ENVIRONMENT DESIGN GUIDE

DRIVERS OF ENERGY AND WATER EFFICIENCY IN COMMERCIAL OFFICE BUILDINGS

Paul Bannister

Summary of

Actions Towards Sustainable Outcomes

Environmental Issues/Principal Impacts

- Buildings in the commercial sector are responsible for about eight per cent of Australia's greenhouse gas emissions, of which office buildings comprise a significant part.
- The link between building technology and energy efficiency performance is far from absolute, with the performance of buildings of the same technological standard varying over a wide range.
- This paper looks at the non-technical factors that might explain this range including variances in management, training, disclosure of energy performance, etc.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:

- Greater energy efficiency can be achieved by better communication of corporate goals that are relayed through the whole organisation.
- This communication needs to be backed up by training in energy efficiency management.
- Programs of incremental and continuous improvement for mechanical and operating systems are shown to have a significant effect. These programs need to identify what equipment isn't working and when equipment needs to be updated.
- The use of economy cycles, that is, using external non-conditioned air when cool enough wherever possible to avoid cooling loads, provides significant gains.

Cutting EDGe Strategies

- Disclosure of energy ratings to tenants and the public is a motivator for greater energy efficiency.
- Ascribing incentives or penalties for good/poor performance has been shown to improve results from building managers and maintenance staff/contractors.
- A culture of continuous improvement is seen to be more effective than a reliance on major upgrades, as the performance of initially efficient systems can be eroded over time by poor maintenance, cost cutting, and revision of control settings if not correctly supported.
- Recommissioning of mechanical parameters and retuning of control parameters are key to any program of continuous improvement.

Synergies and References

- The Warren Centre website contains the full report that this paper is taken from:

  Warren Centre, 2009, *Low Energy High Rise Building Research Study: Final Research Survey Report*, available for download: http://sydney.edu.au/warrencentre/LEHR/main.html
- The Australian Institute of Refrigeration, Air-conditioning and Heating (AIRAH) produce guides for best practice and other training related to air-conditioning : www.airah.org.au
- *Environment Design Guide:*
  - TEC 13: Getting the Best out of Refrigerant-Cycle Chillers

ENVIRONMENT DESIGN GUIDE

DRIVERS OF ENERGY AND WATER EFFICIENCY IN COMMERCIAL OFFICE BUILDINGS

Paul Bannister

This paper summarises a study that looked at the factors that influence both energy and water efficiency for commercial office buildings. Using NABERS ratings for both of these, comparisons were made of various grades of buildings, with the information gathered from a broad range of office buildings nationally. Beyond physical characteristics of the systems used, the communication and management regimes of building managers as well as the skills of those controlling the buildings' efficiency were surveyed to understand the impact of these factors on the buildings' water and energy performance.

Keywords:
base building, behaviour, commercial building, energy efficiency, NABERS, office, tenancy, water efficiency

Figure 1: Commercial office buildings have high energy use, and thus provide significant opportunities for increased energy efficiency

(Photo: © iStockphoto/Craig Jewell)

1.0 INTRODUCTION

The technical issues associated with energy efficiency in the commercial office sector are relatively well established, but application of these remains elusive on anything other than an ad-hoc level. The existence of market failures in the application of energy efficiency in the sector is similarly well understood, and there have been many studies documenting such barriers.

The Low Energy High Rise (LEHR) project was established by the Warren Centre of the University of Sydney to seek methods by which a greater uptake of energy and water efficiency can be achieved. Central to the approach of the project was the decision not to focus on the market failures and barriers but rather to ask what was different about those organisations or buildings where there was apparent success in the face of these problems.

The project is in three stages which are:

- Stage 1: Literature review, industry identification of potential efficiency measures and empirical research into factors with measurable impact on building energy/water efficiency
- Stage 2: Integration of industry nominated and empirically validated measures into natural groupings, testing of grouped measures in case study buildings, and development of materials to assist buildings in uptake of demonstrably useful measures
- Stage 3: Testing of materials to ensure effectiveness in application.

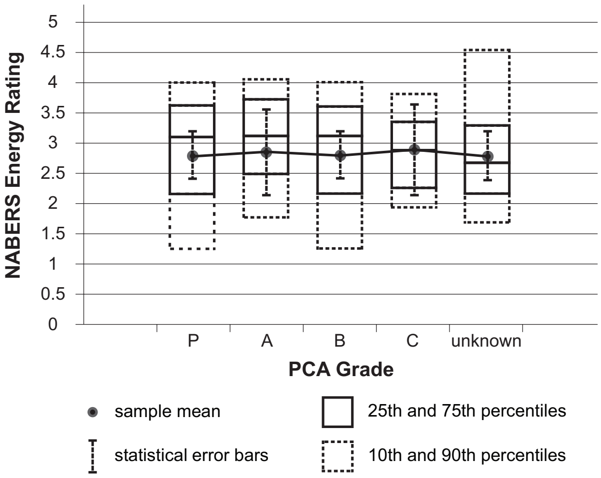

Figure 2: NABERS Energy rating for different property quality grades

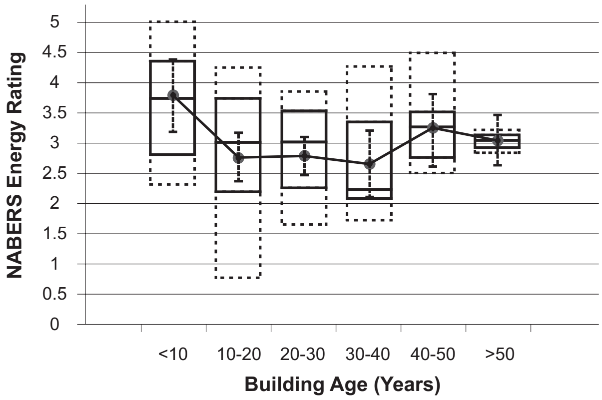

Figure 3: Impact of age on building performance

This paper summarises the report of findings for the first stage of the project entitled *Low Energy High Rise Building Research Study: Final Research Survey Report*. In this study empirical techniques were used to test for the existence of statistically valid correlations between technical and non-technical factors and the energy and water efficiency of a large sample of buildings in temperate Australia (where the majority of office building stock is).

