



The Human Factor of Energy Conservation and Sustainability: A Case Study of the Kumasi Polytechnic Campus

Kingsley Akom¹, Bernard Adjei-Frimpong², Johannex Fefeh Rushman³

^{1,2,3}Department of Electrical/Electronic Engineering,
Kumasi Polytechnic, P.O.Box 854, Kumasi-Ghana.

Abstract: This paper intends to determine the behaviours, attitudes, and levels of understanding among faculty, staff, and students aimed at reducing energy use in Kumasi Polytechnic (KP) buildings. A multi-method approach is used in five diverse pilot buildings including focus groups, behavioural observations, environmental measures, and web surveys. Among the findings, KP staffs are most concerned about conserving energy in KP buildings while students are the least concerned. A significant proportion of survey respondents are not aware of past university efforts to conserve energy; among those who are aware, many felt that university efforts are inadequate. The observations and self-reports reveal an abundance of energy-consuming equipment in offices, and lights and computers are often left on when work spaces and conference rooms are unoccupied. Finally, most occupants are willing to accept higher building temperatures during warm weather months and lower temperatures during cold weather months.

There has been limited work in institutional settings that considers occupant behaviour as a factor in designing programs to conserve energy. The research uses a multi-method approach to understand what people do with energy use and conservation. Additionally, the research is aimed at sensitizing behaviours of occupants KP buildings. These programs have been implemented in the five pilot buildings; plans are underway to enhance the effectiveness of the programs

Keywords: Energy; Conservation; Behavioural; Kumasi polytechnic(KP), Planet blue

I. Introduction

Polytechnics and other tertiary institutions throughout the world are faced with rising utility costs that are increasing much faster than the rate of inflation. Many colleges and universities are bolstering their efforts to contain utility costs, and are developing new “sustainability” programs to address the burden of their escalating energy expenses (Hignite, 2008). For many, the goals of these institutions are to contain utility costs and reduce their environmental footprint (Rappaport, 2008; Parker, 2007). For example, over six hundred US college and university presidents have signed on to the “President’s Climate Commitment” (ACUPCC) since it was introduced in 2006 (www.presidentsclimatecommitment.org). In Ghana, the growing energy budgets and the scarcity of electricity power are forcing universities and Polytechnics leaders to make critical decisions that have long-term implications. Kumasi Polytechnic (KP) the leading polytechnic in Ghana now has taken some decisions and measures to maintain its standard. Options include cutbacks in building maintenance, curtailing the building of new classrooms, laboratories, and libraries, updating older facilities, reductions in faculty and staff salaries, higher student fees, and reduced student financial assistance. Other current approaches to controlling utility expenses include building new structures that conform to leadership in energy and environmental design (LEED) standards, establishing programs that reduce transportation costs, and promoting energy conservation. These critical choices have implications for the quality of higher education and ultimately on a country’s intellectual capital and long-term growth.

General Objective

This paper describes a pilot study conducted in 2011 by the department of Electrical/Electronic Engineering (EEE) of Kumasi Polytechnic’s Institute for Social Research (ISR) on energy under the Faculty of Engineering (FoE) in order to gain a better understanding of energy conservation-related attitudes and beliefs among faculty, staff, and students. When Ghana began experiencing load shedding as a result of power shortage, KP decided to purchase a power plant as an alternative power supply for the School. The costs of operating the internal power plant as compared to the national grid is very expensive, hence the need to conserve electrical energy at KP.

The paper discusses the broader institutional context of the study, explains the multiple methodologies used to gather information, and presents key findings. Besides, gaining insights about what occupants know, what they do with respect to energy use, and their views about the work environment, energy conservation, and sustainability, the pilot study was also intended to test measurement procedures that could apply to other KP buildings and their occupants and to buildings at other Polytechnics. Next, the paper outlines a series of

recommendations emanating from the findings. The paper then discusses how the recommendations of the ISR study have been implemented within a new energy conservation initiative at KP, known as KP load shedding. Finally, the paper describes efforts to launch the Planet Blue initiative throughout the KP campus.

Background of the KP

Kumasi Polytechnic is one of the famous, elegant and vibrant Polytechnics in Ghana. It is a spectacularly beautiful institution, which is located at the heart of the Garden city of West Africa, the capital city of the Ashanti Region of Ghana (Kumasi).

