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AN ASSESSMENT OF MOTIVATION AND METHODS UNDERLYING ENERGY MANAGEMENT IN 22 COMMERCIAL BUILDINGS

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Introduction

During the last decade, the Energy Research Group at the Victoria University of Wellington School of Architecture has been investigating the energy consumption of the 1100 commercial buildings in the Wellington Central Business District (CBD) via a series of projects (1, 2, 3, 4). The results from one such project (2) indicated that significant reductions in energy consumption had occurred in a number of buildings. Interest was thus aroused in discovering the reasons for these reductions, the methods used to achieve them and whether they had been sustained; with a view to improving the energy (management) performance of commercial buildings in New Zealand.

Methodology

Buildings that achieved at least a 15% reduction in their overall energy consumption between 1977 and 1980 were identified, and it was decided to concentrate on the bigger energy consumers rather than look at a large number of smaller consumers, as the former dominate the energy use of the CBD (20% of the buildings use nearly 80% of the energy consumed). The final sample of twenty-two comprised those buildings which initially used over 600 GJ/year, which achieved energy reductions of at least 15%, and for which a reasonably complete set of reliable data was available.

Having selected the group of twenty-two buildings, a two stage survey was conducted. The first stage involved visiting each building to ascertain its basic physical features, the types of energy consuming services installed, the nature and timing of any modifications during the 1977-1982 period, and the type and duration of occupancy of the building. In addition, the manager of each building was interviewed to obtain information on any energy conservation measures that had been carried out and to gain some understanding of the decision making processes involved. Notes on the results of this first stage were prepared, which included a summary of annual metered energy consumption and costs.

The second stage of the survey involved contacting the building managers to confirm that the data and notes were a correct interpretation of events during the 1977-1982 period and to probe further into the methods by which reductions in energy use and/or costs had been achieved, and the motivation behind them. In other words, to investigate the management processes involved in any decisions related to energy consumption and conservation.

Classification of Energy Management Processes

In terms of the energy management processes involved in these buildings, two main categories emerged, each of which was divisible into two levels. The first category was the ENERGY MANAGEMENT DECISION LEVEL which was divided into TOP MANAGEMENT and MIDDLE MANAGEMENT decision levels. The 'absolute' level of top management varied from building to building, but analysis indicated top management involvement with the energy management decision making processes of thirteen of the buildings. Middle management decisions had been involved in six of the buildings with top management being unaware, disinterested, unsupportive or otherwise not directly involved. In the remaining three buildings the reductions were not due to energy management initiatives of top or middle management, but changes in building use - they will not be considered further in this paper.

The second category involved the DIVISION OF RESPONSIBILITY FOR ENERGY COSTS, split here into SINGLE RESPONSIBILITY and DIVIDED RESPONSIBILITY. Single responsibility implied that a single organisation paid directly for ALL THE ENERGY consumed in the building. Ten of the buildings fell under this heading and these included offices, hotels and retail premises. Divided responsibility was where one organisation paid directly for CENTRAL BUILDING SERVICES, while another (or others) paid directly for TENANT SERVICES. Nine of the twenty-two buildings came under this heading, with responsibility for energy consumption divided between central and tenant services. The proportion of energy costs attributable to tenant services ranged from 16% to 62% of the whole building costs and averaged around 40%.

The overall classification of the 19 buildings is presented in Table 1. While the number of buildings in each group is relatively small and one should not read too much significance into the percentage savings, some interesting trends are indicated by the figures.

It will be seen that the average percentage cost saving for all 19 buildings is just over 20%, and this did not seem to vary significantly with level of management or division of responsibility. However, in buildings with divided responsibilities, it was found that the cost of tenant services had increased by one-third, no matter the energy management decision level. In the case of the central services, on the other hand, average cost savings of 47.2% were found for the six buildings where top management decisions were involved, and 25.1% savings for those three with middle management involvement only. In other words, where the metering was such as to allow the separation of central and tenant services, the impact of energy management by the building owner is clearly revealed.

Having classified the buildings from an energy management point of view and given an overview of the savings achieved between 1977 and 1982, each of the groups will now be examined in more detail.

ENERGY MANAGEMENT DECISION LEVEL	RESPONSIBILITY FOR ENERGY CONSUMPTION						
	BUILDINGS WITH SINGLE RESPONSIBILITY		BUILDINGS WITH DIVIDED RESPONSIBILITY				AVERAGE SAVINGS
	BLDG	COST SAVINGS %	BLDG	COST SAVINGS %			
				Whole Bldg	Central Services	Tenant Services	
TOP MANAGEMENT	1.1	26.9	2.1	26.6	57.5	44.9*	
	1.2	10.5	2.2	19.8	25.8	39.9*	
	1.3	20.4	2.3	21.7	49.0	17.4*	
	1.4	15.4	2.4	55.6	62.8	21.8*	
	1.5	2.7	2.5	39.0	58.5	21.2*	
	1.6	30.7	2.6	4.7*	29.7	55.0*	
	1.7	33.8					
	average	20.1		26.3	47.2	33.4*	23.0
MIDDLE MANAGEMENT	3.1	3.2*	4.1	25.4	35.1	4.4	
	3.2	51.3	4.2	1.3*	8.0	73.0*	
	3.3	13.1	4.3	16.8	32.3	35.4*	
	average	20.4		13.6	25.1	34.7*	17.0
AVERAGE SAVINGS		20.1		22.1	40.0	33.8	21.1

Table 1 : Classification of the Survey Buildings by Energy Management Decision Level and Responsibility for Energy Consumption, together with the corresponding percentage cost savings comparison between 1977 and 1982.