In parallel with this work, a literature review was conducted and a series of industry working groups was convened for the project from property owners and service providers, who assembled lists of practical measures they have been using to achieve energy efficiency. These parallel work groups informed the work reported in this paper as part of the scope of Stage 1. In Stage 2 of the project, which commenced in early 2010, the industry-developed initiatives will be integrated with the empirical findings reported in this paper, in order to develop coherent and practical implementation packages. The effectiveness of these will be tested in Stage 3 of the project, subject to funding.

Energy consumption in commercial buildings can generally be attributed to lighting, air-conditioning and tenant equipment. The focus of this paper is on the base building energy use – that which is under the control of the landlord – which is dominated by air-conditioning.

2.0 RESEARCH METHODOLOGY

The results presented in this study were based on three separate surveys that were undertaken concurrently in 2008, being:

- **base building survey** – covering the technologies and management of the building
- **tenant survey** – covering the interactions between the base building and the tenant
- **manager's survey** – covering the knowledge, attitudes, authorities and responsibilities of the building, property and asset managers

Well over a hundred questions were covered within these surveys, which were distributed to 189 buildings, 188 tenancies and 296 managers. Satisfactory responses were received from 127 buildings, 102 tenancies and 173 managers. However the need to cross correlate base building data with tenancy and manager data meant that the cross-survey analyses were based on 67 base building and tenancy sets, 91 base building and manager sets and 53 base building, tenancy and manager sets.

The hypothesis testing processes were based around statistical testing based on building performance as measured against the industry accepted rating system for commercial office buildings in Australia being the National Australian Built Environment Rating System (NABERS). The following types of proposition based on the NABERS Energy or Water rating, were tested:

- Do the answers to an individual survey question correlate with the rating?
- Do buildings with ratings of three or above have statistically significant different responses to an individual question than those with ratings below three stars?
- Do the answers to logically related aggregates of individual survey questions correlate with the rating?
- Do buildings with ratings of three or above have statistically significant different responses to logically related aggregates of individual survey questions than those with ratings below three stars?

In addition, some information was derived directly from manager's responses to what they considered to be barriers or facilitators for efficiency decisions.

The grades are the scale of commercial office standards that as set out by the Property Council of Australia (PCA) ranging from D (lowest) through to A and premium (highest). The grades are an accepted standard within the commercial Australian property industry.

2.1 Efficiency Metrics

In order to provide a consistent basis for analysis, the measurement of efficiency has been simplified into two basic metrics drawn from (NABERS). These are:

- **NABERS Office Energy Base Building rating:** This is a measure of the Greenhouse Gas (GHG) emissions of the base building services on a per unit net lettable area basis. It is corrected for climate region and hours of operation to enable cross comparison of buildings that are affected by such factors. As Green Power was not considered in the analysis, this provides a broad indication of energy efficiency as weighted by GHG production considerations. Where buildings did not report a certified NABERS Office Energy rating, an indicative rating was calculated based on the background data provided. Both Base Building (being primarily air-conditioning, house lighting, lifts and car park services) and Whole Building (being the Base Building plus the tenant light and power) ratings were used within this study. Whole building ratings used an assumed occupant density of one person per $15m^2$ and one computer per person.
- **NABERS Office Water Whole Building Rating:** This is a measure of the total water consumption of the building on a per unit net lettable area basis. It is corrected for climate region and hours of operation.

Both ratings operate on a five star scale (five being the highest achievable rating) which has been fitted to the statistics of the building population so that approximately 80 per cent of buildings score one star or higher, the population median is set at 2.5 stars and absolute best practice at five stars is achieved by only a handful of exceptional buildings.

Further details of the sample data set and statistical background of the study are provided in the Appendix.

3.0 RESULTS

3.1 Most building types can be operated at up to 3.5 stars even if the underlying technology isn't particularly efficient

The average energy rating for Australian office buildings is 2.5 stars, yet most of these can be operated at up to 3.5 stars even if the underlying technology isn't particularly efficient. The basis of this finding is illustrated clearly in Figure 2, Figure 3 and Figure 4. In Figure 2 it can be seen that there is no significant difference between the different PCA grades within the sample, and that furthermore all groups have both high performing examples. In Figure 4, it can be seen that while more recent buildings definitely perform better on average, all age groups have examples of well performing buildings. In Figure 3, it can be seen that buildings which feature variable air volume air-conditioning (VAV) show a wide range of performance from excellent to very poor. Other building types tend to be less diverse, perhaps reflecting their lesser dependence on control for successful efficiency outcomes.

In aggregate, the results indicate that essentially all building types can be made to perform at 3.5 stars or above, and that in most cases four stars is feasible without changing HVAC system type or reducing PCA grade. This is important as it illustrates the strong potential for retrofit upgrades in the building stock rather than knock-down and rebuild.

The system definitions are as listed in Table 1.