The Polytechnic, known earlier as Kumasi Technical Institute, was established in 1954, but started actual teaching and learning in 1955, dealing mainly with craft courses. It became a Polytechnic on 30th October, 1963 and from then on concentrated on Technician and a few Diploma Programs. Additionally, a few professional courses were offered. Following the enactment of the Polytechnic Law 1992, PNDC Law 321, Kumasi Polytechnic ceased to exist in its previous form and became a tertiary institution.

The Kumasi polytechnic has since 1993, come a long way to make its mark in the country as a strong and creditable tertiary institution. It has been making steady strides in its quest to fulfill its mandate of training the critical manpower needed for commerce and industry in Ghana. It has expanded from three Faculties and one Centre in 2009/2010 to six Faculties, one school and two Institutes in the 2010/2011 academic year

The institution is presently developing and strengthening its HND programs into degree programs in anticipation of its conversion to Technical University (TU). It is, therefore, training high caliber personnel in science and technology to equip them with entrepreneurial skills to meet the demands of industry in particular, and to also improve the general socio-economic development of the country.

The rapid growth of KP coupled with current energy challenges facing the nation has caused energy challenge on campus and residential facilities, hence the need to conserve electrical energy at KP. Consequently, a pilot study was planned to examine the behavioral aspects of energy use among faculty, staff, and students in five KP buildings. It was anticipated that this study could help the Polytechnic administrators establish more effective policies and programs by shedding light on the energy consuming practices and attitudes on campus. At the same time, the study would help evaluate the effectiveness of earlier initiatives aimed at energy reduction.

II. Purpose of the pilot study

The pilot study was designed to accomplish several things, within the context of providing guidance in designing a new, behavior-centric energy conservation program at the KP. **First**, the study aimed at measuring the extent to which faculty, students, and staff differed in their behaviors and attitudes about energy conservation.

Second, it intended to assess the impacts and effectiveness of past efforts in dealing with the behaviors of students, faculty, and staff in the five buildings. That is, how effective were the Polytechnic's past energy reduction efforts?

Third, it sought to gather information about:

- the energy use by building occupants;
- their thoughts about and understanding of energy conservation; and
- what they would be willing to do to conserve energy.

Fourth, it was designed to test methods and procedures for identifying peoples' behaviors and thoughts vis-a-vis energy consumption and conservation in the workplace.

Finally, findings from the pilot study were intended to guide Polytechnic officials in developing and testing procedures for engendering energy-reduction behaviors throughout the Polytechnic community.

Building selection

In order to obtain a representative sample of the large campus, the pilot study was carried out in five buildings that were selected by Polytechnic officials to represent different functions associated with the Polytechnic. While offices and conference/meeting rooms were common to each of the five buildings, only two buildings contained lecture rooms and laboratories (IDCE and BTech buildings), one is an administrative office building and Library and the other two were research office building and laboratories.

III. Study Design

A multi-method approach to gathering information was utilized to achieve the above objectives. The first three information gathering methods (i.e. key informant interviews, focus groups and behavioral observations) were used to enable the researchers to formulate hypotheses, which were then tested through web-based surveys for faculty, staff, and students.

Key informant interviews

The pilot study began with a series of interviews with individuals who were knowledgeable about energy issues including the role of energy in the design and operations of buildings. These key informants included

Polytechnic researchers from engineering, architecture, Quality Assurance Directorate, and the computer sciences, plant operations personnel and facility managers responsible for university buildings, LEED certified architects in private practice, and the energy coordinator for the city of Kumasi.

Focus groups

Insights gained from key informants were used to formulate topics and specific questions to be addressed in the focus group sessions. Within each of the five pilot buildings, separate focus groups were conducted with faculty, staff, and students. An additional focus group was conducted with facility managers from the five pilot buildings and other Polytechnic buildings. Behavioural observations and environmental measurement. The key informant interviews also helped in identifying environmental conditions to be measured and the behaviours of occupants to be observed. The measures and observations were made during working hours in three types of spaces in each pilot building: offices and workstations (five buildings), classrooms, meeting rooms, and conference rooms (five buildings), and laboratories (two buildings)[1]. Because of the large number of such spaces in each building, a probability sample of spaces was chosen where measurements and observations would take place. Within the sampled workplaces, relative humidity, and light levels were taken and an inventory of electrical equipment was recorded. When the sampled workplaces were unoccupied, operating electrical equipment and use of lights were noted. Similar measures and observations were made in classrooms-meeting rooms and in laboratories.

