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'NORMAL' SUSTAINABILITY UPGRADES TO OFFICE BUILDINGS: A SURVEY ACROSS AUSTRALIAN CLIMATIC ZONES

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Abstract

Recent refurbishment strategies for commercial office buildings have emphasised improved energy consumption (sustainability) and energy ratings. Buildings in Melbourne and Brisbane were surveyed to identify strategies adopted and energy saving results achieved because they represent the range of climatic conditions that contain most of Australia's commercial buildings. Consequently, these locations would likely display the diversity of technical refurbishment solutions to achieve sustainability objectives in a range of climatic zones.

The results demonstrate the range of upgrade techniques adopted by asset owners and provide evidence of an emerging 'normal' approach to sustainability upgrades. The resultant energy ratings are also identified.

This research captures the early attempts to improve assets' energy efficiency prior to the implementation of compulsory reporting of energy consumption. In surveying existing practice it shows that while normal practice is important in improving energy efficiency, additional improvements are required to meet targets for deep cuts in greenhouse gas emissions. As a result, a more balanced approach to refurbishment strategies that better integrate energy consuming systems and building fabric should be considered.

Keywords

Asset management, Australia, energy saving, existing buildings, refurbishment, sustainability

Introduction

The emission of greenhouse gases (GHG) attributable to buildings is very high – figures in the order of 20-25% of total GHG emissions (GHGE) can be cited, for example, 23% in RAIA (2008). Reducing GHGE by reducing buildings' operational energy consumption (along with measures in other areas) is thought to be vital in mitigating human-induced climate change (Intergovernmental Panel on Climate Change (IPCC), 2007;Stern, 2006). Despite this reduced demand through energy efficiency is under-recognised at present but can be very significant in economical and effective reductions in GHG emissions (World Economic Forum 2010, 2009). In addition, the issue of building-originated GHGE is important to Australia because it is one of the largest per capita GHG emitters in the world (Garnaut, 2008).

Varying targets for reducing GHGE emissions have been suggested at different times, but a reduction by 25% by 2020 is often suggested as necessary to limit global temperature increases to 'acceptable' levels (+2°C). An implication of a cut of this size is that Australian office buildings need to achieve an average energy rating of 4.5 stars on the 5 stars National Australian Building Energy Rating System (NABERS). This coincides with many Australian governments' requirements for their own corporate real estate (Department of Environment Water Heritage and the Arts, 2009).

Two approaches to reduce energy consumption (and GHGE) are evident:

1. Design and construct new buildings requiring less energy to operate. This is a very good approach as it ensures that energy efficiency is optimised at inception; and
2. Altering the existing building stock to increase energy efficiency which is important because existing buildings dominate the built environment.

The first approach has been presumed in the thrust of many of the global energy rating systems, though some have also been applied to existing buildings. It is evident that new sustainable (energy efficient) buildings are the 'main game' in property development (Arnel, 2007). However, new office buildings typically add 2 – 3% annually to the existing building stock (Jones Lang LaSalle, 2005). If all of these new office buildings were maximally energy efficient (5 NABERS stars) it would take between 33 and 50 years to make all office buildings sustainable through replacement. This does also presume that new buildings totally replace existing ones over time, which isn't the case. In addition, the global financial crisis has severely curtailed investment in new buildings. This makes the second approach of refurbishing existing buildings even more important in reducing GHGE by 2020.

When examining the existing Australian office building stock has very diverse attributes by way of:

- Geographic location, urban contexts and resultant climatic conditions;
- Orientation, building materials, and energy consuming services; and
- Qualitative aspects, such as grade of building (for example, the Property Council of Australia (PCA) classifies from Premium to D grades).

All of the above attributes impact on the operational energy consumption. In addition, the qualitative attribute of the age of the building and the expired service life of its component assets can play major roles in refurbishment decisions – whether these are sustainable refurbishments or not.

Two approaches to treating energy consumption of existing buildings are evident – improvements to building management, for example, Warren Centre for Advanced Engineering (2009), or refurbishment of the physical asset, for example, Davis Langdon (2008). However, there are also at least two problems with previous studies.