System Type	Definition
VAV	Variable Air Volume systems use typically larger air handlers that deliver variable amounts of conditioned air to each zone, via ducts, in order to meet the air-conditioning loads in each zone. Heating and cooling for these systems is typically provided by central chillers and boilers, although sometimes electric heating is used.
Fan coil	Fan coil systems use smaller heating/cooling units that serve smaller spaces individually, and are usually sited adjacent to the space they are servicing. These may use heated/chilled water from central chillers and boilers or may use local heat pump units and/or electric heating.
Constant volume	Constant volume systems include a wide range of central air-handler based systems that use ducted air for heating and cooling, typically in conjunction with central plant chillers and boilers and/or electric heating, but unlike the variable volume systems the fans operate at constant speed and so the control of zone temperature is achieved by adjusting the temperature of the delivered air without change to the amount of air being provided to adjust for variations in heating/cooling load.
Mixed	This category covers systems that include more than one of the above systems, such as a VAV perimeter cooling system with a constant volume system serving the core of the building.
Other	This category includes systems such as active or passive chilled beams. These systems do not fit any of the above categories. Note that inadequate data were obtained to enable assessment of new technologies under this category.

Table 1: Air-conditioning system types

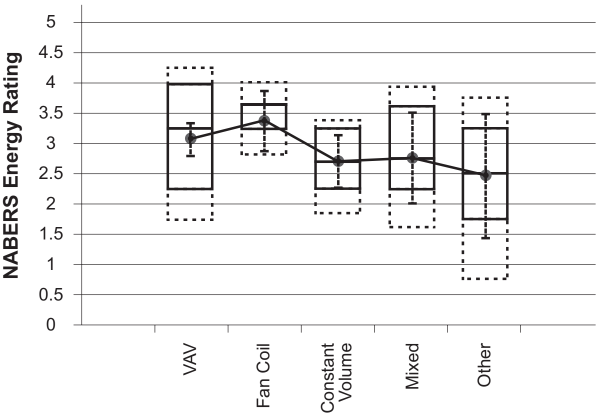

Figure 4: Impact of air-conditioning system type on building performance

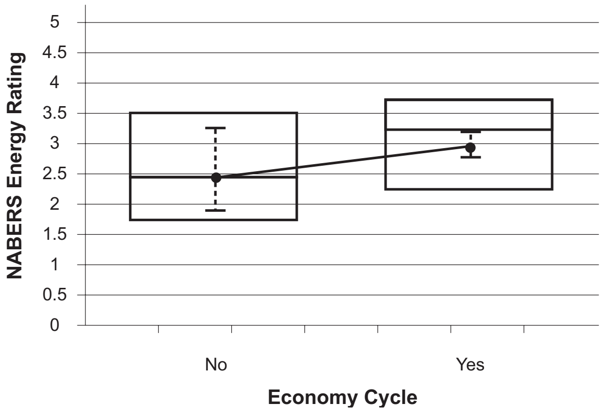

Figure 5: Impact of economy cycle on performance

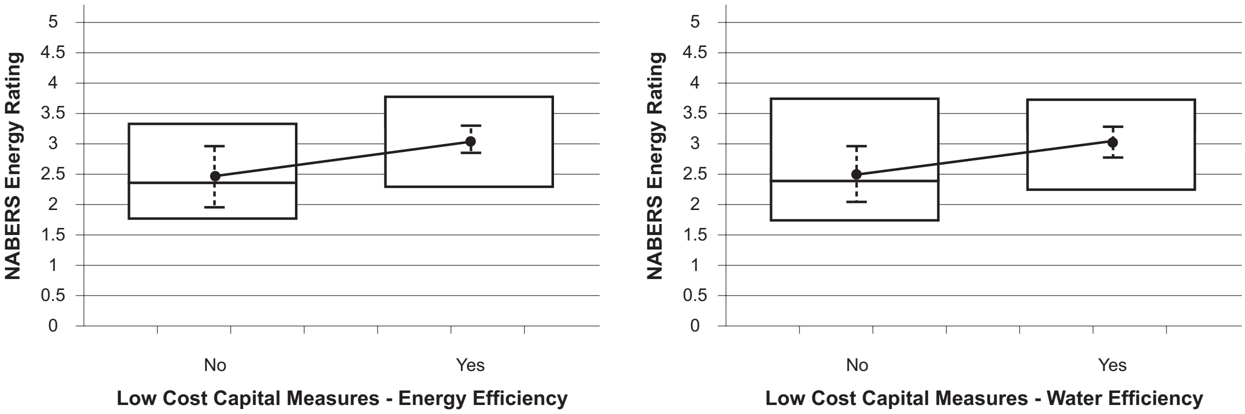

Figure 6: Impact of investing in low cost capital measures on performance

3.2 Economy cycles save energy

The results clearly indicate that economy cycles produce an improvement in building performance. (Economy cycles can introduce 100 per cent 'fresh' air into a building when the external temperature allows it rather than conditioning air). Statistically, the difference in means was 0.6 stars and the statistical confidence was approximately 98 per cent, as illustrated in Figure 5. Of course, this finding has to be qualified to some extent – the sample was biased to temperate climates, and so the results do not indicate that buildings in tropical areas (where external air is rarely cool enough to be utilised) should install economy cycles. However, the use of economy cycles in temperate climates is strongly supported.

3.3 Buildings perform better when they are given regular incremental upgrades which focus on eliminating older and unserviceable technologies

There was strong support in the data for the proposition that sites that had conducted minor works in the past five years performed better on average than those that had not. For NABERS Energy, the effect was 0.6 stars at 98 per cent confidence, while for NABERS Water the effect was 0.51 stars at 96 per cent confidence.

Interestingly, sites that had reported major upgrades did not show a significant performance benefit. This may be because such sites were coming from a very low base, or it may be that many major upgrades genuinely don't produce efficiency benefits. Anecdotal evidence would suggest that both of these factors may be true to some extent.

