BRANZ
THE RESOURCE CENTRE FOR BUILDING EXCELLENCE

CONFERENCE PAPER

No. 77 (2000)

Energy and Facility Management: Developing a Profitable Partnership

Nigel P. Isaacs

Presented at the Facilities Management 2000 Conference,
Auckland, February 15-16, 2000

This paper was funded by the Building Research Levy.

SUPPORTED BY THE BUILDING RESEARCH LEVY

ISSN: 0111-7505

Energy & Facility Management:

Developing a Profitable Partnership

Facilities Management 2000,
Stamford Plaza Hotel, Auckland
15-16 February 2000

Nigel Isaacs
Manager, Energy and Environment
Building Research Association of New Zealand, Private Bag 50908, Porirua City
Telephone: + 64 4 2357 600 Fax + 64 4 2356 070 E-mail: branznpi@ branz.org.nz

Introduction

Energy management combines financial, facilities and information management and links them to action and monitoring.

The most important aspect of energy management is information. The data in the financial accounts and the energy flow meters must be used to identify how much energy is being used, and for what purposes. Then analysis provides the basis to give information to the energy users and to outline the financial costs of their actions. In most buildings, this information feedback does not exist. The reality is that the users of the building demand comfort, and an attempt is made to provide this. The energy bills are certified by service staff and then paid by financial management. But no crosschecking is done. No one matches consumption to comfort. Very little attention is paid to the connection between the cost of energy and the cost of maintenance. Then, at the end of the year, no one can trace why the line item 'Energy' has cost so much.

Research has shown that only half of the variation in energy use between commercial buildings is due to the design of the building and its services (Baird, Donn, et. al. 1984). The building user or operator is responsible for the rest. However without information feedback on the consequences of these requirements, the user has no opportunity to contribute in a positive manner. Case studies continue to show the benefits of providing information in a clearly understandable form, but the problem is how to implement the lessons into a given building. This paper provides an approach.

Energy, Fuel and Expenditure - Terms Defined

Energy management is commodity management rather than purely financial management. Accounts systems deal with expenditure, but energy performance is measured in terms of the fuel use and service. Electricity is measured in thousands of Watt-hours (kWh), coal in tonnes, oil in litres etc. Different fuels are used to provide different services as well as being measured in different quantities – electricity is used for lights as well as heating, cooling, cooking, motors, and computers; gas for cooking, heating and perhaps cooling; coal and oil for heating.

Energy use depends on many things, and no single energy use target or budget can be provided to suit all buildings. Key factors for energy use in a commercial building include:

- climate - sun or shade, wind or shelter, town or country;
- use(s) - office, shops or school;
- size - floor area, number of rooms or number of occupants;
- heating - central air conditioning or unit heaters;
- heating controls - manual, timeclock or computer;
- hours of use - daylight hours only or 24 hours a day;
- installed equipment (lights, computers, chillers, photocopiers…).

None of these 'factors' are entirely independent. The amount of equipment will depend on the type of use - a shop will have more chillers and fewer computers than an office. The size of heating or cooling equipment will depend on the climate and the type of use.

To make performance comparisons between buildings, or for the same building from year-to-year, it is necessary to make allowance for, or standardise these factors.

In office buildings we have found that energy use relates more closely to floor area than number of people in the building. Since heating (and cooling) plant run regardless of occupancy, and the number of staff can vary year by year, the area that is conditioned is normally the more important factor. Although commercial buildings can differ radically in layout and construction, these differences have a relatively minor effect on energy use in most modern buildings. It is also important to recognise that there may be short or long-term actions within the building that may increase energy use – increasing hours of work or increased use of desktop computers may increase energy use, while a new energy efficient boiler may reduce energy use.

Information Flows

There are a number of different stakeholders in building operation. Financial managers are concerned with the collection and analysis of financial data to provide the basis for investment decisions. Building managers are concerned with the week-to-week and year-to-year operation of the building, managing repairs and maintenance and planning for the long term. Service staff or contractors implement the repairs and maintenance requirements, and have a detailed knowledge of the operation of the equipment. As noted before, the users desire the building to provide them with a comfortable environment within which they can carry out their requirements of involvement with the building - employment, obtaining or providing services.

Figure 1: Conventional Energy Management Flows

Figure 1 illustrates the conventional management flow in energy management – the facility or building manager tells the financial manager what is needed, and is provided with the financial authorisation for the service staff to proceed. The information flow is unidirectional, the feedback non-existent and the attitude of the participants unlikely to be positive.

