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Occupant Behaviour and Energy Consumption in Secondary Schools

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During the period following the 1972-73 fuel crisis great advances have been made in the development of energy conserving technology. The energy management of both private households and large public and private institutions has been greatly advanced by recent technical aids to the monitoring and conservation of all forms of energy. The stage has now been reached, however, where future improvements in energy management need to take into account the attributes and abilities of the energy user in order to further extend the progress made so far. The uses made of the more recent advances developed, have become a crucial factor in their success or failure.

The attitudes of scientists and practitioners in the energy field to the energy user is gradually changing. From being regarded as an "ignorant, forgetful and perverse" (i) force confounding serious attempts at energy conservation, the user is now more than ever being regarded as a rational actor within his or her environment, with the power to produce far greater savings in energy than afforded by the implementation of technical measures alone. For example, The Audit Commission for Local Authorities in England and Wales, in its report "Saving Energy in Local Government Buildings" (1985) stated on page 34:-

Local authorities frequently find that savings achieved after the installation of technical measures exceed the theoretical estimate, largely because the building users have also been stimulated to better housekeeping.

The report goes further to state that "half the available savings opportunities" fall into this category of "good housekeeping". It is this half of the available "opportunities" that the present study is ultimately attempting to tap. By a systematic analysis of the activities of the occupants of two British secondary schools, one of relatively high and one of relatively low consumption, it is hoped to identify those activities that represent good housekeeping and the factors that influence these activities.

Hanham High School and St. Katherine's School, both secondary schools situated in the Bristol area of England, combine a high degree of physical similarity to each other with a great difference in the amount of energy they each consume. Both schools were selected from all 39 'E3' schools (secondary schools without indoor swimming pools) in Avon county, based on similarity in terms of construction, heating systems, floorspace and hours of use per year, and dissimilarity in terms of energy performance. Both schools were constructed according to the same design guidelines in 1975, both are used for the same number of hours per year (2,200), have identical heating systems and similar floorspace (Hanham floorspace is 5,824 m^2 and St. Katherine's floorspace is 5,592 m^2.

Energy performance was measured according to general guidelines (2) using a Normalised Performance Indicator (N.P.I.) based on kiloWatt hours per metres squared of floorspace per annum (kWh/m^2 per annum), normalised for regional weather conditions, hours of use and exposure.

The metered energy (electricity and gas) consumptions of Hanham and St Katherine's for the year 1985-86 were 212.33 kWh/m² and 298.36 kWh/m² respectively. This indicates that St Katherine's energy consumption is some 40.51% higher than Hanham. An analysis of figures for past years reveals that this figure also indicates an upward trend in the difference from 29.5% in 1981-82 (when the respective consumption levels were 216.61 kW/m² and 280.53 kWh/m²).

When consumption figures are each corrected for regional weather differences (degree day factor = 0.99 for both schools), hours of normal use and exposure, they produce N.P.I. values of 175 for Hanham and 228 for St. Katherine's which still indicate an unexplained difference of 30.29% between the two schools. As there was no recorded difference in the hours of extra-mural use between the schools, it was concluded that such a large difference was due to the patterns of energy use in each school and the actions of their occupants in terms of energy consumption.

An initial study in two parts was initiated to comply with a research brief set by Avon County Council as joint sponsor of the project. This brief can be summarised into three research objectives:

i) to determine whether particular occupants are more important than others in terms of energy management.

ii) to qualitatively scale 'occupant influence' with respect to building fabric, controls and services.

iii to provide information for an occupant-related energy policy for secondary schools.

The first part of the study took the form of electronic monitoring of air temperatures and the opening and closing of doors and windows in selected classrooms in each school. The second part consisted of administering detailed questionnaires examining each respondent's attitudes, knowledge and activities as related to energy issues in general and his/her role in the school organisation in particular. Besides being energy efficient, it is desirable for schools to be satisfactory from the human comfort point of view. Thermal comfort standards were therefore assessed according to I.5.0 Standard 7730 based on the work of Fanger (6).

The monitoring data collected from corresponding rooms in each school (language laboratories, maths rooms, science rooms, etc) was analysed for any difference between schools or rooms using two-way analyses of variance. Initial t-tests of the ceiling height and head height air temperatures revealed no significant difference between the two schools during the day.*

This and subsequent references to 'day' refer to the normal working school day from approximately 0840 to 1730, Monday to Friday.