The concept of focussing on elimination of older technologies arises from the aggregation of a number of questions relating to building technology, covering glazing, cooling technology, air-conditioning type, air conditioning zoning and reheat, lamp technology and the control technology. A low score on this scale (building technology) might typically reflect high solar exposure (and thus higher levels of air conditioning), poor cooling technology, badly zoned air-conditioning, older lamp technologies and the presence of pneumatic controls (known to be less reliable), while a good score represents limited solar exposure, modern cooling technology, good practice air-conditioned design, modern efficient lamps and a digital control system. As

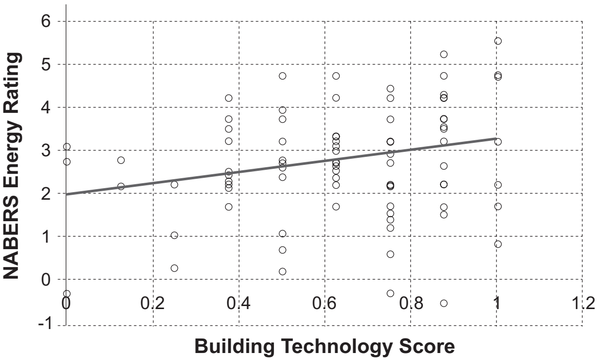

Figure 7: Impact of building technology on performance

A score of 1 represents modern good practice while lower scores represent poorer practice.

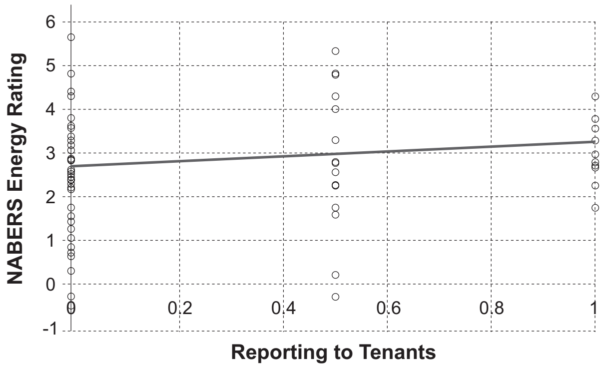

Figure 8: Impact of reporting to tenants on NABERS Rating

The relationship shows a magnitude of 0.5 stars with a statistical significance of 96 per cent.

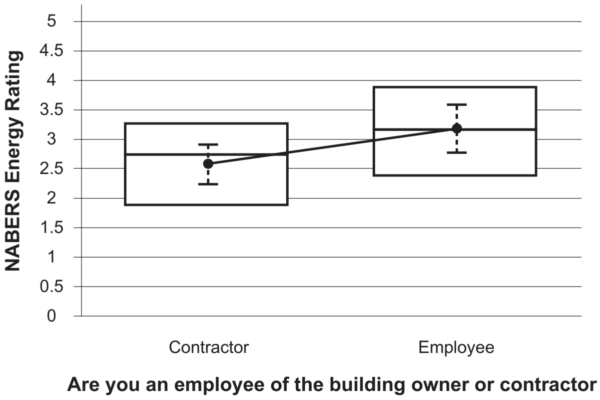

Figure 9: Building managers employment status impact on energy performance

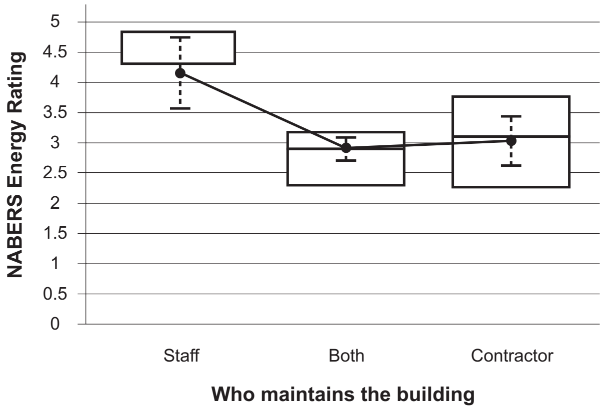

Figure 10: Building maintenance team employment status impact on energy performance

such, it can be seen that the aggregate is not so much a measure of good technology as a measure of the degree to which the building fails to meet good practice. The result therefore indicates that a building with good basic infrastructure has a better chance of achieving a higher performance than a building that has significant impediments in design or equipment. The elimination of such inefficient and often outdated technology of course is often able to be conducted on an incremental basis, supporting the first half of the finding.

3.4 Reporting NABERS performance to tenants and the wider public leads to better performance

The interpretation of the statistical results for this finding required some care as there is a strong risk of reverse causality, i.e. buildings report because they perform well, rather than the other way around. To avoid this problem, the focus of analysis was placed on reporting to tenants separately from reporting to the public, as the former was considered to be less likely to be biased.

The data in Figure 8 were built from the combination of answers on whether the site held regular meetings with tenants and whether they reported energy efficiency performance. Where only one of these practices applied, a score of 0.5 was achieved. As such it is indicative of a level of positive engagement with tenants being correlated with improved efficiency. For comparison, the apparent impact of *public* reporting of energy and water ratings was approximately 0.5 stars at a confidence level of 96-98 per cent.