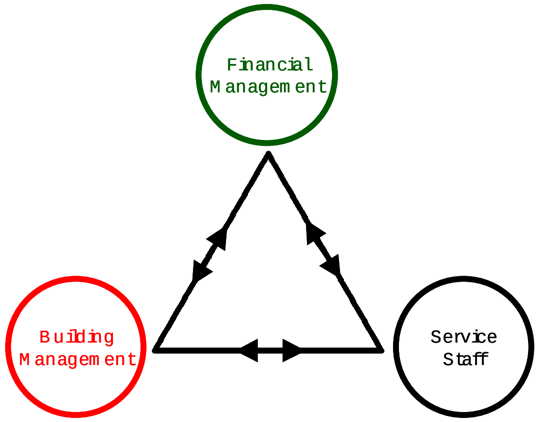

Figure 2: Energy Management - Meeting Stakeholder Needs

Figure 2 provides improved feedback and information exchange. The interactive, two-way flow of information provides opportunities for all participants to understand the issue, but there is still a need to provide opportunities for all participants to work co-operatively towards achieving a common goal. This is not to use less ('conservation'), but to make the energy that is used work harder ('efficiency').

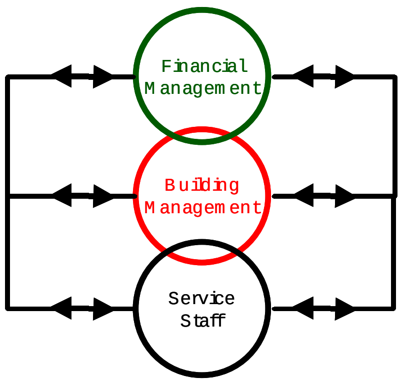

Figure 3: Energy Management - Promoting Co-operation

Figure 3 provides a model of closer links between the key stakeholders. The links are interactive, and involve all the stakeholders. The overlapping circles indicate the often-overlapping roles of the stakeholders. In some smaller establishments these roles may overlap to the point where only one person carries them out.

Energy management does not consist solely of action – it starts with a three-step process:

1. Analysis – using all the available data, evaluate the most important issues and develop options for action.
2. Decision – review the options and decide on the most appropriate for the time and finances.
3. Action – implement the selected option.

Figure 4 illustrates the recommended flow of energy management information. Essentially the diagram emphasises the importance of communication between the stakeholders at each step in the building management process, and the need for information feedback. The feedback includes not only information resulting from the improvement in the operation of the building, but also management feedback ensuring all stakeholders are in a position to review any decision(s) for action. Without this interactive communication, the data collected from the building about energy use, expenditure etc never becomes information on which decisions can be made about energy use and maintenance. The end result is that the action to achieve energy efficiency may not result in successful implementation.

Even after these three steps, the critical management action remains – Figure 4 shows that the feedback loop must be closed with a review. This review of the consequences of the actions should occur after a suitable period of time – no management action can be guaranteed to be perfect, and the results may not be those expected.

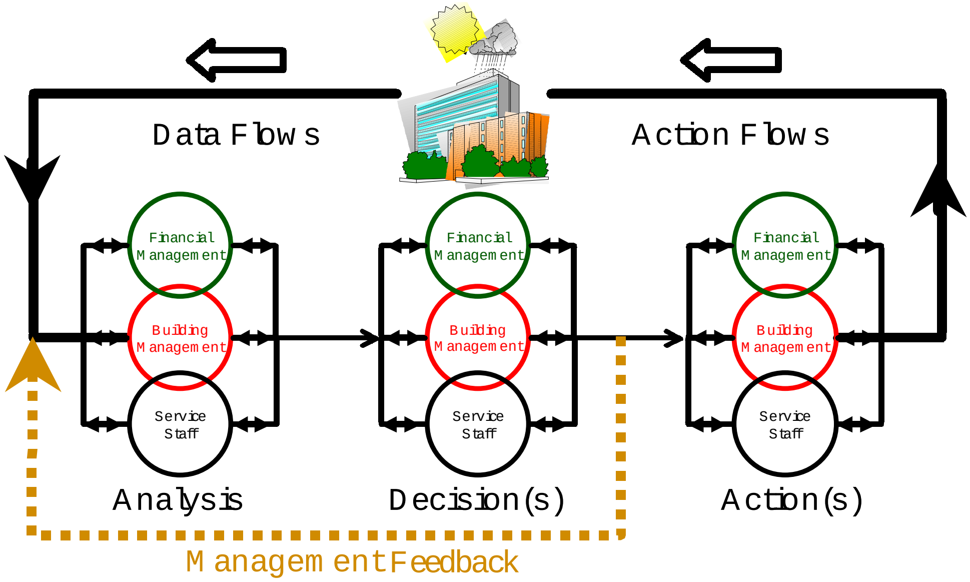

Figure 4: Energy Management - Recommended Information Flow

Too often the links between the financial management, the building management and the service support do not exist. The indicators and standards suggested here are aimed at ensuring these links exist, and that the necessary flows of information can occur.