NOTES (i) Cost savings are given in terms of 1982 energy prices and are calculated as follows:

$$\left(\frac{1977 - 1982}{1977}\right) \times 100 \text{ percent}$$

(ii) A percentage cost <u>increase</u> is identified by *

Group 1 Buildings : Top Management/Single Responsibility

The seven buildings of this group housed private companies (1.4, 1.6 and 1.7), hotels (1.2 and 1.3) and government departments (1.1 and 1.5)(see Table 1). It was found that the cost of energy was the prime motivating factor for the private companies and hotels, while conservation of energy (oil and electricity) lay behind the efforts made by the two government departments.

Top management 'support' took many forms. It could be simply the expectation of middle management that any economic measures likely to reduce costs (the fact that they might relate to energy consumption was incidental) would receive the support of top management. It sometimes took the form of top-down directives (both energy use and energy cost related), some with no effective feedback mechanisms, others with excellent monitoring and control procedures.

Of the technical methods which resulted in reduced energy costs, conversion of the boilers from oil to gas firing and adjustment of the running hours of the boiler were by far the most popular and most lastingly effective.

While most effort appears to have been directed at central heating systems, attempts were also made to reduce the consumption of electricity. These ranged from exhorting staff to switch off lights and appliances when not in use, to reducing fan and chiller running hours. It is always difficult to assess the outcome of such measures, given that these loads were not separately metered. However, in general, electricity use was not seen to be readily manageable.

Awareness campaigns had been tried in four cases but these had mostly lapsed. Energy monitoring was carried out in two buildings (1.1 and 1.3) as part of the routine budgeting and cost allocation procedures. It may be relevant to note that these two had the highest cost savings of the seven. A monitoring programme was also instituted in Building 1.5 but this had lapsed due, it would seem, to lack of feedback from top management to those doing the monitoring.

Group 2 Buildings : Top Management/Divided Responsibility

For these six buildings, it was possible to distinguish between central services and tenant services energy costs. It should be noted that while the average whole building savings amounted to some 26.3% and major savings (averaging 47.2%) had been made in central services energy costs, tenant services energy costs had INCREASED significantly in every case (ranging from 17.4 to 55.0%). The predominant activity in all six cases was private administration and all but one of the buildings were under the care of the property division of a (different) company which owned and operated other buildings too.

In all cases, personnel at the property division appeared to be informed on energy matters generally, and had incorporated various means of identifying and comparing energy costs within their overall management procedures. As a starting point, the ability to conduct comparisons between different buildings in a given property portfolio had been found useful, and in most cases this had developed into a regular monitoring procedure - energy costs being the main motivating factor. The emphasis placed on continued energy cost monitoring and its incorporation into the standard management procedures of the property companies or divisions involved appears the main difference from the buildings of Group 1. However, the main methods used to obtain energy cost savings, and the technical means employed were fairly similar for both groups of buildings. Conversion of oil fired boilers to gas and the reduction of the hours of use of the heating system were the most popular methods.

Time clocks were used to reduce the running hours of the heating systems in four buildings - these had to be installed or replaced in three cases - and there was much less emphasis on manual operation. In two cases, a centralised computer based system was employed to control (inter alia) the heating system. There were very few reported attempts at reducing electricity use. While it was true that some of this electricity was paid for directly by tenants, central services electricity costs were not insignificant and must warrant more attention than was given in these buildings. Energy awareness campaigns, directed at the building occupants, were much less in evidence here than in Group 1, a reflection perhaps of the division of responsibility (in Group 2) between owner and tenant. Emphasis was placed much more on management procedures and technical methods for the reduction of energy costs.

Group 3 Buildings : Middle Management/Single Responsibility

Group 3 contained three buildings, each with a different predominant activity; retail trading, private administration and a private club. These diverse activities produced a range of conservation responses to different motivations. In all cases however, these responses were initiated and actively supported at middle, rather than top management level.

In the retail trading case, external floodlighting and internal spotlighting were the main targets, in an attempt to reduce hours of operation and hence electricity costs (by far the dominant cost in this instance). Top management appeared to have reservations about some energy savings measures and their possible conflict with the retailing activity. In the case of the private club, the manager was motivated primarily by the 1979/80 oil restrictions* and himself switched the heating system on and off each day (it had previously operated continuously). Now that these restrictions have been withdrawn, costs have increased again. The third building of this group lay on the borderline with Group 1. Even though it housed the property division of the larger company of which it was part, and the personnel of that division were active in reducing energy costs, top management were not directly involved, other than in overall budgetary terms.