Occupant surveys

Insights from the focus groups, key informant interviews, and observations were used to design two questionnaires – one for faculty and staff and one for students in the two buildings containing classrooms and laboratories [2]. Five thematic areas were covered in the questionnaires:

- (1) What do people know and understand about energy conservation in general and at the KP?
- (2) What do people think about energy conservation in general and at the KP?
- (3) What electrical equipment and appliances do people have in the workplace?
- (4) What energy conserving practices do people engage in at home and at KP?
- (5) What might motivate people to conserve energy at the KP?

Using addresses of faculty and staff personnel in each building and addresses of the selected students, building occupants were contacted and asked to complete a questionnaire that was distributed. In order to insure a reasonably high response rate, incentives or token gifts were offered [3]. Overall, 3,248 faculty, staff and students in the five buildings were contacted; 1,473 completed a questionnaire.

Most likely to respond were the staff (88.4 percent) while students were least likely to respond (34.8 percent). The response rate for faculty members was 78.5 percent. These figures are represented in Table I.

IV. Findings

The voluminous data collected from the focus groups, observations, and surveys were synthesized and analyzed to show differences and similarities among faculty, staff, and students and among the five pilot buildings. These findings are reported in Marans and Scott, 2007[4].

For this paper, a selected number of findings are presented. They deal with:

- people's understanding and assessment of KP energy conservation efforts including its poster campaign and the annual Energy Fest;
- the amount of energy-consuming equipment in offices;
- people's behaviors with respect to computer use and lighting; and
- people's willingness to change their behaviors in order to reduce energy use.

Table 1 Web survey response rate by buildings

Building	Administration Block	IDCE Block	BTech Block	Staff Flats	Central Lab.	Total
Occupants contacted	336	67	2450	206	159	
Completed questionnaires	285	56	909	119	104	
Total Completed	1473					1473
Faculty %	63.1	60.0	59.6	75.6	-	
Staff %	89.9	87.7	85.4	87.8	-	
Combined %	79.4	83.6	73.9	81.7	65	
Students %	-	-	34.5	41.5	-	

Understanding and assessing past KP energy conservation efforts

A significant proportion of faculty, staff, and students in the five buildings said they were unaware of KP efforts to reduce utility costs on campus and in their building. Similarly, they were unaware of the role played by KP's

leadership in the area of energy conservation. When asked to rate KP's efforts and the efforts made in their building to reduce utility costs, a third of the faculty said "don't know" to each question. About one in three staff members were also unaware of KP's cost reduction efforts and one in five were unaware of efforts in their particular building. Similarly, a third of the students said "don't know" when asked to rate KP's reduction efforts and 43 percent said "don't know" when asked about efforts in their department. Of the faculty and staff who rated

KP in its efforts to reduce utility costs, about six in ten said "fair" or "poor". More than half of the faculty (55 percent) and half of the staff gave similar ratings to efforts in their building (Figure 1). Ratings were similar among students, irrespective of how long they attended KP.

Half said the polytechnic's efforts to reduce energy costs on campus were "fair" or "poor" and more than half (55 percent) who rated utility reduction efforts in their department gave them "poor" or "fair" marks.

Responses to the energy posters in KP's buildings were also revealing. Half of the faculty and a quarter of the staff said they were unaware of them. Students were equally unaware of the posters.