There were no significant main or interaction effects of school or room on either the number of times any door or window was opened during the day, or the percentage of time any door or window was left open during the day. There was, however, a slight, non-significant effect of school ($F = 3.117$, $df = 1$, $p = 0.08$) and a significant interaction effect of school x room ($F = 2.963$; $df = 1$; $p = 0.01$) on the total time any door or window was left open in minutes.* For example, windows and doors were left open longer in the Hanham School maths room than the St Katherine's School maths room but this situation was reversed for the two language laboratories.

This seems to indicate that occupants of St. Katherine's may be leaving windows and doors of certain rooms open over night, more so than occupants of Hanham. This may explain the slightly lower night time temperatures recorded in St. Katherine's but is unlikely to account for the difference in energy consumption on its own.

These results suggest that there is very little difference between the ways in which doors and windows are operated in the two schools although what difference there is could have an effect on energy consumption if it was sufficiently consistent and widespread. It must also be remembered that such obtrusive assessment of behaviour may produce Hawthorne effects in the activities of teachers and pupils, although an attempt was made to reduce this by having extensive lead-in periods where equipment was left assembled in the classrooms two weeks before monitoring began.

In terms of comfort, St. Katherine's school rooms were generally reported as more comfortable than those at Hanham ($t = 2.16$; $\alpha = 0.042$). This may indicate a more complex difference between the populations than simple behavioural variation, given that there were no differences between the temperatures of the rooms in each school.

It seems likely that the source of the difference between the two schools lay in the whole pattern of how each building and its resources are used rather than differential responses to discomfort. In terms of energy use it is far more profitable to view a school as being occupied by a single organisation rather than a collection of individual people or groups. In this way it is not only possible to study the activities of the people and groups within the organisation but also to build up a picture of the interrelationships between these people and groups. the extent and effectiveness of communication between the parts of the organisation and the relative 'influence' of this communication on the organisation's activities as a whole will play an important part in determining how that organisation utilises energy.

In the light of results brought out in the first half of the study, the questionnaire information was analysed in order to identify more complex energy-related activities and the social and organisational factors that

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influence these activities. As the questionnaires were role group specific, they will be discussed in terms of the relationship between two or more role groups.

Teachers, pupils and caretakers

In response to the question "If you were feeling too warm in a room at school what would you do?", the majority of pupils asked (Hanham pupils = 73.3%. St. Katherine's pupils = 35%) indicated that they would "complain to a member of staff" and according to subsequent responses, the majority of these (Hanham pupils 75%, St. Katherine's pupils 78.3%) would complain to the class teacher. This would have the effect of moving the responsibility of when and how to respond to unsatisfactory conditions up from the pupils to the teacher. From the responses of teachers to the same question, it is possible to list a repertoire of probable actions that may be taken by a teacher in these circumstances.

Open windows	(95.34%)
Adjust Thermostat	(51.62%)
Open Doors	(41.86%)
Complain	(37.21%)
Tell Caretaker	(32.55%)

The first and third most popular actions have already been examined for their effects in the first half of the study and the second most popular action tends to contradict subsequent teacher responses because only eight teachers reported ever having adjusted a thermostat. It must also be remembered that these actions refer to responses to personal discomfort and not to the reported discomfort of others. Teachers may utilise a different repertoire of actions when responding to complaints from pupils. Complaint may lead to further complaint.

If we therefore concentrate on the last two most popular actions, complaining and telling the caretaker, we find that these are highly related. The majority of teachers (60.47%) report that they would complain directly to the caretaker (followed by the Bursar (25.58%). In terms of the school organisation this is important. Since informal complaints tend to be communicated horizontally, from teacher to caretaker, rather than vertically, from teacher to headmaster, this may reveal a deficit in communication between the headmaster and other occupants of the school. This is further highlighted when the same information is broken down by school. Not only is it the case that only two people from each school reported ever having complained directly to the headmaster but nearly twice as many teachers at St. Katherine's reported complaining to the caretaker than teachers at Hanham (78.5% as opposed to 42.1%).

The latter represents an important difference between the two school organisations. Although more people said they had complained at Hanham (47.6%) than at St Katherine's (38.1%), these complaints tended to be directed to a wider range of people and organisations. The occupants of Hanham reported complaining to the local Council and the Health and

Safety Officer as well as to people within their particular school. The effects of these complaints on the actions of any particular member of the school organisation is lessened somewhat by the absence of any cumulative support. The complaints of occupants of St. Katherine's, however, by being principally directed to the caretaker, are likely to have a marked effect on his actions by virtue of their cumulative weight.