3.5 Buildings that perform better provide operators and maintenance personnel with reason to care about the performance of the building

This finding is based on three separate statistical results, illustrated in Figure 9, Figure 10 and Figure 11. The first, and possibly most controversial, is that buildings that are managed by staff significantly outperform buildings managed by contractors. The second finding was that staff maintained buildings performed better than contractor maintained buildings, which showed a remarkably large impact of 0.9 stars at 98 per cent

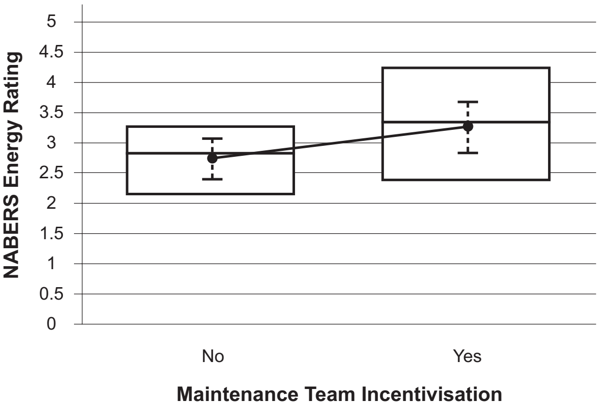

Figure 11: Efficiency-related incentives impact on energy performance

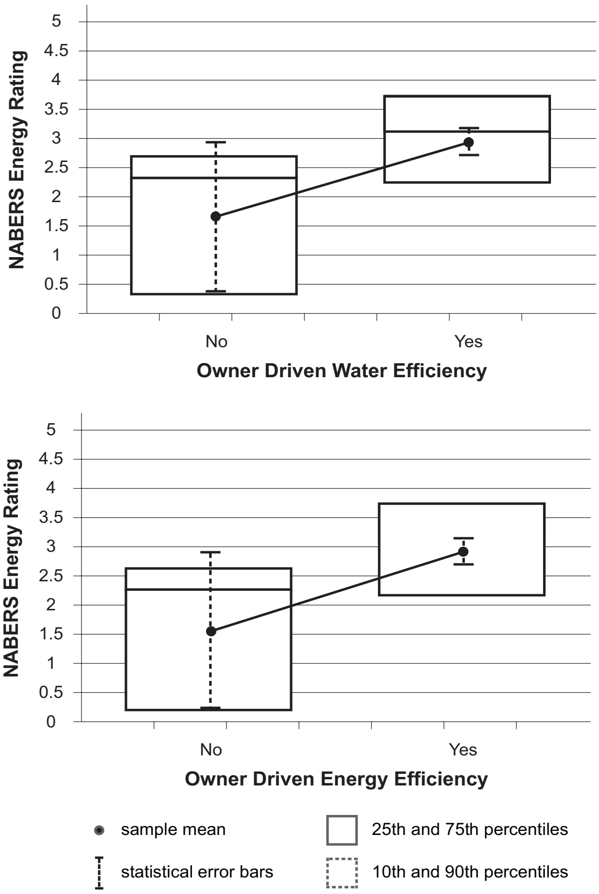

Figure 12: Owner driven energy efficiency impact on energy performance

significance. Finally there was a further result that the provision of incentives for efficiency to the maintenance contractors correlates with better performance. It is noted in this context that all respondents with such incentives actually applied penalties for non-performance rather than incentives for good performance.

While it is tempting to take a simplistic interpretation of these results and argue aggressively for insourcing of operation and maintenance, the depth of the sample and results are probably insufficient to draw such a strong conclusion. As a result, a less aggressive interpretation is preferable. In this case, it is clear throughout the results that better results accrue when the operators and maintenance workers have a reason to care about performance, be it because it affects them directly as staff of the owner or because there are penalties or incentives applied in relation to efficiency.

3.6 Buildings that perform better have strong management leadership in and share common objectives for efficiency throughout the management chain and retain efficiency savings in budgets

There were several results supporting this finding, specifically:

- Sites reporting that the main driver for energy or water efficiency came from within the ownership group had better performance on average by 1.3 stars (same for both energy and water) at a confidence level of 99 per cent (Figure 12).
- Sites where multiple layers of management reported that they felt they had the ability to control energy efficiency had better performance on average by 0.9 stars at a confidence level of 99 per cent (Figure 13).
- There was a weak but significant correlation between the number of years that savings were retained in budget and the NABERS performance (Figure 14).

3.7 Buildings perform better when the staff are given training in energy efficiency and are not overly conservative with respect to efficiency technologies

Again, this finding was supported by multiple results:

- Sites that reported that they had a training program for energy efficiency demonstrated a rating 0.5 stars higher than those that did not, at a confidence level of 98 per cent (Figure 15).
- Sites where the building managers reported that they had a higher level of skill in energy efficiency achieved better ratings (Figure 16). This was the only result where skills appeared to translate to an impact on performance – notably formal qualifications did not appear to cause any impact on building performance. This probably reflects the lack of direct relevance in available formal qualifications
- Sites where the building manager reported that they only considered investments in proven technology showed a generally poorer performance (Figure 17). Interestingly, the strongest impact was that conservatism about water efficiency technologies had a 0.5 star impact at 97 per cent confidence on the energy rating (and a similar impact on the