Energy Management - Information for Action

The desirable information flow illustrated in Figure 4 must be supported firstly by the collection of data. This data is then used for analysis, and this in turn is followed by decisions based on the information gained from the analysis and thence to action. The feedback loops ensure that both the actions are successful and that they are the correct actions to take.

Data collection

Energy expenditure ($) and consumption (energy unit) records should be maintained in the most appropriate location. At a minimum this raw 'data' may consist of the regular supplier accounts recorded in a manner that permits later analysis. Other data available for analysis should include:

- building "production" (e.g. number of person hours worked, or kilograms of widgets produced);
- building use or activity pattern (e.g. building occupied nine hours a day, five days a week including public holidays);
- plant operation (e.g. Boiler 2 has been closed down for the past six weeks due to lack of spare parts); and
- climate information may also be of value, particularly with buildings similar in scale to houses (under 150 square metres). Temperatures are relevant to all buildings, but Relative Humidity (RH) may be important if the building has air conditioning or humidification.

Analysis

The most common energy management tool is the area energy use index (AUEI), which normalises energy use by floor area (e.g. kWh/m^2). This means that if the energy use increases due to expansion (e.g. taking over more floor area) then it will not affect the AUEI. Other normalising indicators can also be useful for different building types and uses – for example energy units per hour or day of work time. The idea is that if the energy use increases just because a new shift is using the building more this year than last, then it will not affect the AUEI (in say, Mega-Joules or kilowatt hours per square metre) for the building.

Pareto analysis provides guidance not only for those involved in the management of groups of buildings, but also for single buildings by providing a point of reference – how good (or bad) is my building's energy performance?

In research in schools, for example, it was been found that a large proportion of the total energy consumption is used by a relatively small number of schools.

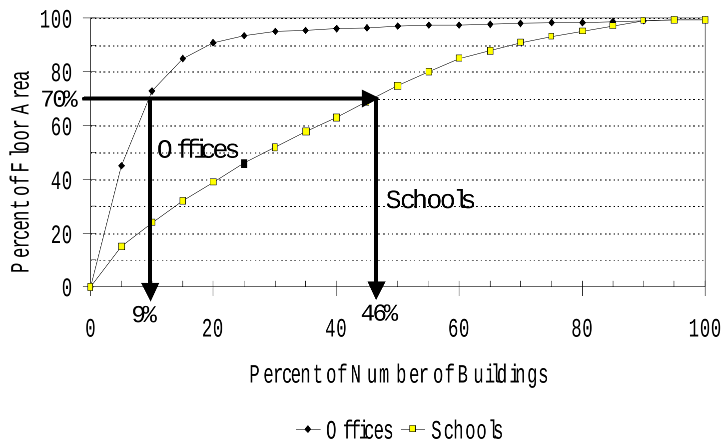

Figure 5: Pareto Distribution

Figure 5 shows a Pareto analysis, on two different groups of buildings. For the schools, 46% of the schools consume 70% of the total energy. For the office buildings, the figures are even more radical: 9% of the buildings consume 70% of the energy. To best plan energy management investment, it is clearly important to spend money where the total return from the investment will be high. This high return on investment is most likely to happen when the energy management investment is made in a school selected from those 50% of the buildings (schools) which consume 60-80% of the total energy.

