting-related behavior in the absence of some extrinsic motivator, such as the desire to reduce energy costs, to reduce energy-related carbon emissions or to conform to perceived social norms.

Table 1. Indoor Lighting Conditions, Capacity, Commitment, Behavioral Target

	Conditions % lighting levels about right	Capacity % with capacity to do task	Commitment % always or often doing task	Behavioral Target % occasionally or never doing task
Turn lights off	76%	52%	39%	13%
Day lighting	76%	76%	40%	36%
Task lighting	76%	32%	27%	5%

Respondents were questioned about activities related to turning lights off. Some 52% of respondents indicated that they had the capacity to turn lights of in their work area, while 48% indicated that did not have this ability. The ability to turn lights off was typically met through local on-off controls or motion sensors, and the inability to turn lights off was typically due to the fact that large work areas were controlled by a single on-off switch or by were programmed by a centralized control system. Those respondents who had the capacity to turn lights off were asked whether they turned off lights always, often, sometimes or never when the space was unoccupied. About 39% of respondents noted that they always or often turned off lights when their work area was unoccupied, while just 13% indicated that they did this occasionally or never. This latter 13% of respondents are the target for behavioral change, because they have the capacity to perform the action but do so only occasionally or never.

Respondents were questioned about activities related to the use of day lighting as a substitute for or supplement to overhead lighting or task lighting. Some 76% of respondents indicated that they had day lighting in their work area, while 24% indicated that did not have day lighting. The ability to use day lighting was typically met by those whose work are was adjacent to external light, typically windows and less often sky lights. Respondents who had the ability to use day lighting were asked whether they used day lighting always, often, sometimes or never. About 40% of respondents noted that always or often used day lighting, while 36% indicated that they used day lighting occasionally or never. Thus the target for behavioral change is the 36% of respondents who have the capacity to use day lighting but do so only occasionally or never.

Respondents were questioned about activities related to the use of task lighting. Some 32% of respondents indicated that they had task lighting in their work area, while 68% indicated that they did not have task lighting in their work area. The availability of task lighting was often met through fixed lights as part of office furniture or through the use of moveable lamps. Those respondents who had available task lighting were asked whether they used the task lighting always, often, sometimes or never. About 27% of respondents noted that they always or often used task lighting, while just 5% did this occasionally or never. It should be noted that use of task lighting is not an energy conservation action if it is not substituting for area lighting.

This analysis indicates that there are significant remaining opportunities to reduce energy consumption for indoor lighting in British Columbia workplaces. The most significant opportunity is for greater use of day lighting, followed by turning lights off more consistently in unoccupied work spaces and by greater use of task lighting.

Air Conditioning

Table 2 summarizes survey information on air conditioning conditions, capacity, commitment and behavioral target. Respondents were first questioned about the appropriateness of air conditioning levels, that is, they were asked whether the temperature level is too hot, too cold or about right. About 44% of respondents indicate that air conditioning conditions in their place of work were about right. As in the lighting case, these respondents have little reason to change their air conditioning-related behavior in the absence of some extrinsic motivator.

Table 2. Air Conditioning Conditions, Capacity, Commitment, Behavioral Target

	Conditions % cooling levels about right	Capacity % with capacity to do task	Commitment % always or often doing task	Behavioral Target % occasionally or never doing task
Open windows	44%	53%	33%	20%
Close blinds	44%	64%	46%	18%
Raise temperature	44%	35%	26%	9%

Respondents were questioned about activities related to open windows to get free cooling. Some 53% of respondents indicated that they had the capacity to open windows in their work area, while 47% indicated that they did not have this ability. Those respondents who had the capacity to open windows to get free cooling were asked whether they opened the windows always, often, sometimes or never. About 33% of respondents noted that they always or often opened the windows to obtain free cooling, while 20% indicated that they occasionally or never did this. This latter 20% of respondents are the target for behavioral change, because they have the capacity to perform the action but do so only occasionally or never.

Respondents were questioned about activities related to the use of closing blinds to reduce solar infiltration and consequent solar gain. Some 64% of respondents indicated that they had blinds which could be closed, while 36% indicated that did not have blinds. Respondents who had the ability to use blinds to reduce solar gain were asked whether they used these blinds always, often, sometimes or never. About 46% of respondents noted that always or often used blinds, while 18% indicated that they used day blinds occasionally or never. Thus the target for behavioral change is the 18% of respondents who have the capacity to use blinds but do so only occasionally or never.

Respondents were questioned about activities related to the use of raised thermostat set points to reduce air conditioning loads. Some 35% of respondents indicated that they had the capability to raise thermostat set points for their work area, while 65% indicated that did not have this capability. Those respondents who had the capability to raise thermostat set points were asked whether they did this always, often, sometimes or never. About 26% of respondents noted that they did this always or often, while just 9% did this occasionally or never.