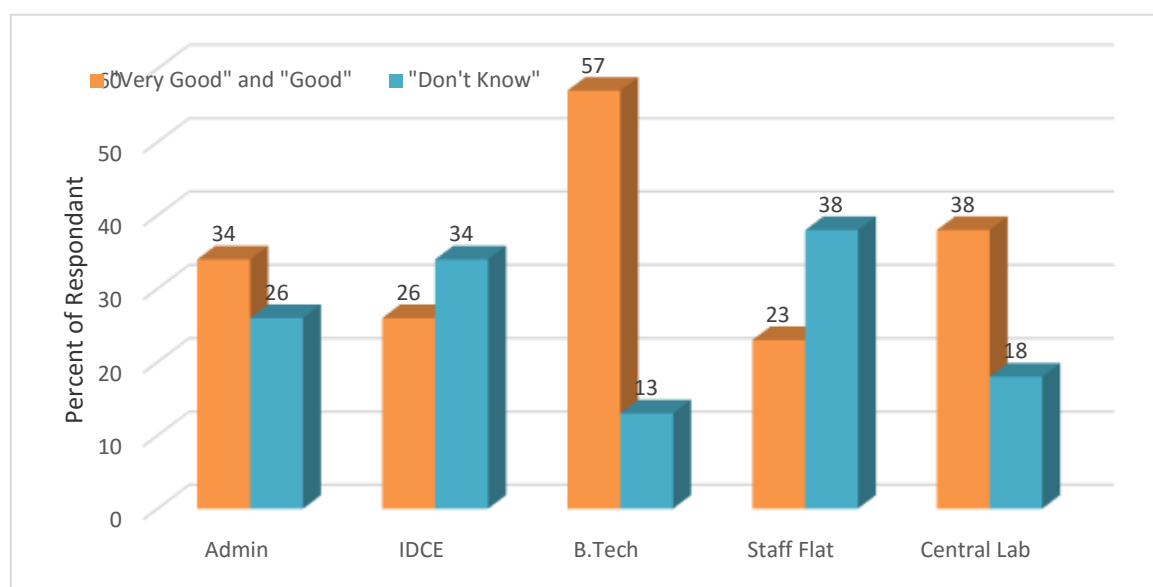


Figure 1. Ratings of KP conservation effort by building in Percentages

Behavior with computers and lighting

More than four in ten faculty and staff members (46 percent) said they do not turn off overhead lights when leaving their office during the day. The same proportion having supplemental lighting said they never turn off their task lights when leaving the office and less than a third (31 percent) said they "always" turn off their task lights.

However, most participants (94 percent) said they turn off their lights when they are the last person to leave the office at the end of the day. When unoccupied offices and work stations having supplemental lighting were visited, these light were on in 17 percent of them. For faculty and staff using classrooms or conference rooms and who were the last to leave the room, 70 percent said they "always" turn off lights when leaving and 4 percent said they "never" turn off the lights. Among students who said they were the last to leave a classroom, a third "always" turned off the lights and one-fourth said they "never" turned off lights. More than four in ten faculty and staff members (44 percent) said they "always" turn off their main computer when leaving the office at the end of the day; a third (36 percent) said they "never" turn off their computer. During the workday, two-thirds of the faculty and staff said they never turn off the computer when leaving the room whereas 8 percent said they "always" turn it off. Behavioral observations revealed that computers indeed remained on when no one was at the work station. Of the 191 unoccupied work stations observed, the computer was on in half of them. A quarter of the building occupants said they regularly access their office computers from home or while traveling. Willingness to change behavior Faculty members, staff, and students were willing to accept physical changes to their buildings and to alter their behaviors in order to reduce building energy costs and carbon emissions. This was reflected in responses to several questions. Corridor lighting. Nearly, nine in ten from the faculty-staff group said they had be "very willing" or "somewhat willing" to work in buildings where corridor lights only go on when someone enters the space. Respondents who were "very willing" outnumbered those who were "somewhat willing" by three to one (65 percent versus 23 percent). Students were equally willing (88 percent) to work or study in buildings where corridor lighting was activated by the presence of someone in the space.

Acceptance of less comfortable working conditions

When asked if they would accept less comfortable office temperatures under various scenarios, the most positive responses were associated with energy cost savings being returned to their department (72 percent). About half would accept less comfortable temperatures if it resulted in reduced burning of fossil fuels and if they received regular updates on energy savings. Students were also amenable to less comfortable temperatures. When asked if they would accept less comfortable classroom temperatures, two-thirds said they would do so if it resulted in reduced burning of fossil fuels and nearly half (46 percent) said they would do so if they received regular updates on energy savings. When asked if they would accept less comfortable classroom temperatures if energy cost savings were returned to their department, half responded affirmatively. Students were most likely to say they would accept less comfortable classroom temperatures if the savings resulted in reduced tuition increases (Figure 3).