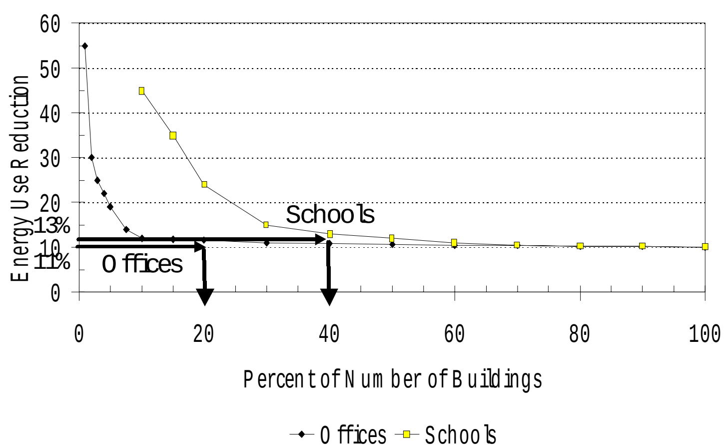

Figure 6: Inverse Pareto Distribution

Figure 6 inverts the data in Figure 5. The overall energy savings able to be achieved in a group of buildings are shown cumulatively on the vertical axis. If the largest are tackled first, there are opportunities to achieve a larger reduction in energy use for the investment of time, effort and finance. Thus for the commercial buildings if only the largest 20% of them achieve an 11% saving in energy use, then the overall saving for the whole group is 10%. For schools the figures are: if the 40% of them which are the largest consumers of energy achieve a 13% saving, then overall there will be a saving of 10%.

Certain building uses are likely to result in higher energy use. Buildings in use twenty-four hours a day, or with particular climatic requirements will use more energy. Hospitals are both in continuous operation, and require higher internal temperatures than many other commercial buildings. This can result in very high energy density - a large hospital can approach the energy use of a small town. In cases such as these, it is important to ensure that ‘like’ is being compared to ‘like’.

Decision(s)

The data available to each specialist group (shown in Figure 4) needs to be integrated and analysed in a form that provides whatever useful knowledge is required for the particular building, use, location, management system etc. For example, the service staff may be interested in the energy use compared to the indoor and outdoor temperatures, the financial staff in energy expenditure per unit of output, and the building manager in energy use per unit of floor area. All could be interested in the change in their particular measure since the same time last year.

The common pattern of energy use in commercial office or institutional buildings has a baseload of energy use through the year due to lighting and office equipment, with variable summer cooling and winter heating. These energy uses must be separately reported, to permit valid comparisons to be made. Thus an apparent leap in energy use from one month to the next could be due to equipment problems, or merely due to the arrival of summer and the need for cooling.

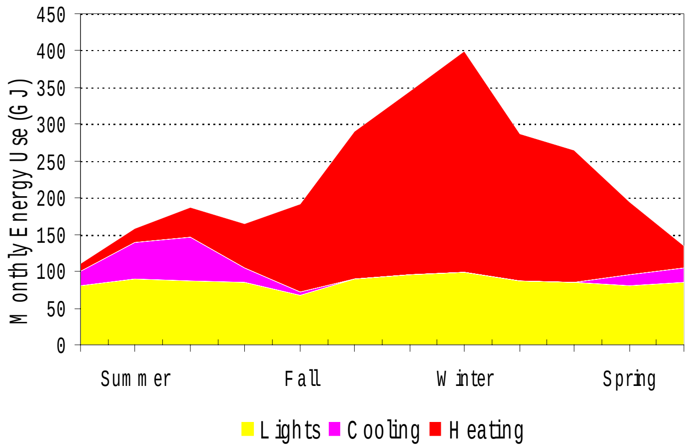

Figure 7: Example of Season Energy Use Pattern

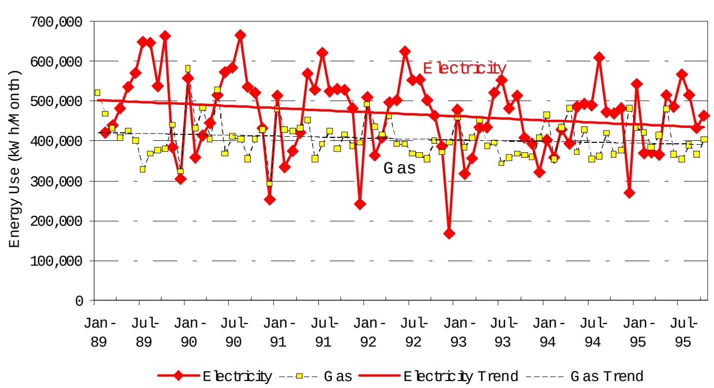

Figure 8: Season Energy Use Trend

The graph in Figure 7 shows a standard pattern of energy use found in many commercial office or institutional buildings. Lighting energy use is almost constant through the year. Cooling can be seen to be a summer phenomenon, while heating occurs in winter.

However, the simple visual presentation of Figure 7 tells the manager and the caretaker nothing that they do not already know, unless it is either compared with the same building the previous year, or with other similar buildings.