This analysis indicates that there are significant remaining opportunities to reduce energy consumption for air conditioning in British Columbia workplaces through appropriate behavioral change. The most significant opportunity is greater use of window opening to obtain free cooling, followed by closing blinds consistently to reduce solar gain and by greater use of thermostat set back.

Space Heating

Table 3 summarizes survey information on space heating conditions, capacity, commitment and behavioral target. Respondents were first questioned about the appropriateness of space heating levels, that is are temperatures too cold, too hot or about right. About 49% of respondents indicate that space heating conditions in their place of work were about right. As in the previous cases of lighting and air conditioning, these respondents presumably have little reason to change their space heating-related behavior in the absence of some extrinsic motivator.

Table 3. Space Heating Conditions, Capacity, Commitment, Behavioral Target

	Conditions % heating levels about right	Capacity % with capacity to do task	Commitment % always or often doing task	Behavioral Target % occasionally or never doing task
Open blinds	49%	64%	56%	8%
Reduce temp	49%	35%	18%	17%
Close doors	49%	76%	12%	64%

Respondents were questioned about activities related to opening blinds to increase solar radiation. Some 64% of respondents indicated that they had the capacity to open blinds in their work area, while 36% indicated that did not have this ability. Those respondents who had the capacity to open blinds were asked whether they performed this action always, often, sometimes or never. About 56% of respondents noted that they always or often performed this action, while just 8% indicated that they did this occasionally or never. As in the cases discussed above, this latter 8% of respondents are the target for behavioral change.

Respondents were questioned about activities related to the use of thermostats set back as a means of reducing heating energy requirements. Some 35% of respondents indicated that they could reduce temperature settings in their work area, while 65% indicated that they could not do so. Those respondents who had the capability to set back temperature settings were asked whether they did this always, often, sometimes or never. About 18% of respondents noted that they performed this action always or often, while 17% indicated that they performed this action occasionally or never. The target for behavioral change is the 17% of respondents who have the capacity to reduce temperature settings but do so only occasionally or never.

Respondents were questioned about activities related to the closing of outside doors to keep warm air inside the building and prevent cold air from entering the building. Some 76% of respondents indicated that they had access to relevant outside doors that could affect indoor temperatures if they were left open, while 24% indicated that they did not. Those respondents who had the ability to close outside doors open were asked whether they did this always, often, sometimes or never. About 12% of respondents noted that always or often closed outside doors, while 64% did this occasionally or never.

This analysis indicates that there are still significant remaining opportunities to reduce energy consumption for space heating in British Columbia workplaces. The most significant opportunity is to ensure that outside doors are closed to prevent loss of warm air, followed by reducing temperature set points and by greater use of blind opening to increase solar gain.

Aggregation

A relevant issue in designing energy related behavioral research is the trade-off between information disaggregation and response burden on survey participants. On the one hand, disaggregated information may produce insights that are lost in aggregated information; on the other hand, increasing the number of issues examined may create an unrealistic burden on respondents. Because the present research used an on-line panel of respondents, we were able to: (1) ask more detailed questions than might be feasible when using a telephone survey and (2) consider the effects of aggregation of information. Because there is no variation in conditions within each of our three end use areas, we focus on variation with respect to the questions on capacity and on commitment. The basic method is to look at the three energy conservation actions for each end use area separately with respect to capacity and to commitment. We then have two sets of null hypothesis (H_0) and alternative hypothesis (H_1).

Capacity H_0: Proportions of respondents indicating yes for capacity are not the same across the three actions in each area.

Capacity H_1: Proportions of respondents indicating yes for capacity are the same across the three actions in each area.

Commitment H_0: Proportions of respondents indicating always or usually for commitment are not the same across the three actions in each area.

Commitment H_1: Proportions of respondents indicating always or usually for commitment are the same across the three actions in each area.

Table 4 presents the results of our examination of the potential impacts of data aggregation. For each of the six areas examined, the chi-squared statistic is significant at the 5% level, and for five of the six areas, the chi-squared statistic is significant at the 0.1% level. Thus in each case we accept the null hypothesis that the differences across the three actions in each area are statistically significant. This suggests that in understanding the potential for energy efficiency, it is important to disaggregate energy efficacy actions within a particular end use area.