- They are generic with regard to the buildings' attributes and locations, as they must as generic studies. Consequently, these studies only provide generic cost and investment (capital expenditure) advice. Depending on attributes and locations refurbishment costs vary wildly, with figures from as low as $6/m^2 (Arndt, 2009) or as high as $962/m^2 (Davis Langdon, 2008); and

- They are single case studies, for example, the (CRC for Construction Innovation, 2008) 'Re-lifing commercial offices' project which used a near obsolete asset as its example.

Both these problems make detailed and specific decision-making by asset owners difficult because of the challenges of applying these studies' knowledge to their particular circumstances.

Though there may be problems in applying research results to specific circumstances Australian asset owners have proceeded with investments to improve their buildings' energy efficiency. This is in response to market demands for more energy efficient buildings and the introduction of compulsory reporting of energy use from 1st November 2010 when selling a building or making a lease commitment – either new or renewing.

Several questions arise from this situation.

1. How are the buildings being altered, that is what component assets are being changed?
2. Do the altered building components vary depending on the building attributes?
3. What energy ratings are being achieved as a consequence?
4. Is that sufficient to meet the 4.5 NABERS star rating required to reduce GHGE by 25%?
5. If not, what else can be done to achieve the required ratings?

It is a useful time to report this paper's research as the data analysis took place just prior to the introduction of compulsory reporting of energy ratings. The results can therefore be said to represent current, market-based best practice in upgrading existing buildings.

Paper's aim

This paper reports part of a project that addresses the questions noted above. Specifically, the paper aims to:

- Investigate and display the range and type of ESD refurbishment techniques that Australian property asset owners currently apply;
- Report the energy efficiency results these refurbishments are achieving;
- Identify whether different refurbishment techniques are used for different climatic conditions (Melbourne and Brisbane are used); and
- Determine whether a 'Standard' or 'Normal' green refurbishment may be emerging.

Overall, this paper provides a snapshot of property asset owners' state of practice in achieving more energy efficient and sustainable buildings in Australia.

Method

The research surveyed a sample of 41 buildings (30 buildings in Melbourne and 11 in Brisbane) that had, by early 2010, undergone a 'green refurbishment'. This breadth of survey contrasts with much of the reporting of sustainability upgrades which features single cases in isolation. Data was complied from several public domain sources with the primary locations indicated as to which data sources applied:

- NABERS Rated Buildings Listing (Melbourne);
- Green Star Rated Buildings Listing (Melbourne);
- Green Building Fund Grants Listings (Melbourne and Brisbane);
- Property websites – for example: http://www.melbourne.vic.gov.au/1200buildings/Documents/1200_Buildings_MCC_500_Collins_St_Case_Study.pdf (Melbourne and Brisbane); and

- Property case studies – for example: http://321exhibition.com.au/pdf/321exhibition-ESD_initatives.pdf (Melbourne and Brisbane).

Melbourne and Brisbane are chosen as they represent different climatic zones (a building attribute). While these two cities may not contain the extremity of climatic conditions of Hobart and Darwin, they do define the ends of the geographic area containing most of Australia's commercial office buildings.

Based on publicly available information, each building's refurbishment was analysed against an 'Analysis Framework for Green Building Strategies' (Table 1)

Table 1. Analysis Framework for Green Building Strategies

SUSTAINABILITY DIMENSION		DETAILED ESD STRATIGIES	
1.	Energy	1.1	Solar electricity
		1.2	Solar thermal
		1.3	Geo thermal
		1.4	Efficient lighting
		1.5	Other power generation
		1.6	Electricity metering
2.	Emissions	2.1	CO_2 monitoring
3.	Water – effluents	3.1	Rain water collection
		3.2	Water efficient fittings
		3.3	Water meters
4.	Land	4.1	Land Initiatives
5.	Transport	5.1	Transport Initiatives
6.	Indoor Environmental Quality (IEQ) and Occupant satisfaction	6.1	Passive cooling
		6.2	HVAC: Efficient cooling/heating
		6.3	Daylight use
		6.4	Façade upgrade
		6.5	Heat recovery
		6.6	Air quality/ventilation
7.	Materials – waste, toxic materials	7.1	Biomass
		7.2	Building material ecology
8.	Waste	8.1	Recycling
9.	Management	9.1	Building automation / management system