Figure 8 graphs the monthly electricity and gas use for a building over seven years. The trend lines go steadily downwards – the energy management is reducing energy use.

Action

Analysis must be provided to those able to use it if action is to follow. If the person carrying out the analysis can see a gradual increase in (for example) energy use per unit area, this information needs to be provided in a form usable by the building manager and also the service staff. All groups need standards by which to measure their building's performance – for example 'litres per 100km' may be meaningful to many automotive specialists, but 'MJ per km' may only be useful for a select specialist group.

The person responsible for implementing the action, e.g. supervising the boiler operation, must be provided with feedback within a reasonable time to allow them to understand whether their actions have been successful. If the actions have not been successful, then the analysis should be able to provide additional guidance on how to achieve the desired management improvement.

Closing the Information Loop

The provision of feedback on the results of the energy affecting activity are crucial. Energy management can easily be dismissed as a technical problem that should be the sole perogative of the technical service staff. However, unless the linkages between the financial management, building management and service staff are robust and well used, there is an almost certain guarantee that energy costs will increase.

In one school building (operation hours 9 am to 4 pm), our monitoring found that the heating system was operating continuously. The financial management was happy as this pattern had been in place for a number of years, and no variation was detected year-by-year. The building management were happy, as they faced no complaints from the building users. The service staff were happy as their equipment seemed to be working and they had not been informed of any complaints. However the cost was excessive.

It was only when the Pareto analysis indicated this school should be subject to more detailed investigations that the 'problem' was found. The resolution was prompt, the savings paid for the work in a number of months, and in fact complaints started as the buildings were not always warm whenever someone came in to work later hours! This problem was easily resolved by the provision of after hours operation controls which turned the system on for a limited period of time.

The key to closing this information loop was not the expenditure of large amounts of money - it was the opening of the information pathway, to ensure that all had the information they needed in the form they understood.

NZ Building Code Clause H1: Energy Efficiency

This paper presents a very brief introduction to the proposed changes to New Zealand Building Code Clause H1: Energy Efficiency. Further information is available on request from the author. It should be noted that the NZBC requirements for energy efficiency only apply to new buildings.

Since 1978 New Zealand has had national mandatory requirements for thermal insulation in new homes. With the implementation of the performance-based New Zealand Building Code (NZBC) in 1993, these requirements were converted to performance terms for residential buildings, and requirements developed for commercial buildings. As with all NZBC clauses, the energy efficiency clause is subject to a five-year review, which started in 1994 and was completed with recommendations being made to the (former) Government in 1996.

The analysis work on which these recommendations were based, included (uniquely) a review of the 'size' of New Zealand buildings. It was found that the large majority of buildings built over the past two decades were residential and under 300 square metres in floor area. The majority of non-residential buildings were over 300 square metres in floor area, but less than three storeys in height.

This work resulted in a proposed Approved Document, including 'Acceptable Solutions' for all buildings and a 'Verification Method' for houses. These provide a range of approaches suited to various levels of building design involvement. For the majority of small buildings, and for larger commercial buildings which have minimum design input, 'schedule' tables provide the required insulation levels. However the designer can alternatively use a simple calculation method or a more sophisticated thermal simulation tool.

Table 1 summarises the proposed 'Acceptable Solution' prescriptive or 'Schedule Method' requirements for the 'housing' or 'small', and 'large' buildings. This approach does require consideration of floor area except for small commercial buildings, and retains the previous code split between 'Housing' and 'Commercial'. By definition, all 'residential' buildings (housing, apartments etc) are included in the 'small' building category. It is expected that the Schedule Method will predominantly be used on 'small' or simple 'large' buildings.

Lighting power density, an issue only in 'large' commercial buildings, is provided with comparable analysis tools to envelope R-values. No code benefits are given for sophisticated lighting controls – if they are appropriate then the designer is expected to use them without code compliance requirements. Note that values given in Table 1 may still be changed (for technical or other reasons) before final implementation.