Caretakers and headmasters

It is interesting to note that the Hanham School caretaking staff seem less responsive to complaints than their St. Katherine's School colleagues in any situation. Only 10% of Hanham teachers reported getting a quick response (less than 1 minute) to their last complaint as opposed to 30% of the teachers at St. Katherine's. Similarly, 60% of Hanham teachers reported getting a slow response (greater than 1 day) to their last complaint as opposed to 40% of St. Katherine's teachers. Furthermore, in answer to the question "If you receive complaints from teachers that the school is too cold, what do you do to alter the temperature"?, the Hanham caretaker replied that he "cannot physically do anything" whereas the St. Katherine's caretaker listed "check boilers ... adjust the valves ... check thermostats". These answers are mediated, however by those of the two assistant caretakers to the same question. The Hanham assistant caretaker answered similarly to the St Katherine's caretaker whereas the assistant caretaker at St. Katherine's replied "leave it to them".

Although the caretaker at Hanham maintained that teachers, pupils, office staff and the assistant caretaker all altered room thermostats as well as himself, his assistant refuted this by pointing out that the securing screws on most thermostats had been replaced with Allen screws, making it impossible for any one to alter the settings without the necessary equipment. The caretaker at St. Katherine's maintained that no one but himself ever altered the heating controls, including the E.M.S. settings, whereas the caretaker at Hanham reported that the headmaster regularly alters the E.M.S. settings.

This is supported by information given by both headmasters. The headmaster of Hanham reported having turned down room thermostats and altered lunch-time E.M.S. settings, whereas the headmaster of St Katherine's insisted that he never interfered with any of the heating controls.

Both headmasters named their respective caretakers as key people in the schools' energy management and both reported having "influenced" the settings on heating controls made by the caretakers. This influence seems to have been by way of informal "suggestions" and discussion in the case of St Katherine's headmaster but more direct in the case of the headmaster of St. Katherine's (e.g. asking for heating to be switched off, complaining of being too hot, etc.)

Discussion

It is important to remember that the present paper is a report on work-in-progress and as such is lacking in a complete analysis of the data so far collected. For example, other important occupant role groups in the school organisation, such as catering and clerical staff, have not yet been integrated into our analysis. No doubt their influences on the functioning of the school organisation represents an important factor in the way it consumes resources such as energy. Furthermore, the data utilised by this analysis was not collected with the aim of providing complex relational information but rather to provide information on the activities of specific occupant role groups.

Nevertheless, with the information already available to us, we are able to present a number of interesting, if tentative, conclusions concerning the consumption of energy by secondary schools.

Firstly, it seems likely that a crucial factor involved in how energy is used in such schools is the communication on information within the school organisation concerning the functioning of its physical services. If one views complaint as negative feed-back on the performance of services, then their directions within the organisation and the responses made to them become vital in terms of energy conservation.

If complaints are conveyed horizontally within the organisation, as in the case of St. Katherine's School, and are then responded to at this level, there may be a risk of over-reaction and a decision based solely on the feedback from classrooms without any mediative input from administrative levels. Conversely, if complaints are conveyed to a more diffused range of people and organisations, as in the case of Hanham High School, then the effectiveness of complaint as an active feed-back mechanism is lost. Complaints to bodies outside the immediate school organisation further exacerbate this loss.

These communication networks can be two-directional however, and the "influence" of those at higher levels of the organisation on the energy consuming activities of those at the lower levels must also play a vital part in the ways in which the organisation as a whole consumes energy. As the main administrative decision-maker in the school organisation, the headmaster should not only play an active role in responding to complaint, but should also be sufficiently motivated to exert a 'conservationist' influence on the activities of those below him.

A deeper, systemic analysis of the dynamics of school organisations seems a profitable way forward in an attempt to understand their use of energy. For example, future studies could examine the co-orientation between the different occupant role groups rather than their specific energy-related activities. This would allow a deeper understanding of the school's social system and the way each role group interacts within this system; so providing insights into the school's use of energy as a whole.

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Glossary of Statistical Terms

t-test: Several widely used hypothesis testing procedures, the relevant procedure used in the above examines the null hypothesis that the means of two populations are equal to each other.

Analysis of Variance (ANOVA): An inferential statistical procedure used to test the null hypothesis that the means of three or more populations are equal to each other.

α: Also called the "alpha level" or "level of significance" of an hypothesis test. It is the probability of rejecting a true null hypothesis.

p: is used to denote this probability in analyses of variance.

df: The degrees of freedom of a population, usually N-1.

F: The value calculated by ANOVA to indicate the validity of a null hypothesis.