After: Green Building Council of Australia (GBCA) (2008) and Seo et al. (2005)

Out of the most important areas, Melbourne refurbishments use all but geo-thermal; Brisbane sustainable upgrades have incorporated only 50% of the possible options (efficient lighting, HVAC, façade upgrade and building automation). This indicates that Melbourne uses more areas of improvements for a sustainable upgrade than Brisbane; not just in regards to the overall number of areas but also the ones that have a major impact on the operational energy consumption of the respective building (and therefore on GHGE). This may also be a reason why Brisbane buildings have a much lower average rating than Melbourne's have.

Especially in regards to the overall aim to diminish the GHGE it is interesting to see that the following areas are rarely been looked at: geo-thermal, passive cooling, daylight use, façade upgrades and heat recovery.

In both cities geo-thermal has not been used at all. The reason can be found in the system itself, either based on piles in the soil (for conditioning spaces using mainly radiation) or horizontal 'tubes' or labyrinths to condition via convection. In both cases, area is needed underneath or besides the building that is hard to obtain when the building is already built and located in urban areas where buildings are built to the property boundaries.

Although passive cooling and heat recovery might be more useful in the Melbourne rather than Brisbane climate, the intensive use of daylight can be implemented in both cities, not just for improving visual comfort but also reducing use of artificial light and cooling loads at the same time.

Only nearly 7% and 18% of the investigated refurbishments in Melbourne and Brisbane are improving the performance of the façade. This is interesting in so far as it is contradictory to the literature indicating the façade to have a significant impact on the operational energy consumption, which can result in savings of the energy consumption of 35-50%. If the building envelope improvements are combined with mechanical system, savings of 50-75% are achievable (Harvey, 2009). This suggests, though considered in this study's buildings, that there are much greater opportunities to optimise façade and HVAC refurbishments to economically improve sustainability.

As there are several tools available for analysing buildings' Environmentally Sustainable Design (ESD) and reported in the study's data, a consistent framework was needed to create comparability in analysing office building refurbishment strategies.

The most widely used Australian green building tools are:

- The National Australian Built Environmental Rating System (NABERS) - now incorporating the Australian Building Greenhouse Rating (ABGR) Scheme; and
- The Australian Green Buildings Council's Green Star Rating System.

Analysing these tools show they both have strongly correlated sustainability dimensions representing very similar approaches to ESD assessment. Several dimensions were found to be directly similar, for example, Energy, Water, Transport and Management appear in both tools. Others were found to be indirectly connected though they could be considered parts of more generic dimensions. For instance, NABERS' Refrigerants indirectly equates to Green Star's Emissions which could capture a wider range of potential emissions, and NABERS' Landscape diversity' and Green Star's 'Land use and ecology' represent land initiatives that could be part of a generic 'Land' dimension.

This suggests that the two tools identify a basic set of sustainability dimensions suitable for an office building ESD refurbishment framework and that a comprehensive framework can be based on a combination both systems' sustainability dimensions.

Similarly, Kimmet and Boyd (2004) acknowledged that all relevant environmental performance dimensions for office buildings are incorporated in most green building codes. They categorise these performance dimensions as Materials, Energy, Water, Emissions, Effluents, Waste, Transport, Disclosure and Overall Natural Environment Rating. As these classifications correlate well across the rating tools used here, this reinforces the relevance and suitability with this framework's set of dimensions.

However, there are differences within the codes in terms of coverage and exactly what aspects of environmental performance are assessed. A study of environmental rating tools (Foliente et al., 2007) exposes the operational emphasis of NABERS, being geared toward 'Operation and Maintenance', and the development emphasis of Green

Star, which covers the stages of ‘Planning’ and ‘Design’ to ‘End of Life’. This meant that in compiling this framework’s sustainability dimensions we emphasised the NABERS’ dimensions as the basis of this framework.