Component	Acceptable Performance (R-values in $m^2.°C/W$)	
	"Large" (> $300m^2$)	"Small" ($\leq 300\ m^2$) including all Residential
Envelope: Roof	Zone 1, 2 & 3 Normal: R 1.9	Zone 1 & 2 Normal: R 1.9 Zone 3 R 2.5 Solid Wall (all zones) R 3.0
Envelope: Wall	Zone 1 No requirements (R 0.3 for comparison) Zone 2 & 3 Normal: R 1.2	Zone 1& 2 Framed: R 1.5 Solid R 0.6 Zone 3 Framed: R 1.9 Solid R 1.0
Envelope: Floor	Zone 1, 2 & 3 R 1.3 (inside floor surface to outside air)	
Envelope: Glazing	Zone 1, 2 & 3 (to use Schedule Method) 50% of external wall surface area.	Zone 1, 2 & 3 (to use Schedule Method) 30% of external wall surface area.
Envelope: Heated Heated Ceiling Heated Wall Heated Floor	Requirements as proposed for Housing: R 3.0 R 2.2 R 1.7 and $R_{in}/R_{out} \leq 0.1$ (R_{in} = resistance, heating element to inside R_{out} = resistance, heating element to outside)	
Envelope: Other	No requirements (e.g. doors)	No requirements (e.g. doors)
Fixed Lighting	e.g. Offices (on gross lit area) 18 $W\ m^{-2}$ Lighting Power Density	No requirements
Heating System	No requirements	No requirements
Cooling System	No requirements	No requirements
Hot Water	Cylinder meets NZS 4606 (Grade "A" electric or equivalent gas cylinder)	
Note: Zone 1: Warmer North Island; Zone 2: Cool North Island; Zone 3: Central North Island, all South Island		

Table 1: Schedule Method - Recommendations for 'Large' & 'Small' Buildings

The three standards developed for the proposed revision are now available for use:

- NZS 4218:1996 "Energy Efficiency – Housing and Small Building Envelope"
- NZS 4243:1996 "Energy Efficiency – Large Building Envelope" and
- NZS 4305:1996 "Energy Efficiency – Domestic Type Hot Water Systems"

Conclusions

The control of energy costs in buildings is not solely a technical issue. All building users can play a critical role, whether their effect is to reduce, or less desirably increase costs. This paper has provided a model to improve information feedback through improved linkages between the key facilities management stakeholders. Specialist consultants may play a critical role in the evaluation of identified problems or opportunities, and in their satisfactory resolution, but without the general facilities manager being empowered to identify the problems, costs will continue to rise as no solution is ever found.

Acknowledgements

This paper builds on work carried out at BRANZ, and while the author was at the Centre for Building Performance Research, School of Architecture, Victoria University of Wellington. The support of Michael Donn, George Baird and Harry Bruhns are acknowledged with gratitude. The preparation of this paper was supported by the Building Research Levy.

Selected Bibliography

Baird G. & Isaacs N. 1994. A Checklist for the Performance Evaluation of Buildings and Building Services. Engineering for Better Building Performance, CIBSE Australia & NZ Third Regional Conference, Melbourne Australia 16-18 Feb 1994

Baird G., Donn M., Pool F., Brander W. and Chan S A. 1984. Energy Performance Of Buildings. CRC Press 1984 ISBN 0-8493-5186-3

Isaacs N. & Donn M. 1992. Natural Energy Public Library - Design to Reality in American Council for Energy Efficient Economy (ACEEE) 1992 Summer Study on Energy Efficiency in Buildings, 30 Aug - 5 Sept 1992, Pacific Grove, California Vol 1 1.123-1.132

Isaacs N. 1988. Energy in Buildings - Four Rules for Better Management Accountant's Journal (NZ.) April 1988. Vol 67 No 3. pp 36-37.

Isaacs N. 1991. Building in Energy Efficiency Terra Nova. Issue 10. pp 20-22 October 1991

Isaacs N., Donn M., Davies K. & Turner L. 1991. Energy Efficient Architecture Architecture New Zealand, pp 94-98. May/June 1991

Isaacs N. & Donn M. 1996 Evaluating Energy Management in Baird G, Gray J, Isaacs N, Kernohan D & McIndoe G (ed.) 1996 Building Evaluation Techniques pp 119-123 New York: McGraw Hill

Pringle T. 1999 Protecting Your Investment – A Guide to Maintaining Commercial Buildings. Judgeford, Wellington: Building Research Association of New Zealand

Figure 1: Conventional Energy Management Flows 3
Figure 2: Energy Management - Meeting Stakeholder Needs 4
Figure 3: Energy Management - Promoting Co-operation 4
Figure 4: Energy Management - Recommended Information Flow 5
Figure 5: Pareto Distribution 6
Figure 6: Inverse Pareto Distribution 6
Figure 7: Example of Season Energy Use Pattern 7
Figure 8: Season Energy Use Trend 7