V. Discussion

These findings (and others) were summarized into policy recommendations for a new energy conservation program that would incorporate occupant behavior into its mission. These recommendations were organized under five categories:

- (1) leadership;
- (2) better and clearer information;
- (3) motivating more appropriate behaviors;
- (4) changing existing buildings; and
- (5) guidelines for new buildings.

Leadership

It was recommended that UM launch a publicity campaign letting faculty, students, and staff know of its concerted efforts to reduce energy consumption in buildings (and in transportation). Furthermore, the publicity campaign needed the endorsement of the Polytechnic's Rector. An important part of the campaign should be establishing clear energy reduction targets, a program for the action steps to be taken, and a plan for monitoring progress toward the established goals.

Better and clearer information

Findings revealed that many occupants of the five pilot buildings were unaware of KP's energy reduction efforts. The practice of distributing posters to facility managers in each building and asking them to display them was inadequate. Nor had it been effective to have one brief Energy Fest event at the beginning of the academic year. Regarding posters, it was recommended that guidelines should be developed as to where and how posters should be displayed within buildings. Putting them on bulletin boards where there is competition with other messages does not draw attention. Nor should they be placed in those parts of buildings which are infrequently visited by building occupants. Posters should be located at key locations within buildings such as at entrances, elevators, and common spaces (faculty, staff, student lounges, etc.). "Simplify the posters" was the overwhelming message conveyed in the focus group sessions. Other factors to consider when designing posters are:

- show a connection between desirable behaviors (i.e. turn off lights) and the resulting benefits (i.e. saving utility costs, reducing CO₂ emissions);
- develop and publicize a memorable slogan such as those used in other successful marketing campaigns (i.e. "take nothing but pictures, leave nothing but footprints", "a mind is a terrible thing to waste"); and
- messages should be direct and convey the behavior that is desired (i.e. "turn off your lights", "help us save energy").

Motivating more appropriate behaviors

Based on survey results, focus group comments, and discussions with psychologists and marketing experts, several recommendations were offered. Among them were the following:

- Develop mechanisms for providing feedback on energy savings to individual and administrative and academic units as a way of encouraging on-going appropriate behaviors.
- Within each building and/or academic/administrative unit, create a program of incentives/rewards that would encourage appropriate behaviors among individuals.
- Actively engage faculty and staff within each academic/administrative unit to participate in local decision-making re: energy conservation practices.

Changing existing buildings

The majority of occupants in the five pilot buildings indicated a willingness to accept temperatures that were lower in the winter and higher in the summer and to accommodate these changes by altering their mode of dress (heavier or lighter clothing).

However, there was a significant minority who were unwilling to do so. If building temperatures are changed throughout the year as a means of reducing energy costs, the concerns of faculty, staff, and students who would be unhappy by this action need to be addressed. Programs should be developed at the university level and within buildings and/or academic units that:

- explain the rationale for making temperature adjustments;
- learn more about the objections of individuals unwilling to alter their mode of dress; and
- explore a range of incentives that might minimize resistance to temperature changes.

Another recommendation dealt with changes from incandescent to fluorescent bulbs in desk lamps. Within the five pilot buildings, nearly half of the work stations had a desk lamp or other type of supplemental lighting. Most of these had incandescent bulbs and one in five was on when the work station was unoccupied.

Guidelines for new buildings

Data from the pilot study showed strong relationships between people's ability to control the electrical energy, their satisfaction with temperatures in the workplace, and the extent to which adverse conditions impacted worker productivity. That is, individuals who were unable to control temperatures at their workplace were more likely to express dissatisfaction with temperatures during warm and cold weather months. And the greater the dissatisfaction with ambient conditions, the more likely it was that people said that adverse conditions impacted their productivity and absenteeism. A key recommendation emerging from this finding suggested that in the design of new buildings, efforts should be made to optimize opportunities for providing environmental controls for each individual at his/her work station. The rationale for this is that initial costs of individualized thermostats and light switches could be offset

by reduced productivity loss and reduced worker absenteeism.