* The 1979/80 oil restrictions were a New Zealand Government regulation limiting heating oil deliveries to buildings during 1979 and 1980 to 80% of their 1978 value.

Group 4 Buildings : Middle Management/Divided Responsibility

As in the previous group, only three buildings fell into this category. In this instance, all of them accommodated mainly administrative activities. As with Group 2, responsibility for energy management was divided between the building owner and the tenants, the costs to the former falling on average and the latter rising (see Table 1).

In all three buildings, successful attempts were made to reduce heating and cooling system running hours and hence costs, by a combination of manual and time switching. These efforts were all initiated and sustained by middle management personnel motivated by the desire to save on running costs. Top management involvement seemed to have had a negligible, or even a negative influence on energy savings initiatives, but this situation appears to be changing. In one case, for example, top management has now become involved and energy cost savings targets have been set.

Discussion of Findings

For the majority of the buildings selected for study (19 out of 22), the energy savings were the result of deliberate management processes. Both top and middle management were involved in this group of buildings. What was perhaps surprising were the relatively few instances of formal monitoring procedures designed to inform management of ongoing energy consumption and costs.

The 'level of management/division of responsibility' classification system proved to be a useful tool for studying such a diverse group of buildings; and it should be capable of modification to cope with larger numbers and other building types. During this study, it served to highlight the conservation methods that had been found applicable to particular categories. For example, nearly all the buildings with top management involvement had been converted to gas fired boiler systems and had reduced the operating hours of their heating systems; those with middle management involvement had reduced operating hours too, but appeared reluctant or at least tardy in implementing conversion to gas firing. Energy conservation awareness campaigns had been promoted exclusively in buildings with single responsibility for energy use but these did not appear to meet with any lasting success; and it was also apparent that managers of buildings where tenants were directly responsible for some of the energy costs did not see such campaigns as worthwhile. Data from the category of buildings with divided responsibility for energy consumption made it abundantly clear that while considerable savings were being made in the energy costs of central services, those related to tenant services were on the increase.

The main motivation for undertaking these conservation measures was almost invariably expressed in terms of expected cost savings. It is apparent that the 1979/80 oil restrictions and related energy conservation campaigns acted as a catalyst to building management. However, the price of oil jumped significantly at that time too (from less than $5/GJ in 1979 to over $15/GJ in 1982), while that of gas remained relatively static, considerably improving the economics of boiler conversions.

As far as the management of central services is concerned, it is clear that considerable experience has been gained in relation to the operation of central heating systems. Dissemination of that experience would be useful to other building managers as the methods used are not very complex. In this connection, it would be desirable to have typical or target figures available, especially for the owners of single buildings who may not have a basis for comparison of their energy consumption data. This is being addressed in New Zealand (5) and is a matter of concern in other countries too (6). In addition, more attention should be directed towards testing and publicising methods for reducing energy costs in cooling and HWS systems; and to ensuring that energy efficiency is considered when it is time to replace a boiler or heating system, or any other major piece of energy consuming equipment.

The management of tenant services seems to have been neglected as an area of potential energy conservation. There is a need for the development of management systems appropriate to this area, whether responsibility for energy consumption is single or divided. The 33% increase in energy use for tenant services compares poorly with the 40% reduction for central services in the subset of 9 buildings for which such data were available. Energy conservation awareness campaigns need very careful scrutiny before being applied to building occupants; poorly run campaigns can have considerable short term nuisance value and will adversely affect motivation for further energy management activities.

Conclusions

Looking to the future, there are several actions which can be expected to improve the energy (management) performance of commercial buildings. Some of these are based on the results of this study, others are simply reinforced by some of the findings, still others are related to the gaps in our knowledge revealed by the study.

The main methods used to save on energy costs in these buildings were straightforward to apply from a technical point of view and conceptually simple from a management viewpoint. This information could be disseminated more widely, with particular emphasis on the cost savings potential, to encourage other building owners and managers to follow suit. Coupled with this, and aimed at those already active in the field as well as those new to it, would be guidance on the nature and frequency of energy data collection needed to provide information for management purposes, and pointers to methods of saving energy in the operation of equipment other than heating systems. Given the apparently slower pace with which some measures were adopted in the 'middle management' group of buildings there is a need to provide further guidance on how a convincing case should be presented to top management.

Judging from the results, the management of tenant services energy costs seems an almost totally neglected area. Much more thought needs to be put into means of saving energy in this area - ranging from energy criteria for the selection of a building or space to rent, to the management of energy costs in use. An almost inevitable outcome of this will be the need for more judicious energy monitoring by management; not just general energy conservation campaigns directed towards the occupants which have no chance of achieving lasting savings.

Taken together, the 1979/80 oil restrictions and sharp price rises, plus energy conservation campaigns at that time, acted as a catalyst to some of the energy cost savings measures undertaken. New 'catalysts', appropriate to the current situation must now be found. Publicising actual energy cost savings in a range of buildings would go a long way in this area.

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