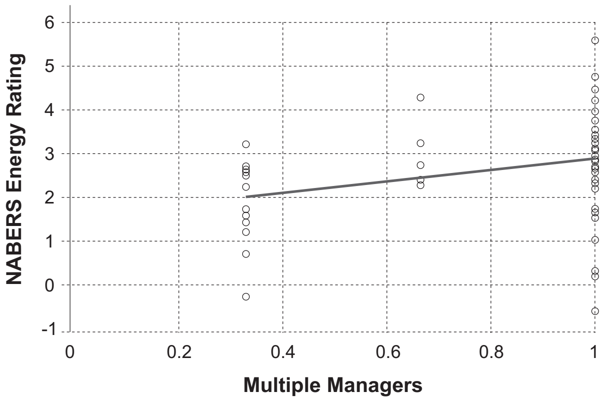

Figure 13: Multiple levels of management control impact on energy performance

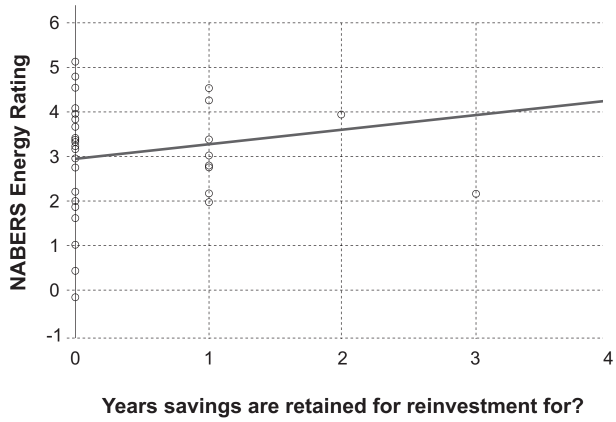

Figure 14: Efficiency savings reinvestment impact on energy performance

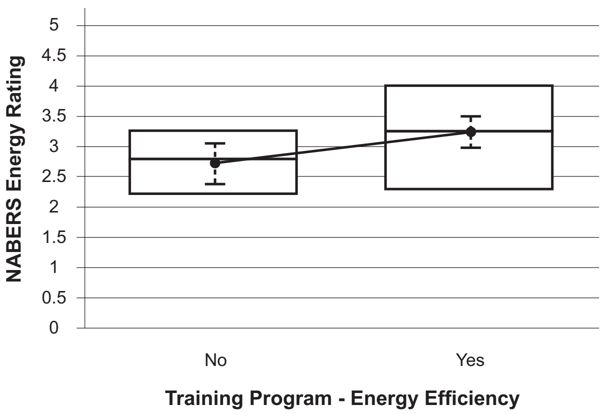

Figure 15: Efficiency training programs impact on energy performance

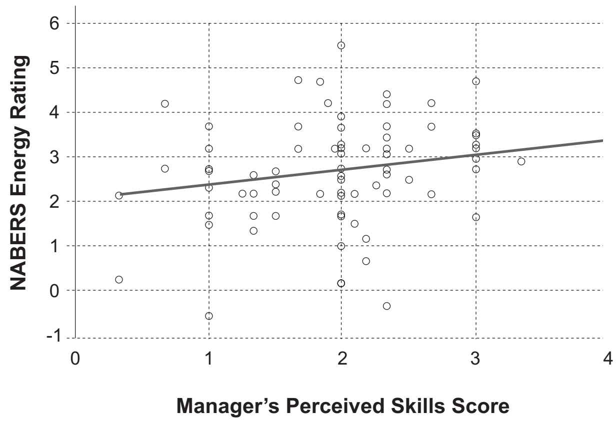

Figure 16: Manager's self-perception of skills impact on energy performance

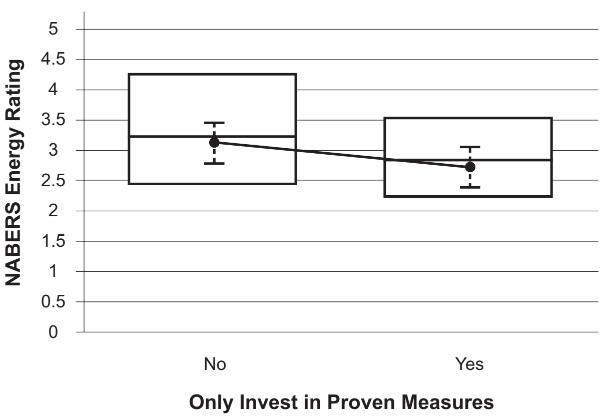

Figure 17: Conservative improvements impact on energy performance

water rating). The impact of conservatism regarding energy efficiency technologies only achieved 81 per cent significance and as a result was not counted. It is suspected that in this context water efficiency can act as a flag for more general conservatism, owing to the more recent appearance of water efficiency as an issue.

4.0 SUMMARY

The major findings of the study are summarised below:

NABERS Energy Impact	Measure Summary
Economy Cycle	
0.6 stars	Buildings with economy cycles outperform those without
Building Technology	
1.4 stars	Buildings with current good practice facade and services technology perform better
Management	
1.3 stars	Buildings where maintenance and management are at least partially internally sourced perform better
0.9 stars	Buildings where building, asset and portfolio manager all feel able to affect efficiency perform better
Weak	Buildings perform better when there is support for efficiency from building owners
Weak	Buildings perform better when energy efficiency savings can be retained in the building budget
Disclosure	
0.5 stars	Buildings that disclose their NABERS performance to tenants perform better
Incentives and Penalties	
0.4 stars	Buildings that provide efficiency penalties/incentives to maintenance contractors perform better
Training and Skills	
0.5 stars	Buildings where there is an efficiency training program perform better
1.3 stars	Buildings where the manager have a higher level of energy efficiency knowledge perform better
Weak	Buildings where the building manager is conservative with respect to new technologies perform poorer
Incremental Improvement	
0.6 stars	Buildings where incremental investments have been made in efficiency perform better than those where no such investment has occurred

Table 2: Summary of major results for various impacts

Energy ratings are shown in NABERS Energy stars

5.0 ASSESSMENT OF ENERGY EFFICIENCY POTENTIAL

Owing to the high level of variation in the circumstances of individual buildings, it is hard to draw on specific evidence to assess the overall energy efficiency potential identifiable from the identified measures on building performance. However, it would appear reasonable to assert that, as there are buildings performing at four stars NABERS for most building technology, PCA grades and ages, there is a reasonable potential for most buildings to be upgraded to this level. This is supported by the results in Table 2, which show nine factors each with an average impact of 0.8 stars, against which the 1.5 star improvement from population mean (2.5 stars) to four stars seems quite achievable.