The detailed ESD strategies in the framework emerged from reviewing case studies of and guidelines for ESD buildings, both new and refurbishments, to identify what, specifically could be done to buildings to make them more sustainable. These were then categorised according to the sustainability dimension they sought to improve.

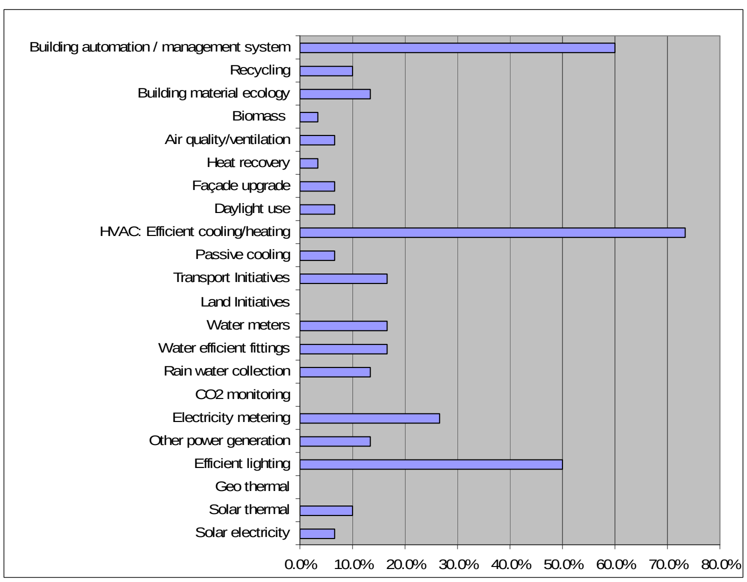
Although further research and detailing of this framework is possible, it provided a suitable basis on which to begin analysis.

Results

The framework indicates areas of improvements that may be used to achieve a sustainable refurbishment. Unfortunately, the available data did not provide much depth in regards to specific systems, methods or technologies that have been applied in the upgrade; they ‘just’ indicate the improvement area such as ‘Heating Ventilation and Air-conditions (HVAC) – efficient heating and cooling’. But this in itself is useful as it indicates a building owner’s ‘focus’ when they do refurbish buildings.

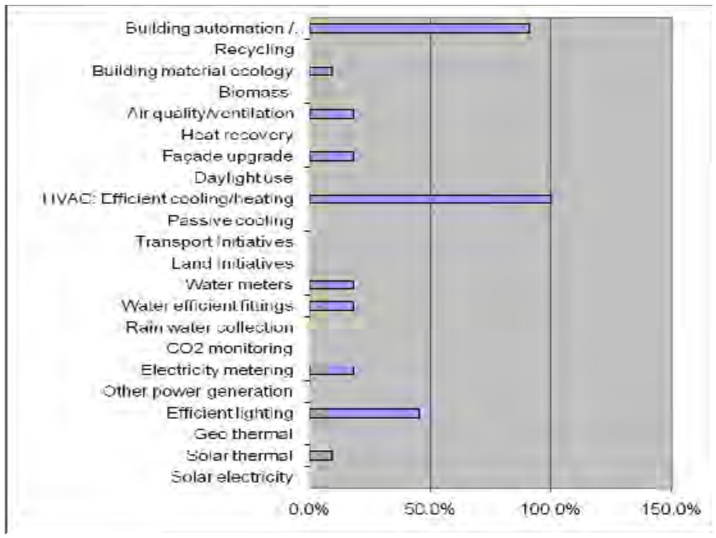
Melbourne’s 30 buildings areas of improvements are shown in Figure 1. The graph shows that 20 out of 22 possible areas of improvement have been used, neglecting geo-thermal and land initiatives. Obviously, the majority of owners upgrade the HVAC system with 73% and building automation with 60%. Every second refurbishment uses efficient lighting systems (50%) and approximately every fourth refurbishment incorporates electricity metering (26%). All other areas indicated in Figure 1 have been applied less than 16 %, whereas nine areas are below 10% and six are up to 16%.