VI. Conclusion

The findings and recommendations resulting from the ISR study were utilized to help design a campus-wide energy conservation program called Planet Blue. This program was implemented during 2014 in the same five buildings that were studied. At the same time, Polytechnic administrators set a goal of expanding the Planet Blue program to 32 additional buildings over three years. Preliminary data indicate that energy use in the pilot buildings has diminished over

the past year. Whether these reductions in energy use are the result of behavioral changes, systems improvements, or variations in climate has yet to be determined. In order to answer these questions, research aimed at evaluating Planet Blue is being contemplated. The pilot study and the implementation of its recommendations in Planet Blue have led to a more comprehensive conceptualization of how attitudes may affect energy conservation behaviour at a large institution – such as how viewpoints about global warming may impact the energy-conservation behavioral intent among faculty, staff, and students (Edelstein and Marans, 2009). The approach used in the ISR pilot study can serve as a model for introducing behavioral research into energy reducing efforts of other universities and large organizations.

VI. References

- [1] Coltrane, S., Dane, A. and Elliot, A. (1986), "The social-psychological foundations of successful energy conservation programmes", *Energy Policy*, Vol. 12 No. 2, pp. 133-49.
- [2] DeCarolis, J.F. and Goble, R.L. (2000), "Searching for energy efficiency on campus: Clark University's 30 year quest", *Environment*, Vol. 42 No. 4, pp. 8-20.
- [3] De Young, R. (1993), "Changing behavior and making it stick: the conceptualization and management of conservation behavior", *Environment & Behavior*, Vol. 25 No. 4, pp. 485-505.
- [4] Edelstein, J.Y. and Marans, R.W. (2009), "Impact of climate change concerns on energy-conservation behavioral intent among faculty, staff, and students", unpublished manuscript.
- [5] Gardner, G.T. and Stern, P.C. (2008), "The short list: the most effective actions US households can take to curb climate change", *Environment*, Vol. 50 No. 5, pp. 12-24.
- [6] Hignite, K. (2008), "Seeking a smaller footprint", *Business Officer*, Vol. 42, pp. 63-72.
- [7] Levy, J.I. (2000), "Economic incentives for sustainable resource consumption at a large university: past performance and future considerations", *International Journal of Sustainability in Higher Education*, Vol. 1 No. 3, pp. 252-66.
- [8] McKenzie-Mohr, D., Nemiroff, L.S. and Beers, L. (1995), "Determinants of responsible environmental behavior", *The Journal of Social Issues*, Vol. 51 No. 4, pp. 139-57.
- [9] McMakin, A.H., Malone, E.L. and Lundgren, R.E. (2002), "Motivating residents to conserve energy without financial incentives", *Environment & Behavior*, Vol. 34 No. 6, pp. 848-63.
- [10] Marans, R. and Scott, L. (2007), "Overview of findings: results from a UM pilot study on the behavioral aspects of energy conservation in buildings", available at: www.isr.umich.edu/energypilot
- [11] Marcell, K., Agyeman, J. and Rappaport, A. (2004), "Cooling the campus: experiences from a pilot study to reduce electricity use at Tufts University, USA, using social marketing methods", *International Journal of Sustainability in Higher Education*, Vol. 5 No. 2, pp. 169-89.
- [12] Parker, A. (2007), "Creating a 'green' campus", *Bioscience*, Vol. 57 No. 4, p. 321.
- [13] Peterson, J.E., Shunturov, V., Janda, K., Platt, G. and Weinberger, K. (2007), "Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives", *International Journal of Sustainability in Higher Education*, Vol. 8 No. 1, pp. 16-33.

- [15] Rappaport, A. (2008), "Campus greening: behind the headlines", *Environment*, Vol. 50 No. 1, pp. 7-16.
- [16] Scherbaum, C.A., Popovich, P.M. and Finlinson, S. (2008), "Exploring individual-level factors related to employee energy-conservation behavior at work", *Journal of Applied Social Psychology*, Vol. 38 No. 3, pp. 818-35.
- [17] Shriberg, M. (2002), "Institutional assessment tools for sustainability in higher education", *International Journal of Sustainability in Higher Education*, Vol. 3 No. 3, pp. 254-70.
- [18] Siero, S., Bakker, A., Dekker, G. and van den Burg, M. (1996), "Changing organizational energy consumption behavior through comparative feedback", *Journal of Environmental Psychology*, Vol. 16, pp. 235-46.