This overall result asserts the potential for a sector-wide performance improvement of approximately 30 per cent relative to average performance, which coincidentally matches independent assessment by some of the authors based on energy audits (Bloomfield and Bannister, 2007). If these measures were applied to the entire commercial office population of Australia, the gain in energy efficiency from this sector alone extrapolates to a 1.2 per cent reduction in Australia's national GHG emissions total.

6.0 CONCLUSIONS

The Low Energy High Rise Project has undertaken an extensive statistical study of the relationship between key management activities and building attributes and NABERS Energy and Water ratings. The results have demonstrated significant correlations that provide insights into technological and management factors that create measurable impacts on building energy and water efficiency, most of which produce improvements of 0.5 stars or greater in the building's rating. When considered in aggregate, the assessed improvement factors indicate that there is potential for an overall improvement in energy/greenhouse efficiency of at least 30 per cent across the sector.

ACKNOWLEDGEMENTS

This project was very much a team effort, but it the following roles are specifically acknowledged:

Dr Paul Bannister:
Project methodology and direction

Chris Bloomfield and Michael Porter:
Statistical analysis

Robert Quinn:
Data collation, report compilation

Sue Salmon:
Project management and "encouraging" data from respondents

Robert Mitchell and the Warren Centre and the University of Sydney:
Project initiation and the sourcing of funding

The LEHR Working Groups:
Industry engagement and valuable and constructive feedback

Survey Respondents:
A special thanks to those portfolio managers, asset managers and tenants who gave up so much of their scarce time to complete such a comprehensive survey.

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Bloomfield, CJ, and Bannister, P, 2007, *Energy Efficiency Potential of Commercial Office Buildings in Australia*, paper submitted at Sustainable Buildings 2007 (SB07), Hong Kong, December 2007.

Low Energy High Rise Building Research Study: Final Research Survey Report, 2009, The Warren Centre, University of Sydney, Sydney.

NABERS refer to www.nabers.com.au

BIOGRAPHY

Dr Paul Bannister is one of Australia's leading energy efficiency consultants and is the managing director of Exergy Australia.

Chris Bloomfield is an energy efficiency consultant with a strong statistics background and is a director of Exergy Australia.

Michael Porter is a mathematician who is an energy efficiency consultant for Exergy Australia.

Robert Quinn is a director of National Project Consultants.

Sue Salmon was the project director for the Low Energy High Rise Project on behalf of The Warren Centre, University of Sydney.

Robert Mitchell is the Chief Operating Officer of The Warren Centre, University of Sydney.

APPENDIX: SURVEY DISTRIBUTION AND SAMPLE CHARACTERISTICS

Survey Completion and Acceptance

Surveys were distributed to a total of 189 base buildings, 188 tenants and 296 managers. Data exhibited a wide variety of response quality, varying from the complete and plausible, to critically incomplete or non-plausible responses, to those surveys that had not been started at all.

All sufficiently completed Base Building surveys were retained in the primary study, but Manager and Tenancy surveys for which the corresponding Base Building survey was not complete were omitted due to the inability to compare responses with consumption data and hence performance. However, all completed surveys, regardless of the presence of the corresponding Base Building survey, were retained for the purposes of calculating knowledge levels and correlations within survey responses.

Table 1 shows the breakdown of surveys 'distributed' versus those deemed acceptable, excluded and not started.

Given that Tenant and Manager surveys were only deemed suitable for inclusion in the analysis if there was a corresponding acceptable Base Building survey, many otherwise acceptable Base Building surveys could not be used in testing energy/human factor correlations. Table 1 shows the numbers of survey combinations that were useful in this analysis.

Sample Data PCA Grade Distribution

Table 2 shows a breakdown of these buildings by the Property Council of Australia's (PCA) grading system for standard of commercial tenancies, for both the total national office building sector and the 96 base buildings with acceptable surveys that also provided their PCA Grading.

The study sample population has a clear bias towards higher quality buildings. In fact 38 per cent of the total population of premium grade buildings, and 15 per cent of the total population of A-Grade buildings were represented within the sample. By contrast, only 5 per cent of B-grade and close to zero percent of the C and D grade building population was present in the sample.

This bias is due to the fact that those owners or managers agreeing to include their buildings in the survey and/or providing acceptable surveys were typically owners of large, more modern portfolios such as investment funds and Government. These owners tend not to have C and D grade buildings in their portfolios in any significant numbers, and also tend to have better resources, more corporate commitment, are generally better organised, as well as being more exposed to the market forces for the efficiency generated by NABERS.

Figure 1 shows the distribution of all surveys by state broken down into those included and those rejected as having fatal flaws or not started/incomplete. The ratio of included surveys by state reasonably reflects the total population of subject buildings in each state.