Table 4. Chi-square Tests for Differences Across Conservation Actions

	Capacity (chi-squared)	Capacity (probability)	Commitment (chi-squared)	Commitment (probability)
Interior lighting	53.87	<0.0001	8.24	0.0162
Air conditioning	24.04	<0.0001	16.44	0.0003
Space heating	43.37	<0.0001	111.81	<0.0001

Lessons Learned and Limitations

1. **Understanding Conservation Behavior.** The conditions, capacity, commitment model has provided a preliminary framework for examining behavioral energy savings in the commercial sector. Respondents were generally able to answer the structured questions with non-response rates generally below 5%, which is very good for a survey of this type. However, one reviewer questioned whether or not the questions were capturing the underlying behavioral concepts, and this issue needs to be examined in future work. It was also suggested by one reviewer that that the model should perhaps be viewed as one alternative way of identifying behaviors that could be altered through information or other mechanisms, and this is also being examined. Follow-up qualitative and quantitative research will be used to: (1) re-examine the validity of the underlying research constructs; (2) re-assess and the refine the model in light of current research developments; (3) determine the feasibility of asking more detailed questions and covering more end use areas; (4) establish a quarterly tracking system so that the impact of behavior-related DSM activities can be determined.
2. **Applicability of Conservation Actions.** We examined the key energy conservation behaviours or actions in each of three major end use areas: lighting (actions were turning lights off, use of day lighting and use of task lighting); air conditioning (actions were open windows for free cooling, close blinds to keep out solar radiation and turn up temperature set point); and space heating (actions were open blinds to let in solar radiation, turn down temperature set point and close exterior doors to retain heat). Although there was considerable variation in conditions, capacity and commitment across the nine behaviors or actions, we found that conservation behaviors in businesses are

widespread. The most promising areas for behavior targeting include task lighting, day lighting, use of natural ventilation, thermostat set back, and use of window blinds.

3. **Potential Impacts of Behavioral Change.** Load forecasting, DSM program development and integrated resource planning are often premised on the assumption that energy demands within commercial buildings are essentially determined by building shell and equipment characteristics and demands for energy services. This perspective implies that the potential for behavioral energy change in business is quite limited, and only hardware solutions can have significant impacts on energy use and energy conservation. The present research suggests that there may be substantial opportunities for low cost-no cost measures to reduce consumption if current conservation practices are applied more broadly. Less is known about how to motivate agents to perform the desired conservation questions, and this will be the subject of future research. This research should be thought of as the beginning of a process to identify where opportunities lie as opposed to a comprehensive assessment. Specifically, we are working with the Consortium for Energy Efficiency to understand how social marketing can be used to define the relevant behavioral problems, identify means of changing behavior and implement programs aimed at behavioral change.
4. **Disaggregation for Data Collection and Analysis.** A Chi-squared statistical analysis was applied to each end use area to determine whether capacity and commitment were statistically different within energy conservation actions for a given end use. In each case, we accept the null hypothesis that the differences across the three actions in each area are statistically significant. This suggests that in understanding the potential for energy efficiency, it may be important to disaggregate energy efficacy actions within a particular end use area.

References

Ajzen, I. 1985. “From Intentions to Actions: A Theory of Planned Behavior,” in J. Kuhl & J. Beckman (eds.), *Action-control: From Cognition to Behavior*, Heidelberg: Springer, 1985.

California Energy Commission. 2003. *Public Interest Energy Strategies Report*. Staff Report 100-03-012D.

Duke, R. and D. Kammen. 1999. “The Economics of Energy Market Transformation Programs,” *Energy Journal*, 20(4).

Fishbein, M. and I. Ajzen. 1975. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Reading, MA: Addison-Wesley.

Golove, W.H. and J.E. Eto. 1996. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, Berkeley, CA: Lawrence Berkeley Laboratory.

Horowitz, M. and H. Haeri. 1990. "Economic Efficiency versus Energy Efficiency: Do Model Conservation Standards Make Good Sense?," *Energy Economics*, Vol. 12.

Jaffe, A. and R. Stavins. 1995. "Dynamic Incentives of Environmental Regulations: The Impact of Alternative Policy Instruments on Technology Diffusion," *Journal of Environmental Economics and Environment*, Vol. 29.

Janda, K., C.T. Payne, R. Kunkle and L. Lutzenhiser. 2002. “What Organizations Did (and Didn’t Do): Three Factors That Shaped Conservation in California’s 2001 Crisis, *Proceedings of the 2002 ACEEE Summer Study*, Washington, DC: ACEEE Press Vol. 8.

Joskow, P. and D. Marron. 1992. ‘What Does a Negawatt Really Cost: Evidence From Utility Conservation Programs,” *The Energy Journal* 13.

Lutzenhiser, L. 1993. “Social and Behavioral Aspects of Energy Use,” in *Annual Review of Energy and the Environment*, 18:247-289.

Stern, P.C.. 2002. “Toward a Coherent Theory of Environmentally Significant Behavior,” *Journal of Social Issues*, 56.