Survey Type	Distributed	Acceptable	Excluded	Not Started
Base Building	189	127	42	20
Tenancy	188	102	8	78
Manager	296	173	19	104

Table 1: Survey completion and acceptance

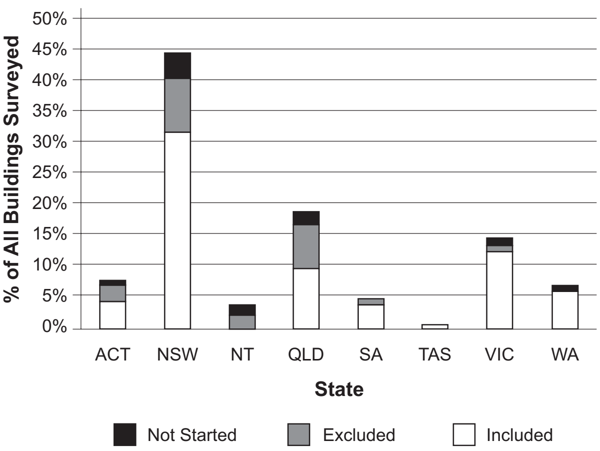

Figure 1: Distribution of building surveys by jurisdiction

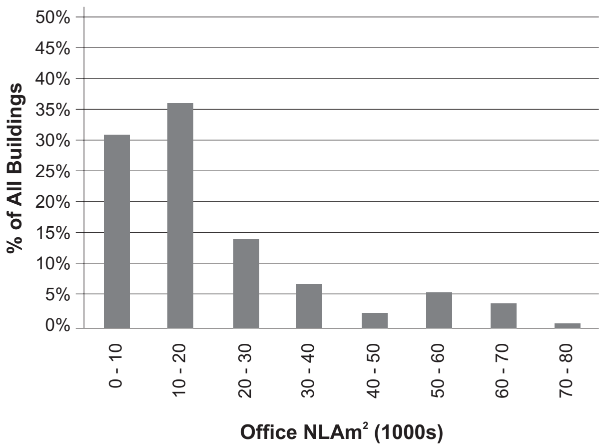

Figure 2: Survey distribution of buildings by net lettable area (NLA)

Population	PCA Grade					
	P	A	B	C	D	Total
Number of PCA ranked properties nationally	32	283	696	730	301	2,042
Portion of properties that have PCA grading	1.6%	13.9%	34.1%	35.7%	14.7%	100%
Sample size	12	43	35	6	0	96
Portion of study sample	10%	37%	30%	5%	0%	18%
Portion of study sample portion of buildings of this grade nationally	38%	15%	5%	<1%	0%	5%

Table 2: Sample and national population PCA graded building comparison

Note that PCA grades referenced are based on the pre-2006 PCA Property Grade Matrix.

Survey Combination	Sites
Building & Tenancy	67
Building & Manager	91
Building, Tenancy & Manager	53

Table 3: Available samples for multi-survey combinations

Response Type	Surveys	Proportion	Mean Rating	Median Rating
Base Building	86	68%	2.87	3.25
Whole Building	41	32%	2.96	2.91

Table 4: Division of responses by rating type

The Median is 50th percentile which gives the midpoint of the distribution and may be a more accurate way to understand the centre of the distribution than the mean, as it discounts outliers or extreme results.

Sample Data Lettable Area Distribution

Figure 2 shows the per cent of surveyed buildings for various ranges of Net Lettable Area (NLA). Buildings less than 30,000 m² accounted for 80 per cent of the total while 65 per cent were less than 20,000 m² and 30 per cent were less than 10,000 m².

Sample Data Energy Rating Distribution

As shown in Table 4, 86 respondents (68 per cent) provided a Base Building rating, while half as many at 41 (32 per cent) provided a Whole Building rating. For these responses the average Base Building rating was 2.87 Stars with an average of 2.96 for the Whole Building rating. This indicates a slight bias in the data towards better performing buildings, but the wide distribution of ratings in the market – which is of greater importance for this study – was present in the sample, as shown in Figure 3.

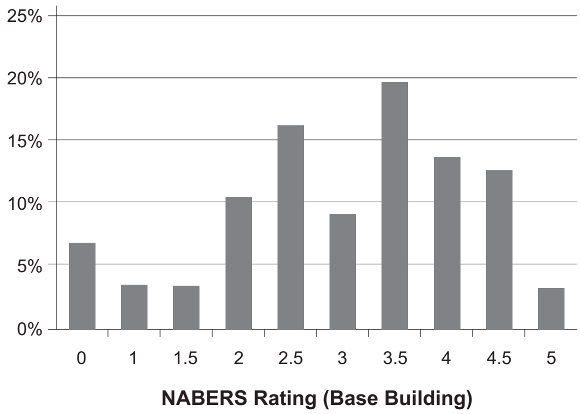

Figure 3: Survey distribution of Base Building NABERS Energy ratings

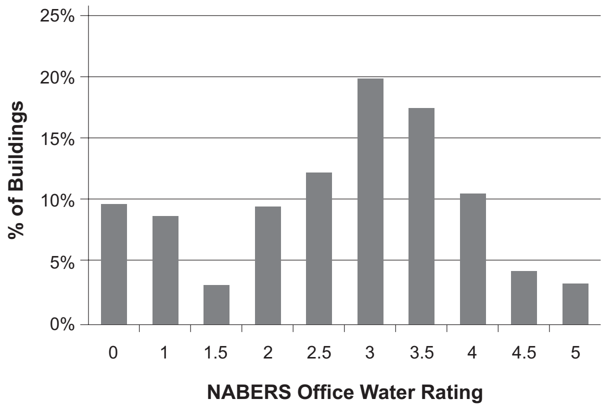

Figure 4: Distribution of NABERS Water Ratings

Sample Data Water Rating Distribution

NABERS Office Water ratings were used as the assessment metric for building water efficiency. These rating were calculated using a combination of formal and estimated ratings. The mean and median ratings were 2.45 and 2.75 stars respectively.

Figure 4 generally exhibits a bell curve distribution with about 45 per cent of buildings having a rating of 2.5 stars or less. Some 50 per cent of buildings scored in the range of 2.5-3.3 Stars. This is a reasonable reflection of the general population.