Figure 1. Areas of improvements for sustainable upgrades in Melbourne CBD (n=30)



For the 11 refurbished buildings in Brisbane (Figure 2) only 10 out of 22 possible areas of improvements have been implemented. Every upgrade did increase the efficiency of the HVAC system (100%) and the vast majority either integrated or improved the building automation or management system (91%), whilst nearly every second refurbishment incorporated efficient lighting system (45%). The other seven areas are relatively seldom used.

Figure 2. Areas of improvements for sustainable upgrades in Brisbane CBD (n=11)



Building energy ratings in the study

As shown in Table 2, less than half (43%) of Melbourne buildings and approximately one third (36%) of Brisbane buildings have identifiable NABERS ratings with an average of 4.6 stars and 3.0 stars, respectively. One sixth (17%) of the Melbourne buildings (average 5 stars) and none of the Brisbane buildings had Green Star ratings.

Table 2. Sustainability ratings from refurbished buildings

	No. NABERS rated	**Average rating**	**No. Green Star rated**	**Average rating**
Melbourne (n=30)	13 (43.3%)	4.6	5 (16.7%)	5
Brisbane (n-11)	4 (36.4%)	3.0	0 (0.0%)	n/a

While the Melbourne NABERS average for the sample buildings is within the target of 4.5 stars. In Brisbane the average is well below, which could also stem from the fact that they have been using only a few areas of improvements (10 out of 20) in comparison to Melbourne (18 out of 20). More concerning is the absence of accessible rating data even though many of the buildings meet the requirements for compulsory reporting of energy use. It is thought that this will change after 1st November 2010 but at the time of the survey (early 2010) this information on energy use was not readily accessible for the studied buildings.

It should be noted that there are considerably more buildings and fit-outs in both cities with energy ratings, for example a survey of buildings on the NABERS website identified 26 buildings in Melbourne (3.5 star average rating) and 31 in Brisbane (also 3.5 star average rating), but not all of these are sustainable refurbishments – some are new and some are fit-outs. .

Discussion

The research results show that sustainability refurbishments in both cities have significant similarities despite the climatic variations, though it should be noted that the percentage difference in HVAC refurbishments (100% for Brisbane and 60% for Melbourne) may be climate-based. It is possible that within the various strategies different technical solutions may be implemented for different climates, for instance, the types and sizes of HVAC technology but at the level of available technical information it is difficult to know.

There are a number of differences between the two cities' sustainable refurbishment strategies that could be climate-based. For instance heat recovery and passive cooling were not used in Brisbane but were in Melbourne. However, there were differences that cannot be accounted for on the basis of climate in that they are counter-intuitive to what might be expected. For instance, rainwater collection, solar thermal and solar electricity were not used in Brisbane when one might expect that they would be very useful climate-based strategies given its sub-tropical location with opportunities for winter sunshine and summer rain (the recently broken drought, notwithstanding).

The significant similarities point towards an Australian 'normal' sustainable upgrade evolving out of current practice. For both cities the most commonly used areas of improvements are:

- HVAC – efficient heating and cooling (80% of the total sample of 41);
- Building automation / management system (68%);
- Efficient lighting (49%); and
- Electricity metering (24%).

There are several possible explanations why this standardisation across climatic zones may be emerging:

- Many office buildings are owned by real estate trusts or form part of a larger portfolio. As such, adopting a generic approach across a portfolio when refurbishing is understandable resulting in greater conformity in sustainability solutions. This obviously does not acknowledge the particular circumstances of individual buildings due to the attributes;
- The four common areas of improvements represent 'low-hanging fruit' where easy and relatively cheap gains can be made because these areas may have aged building component assets with poor performance characteristics, or there are inefficiencies in buildings' original design or subsequent operation;
- The sustainable refurbishment industry and knowledge is relatively new and therefore might still lack sophistication in designing for specific climate and building types and attributes. This may be exacerbated by an amount of expertise in the industry which means that the same consultants are used across cities and buildings which might add to the similarities in sustainability refurbishment focus and a lack of understanding of building interaction with specific climates and reflecting these characteristic in the refurbishment strategies;
- The HVAC, building automation, and light fittings have relatively limited lives – often in the order of 20 years – making it more likely that they require replacement as part of an asset's normal life cycle. This means they are more likely to be present in any refurbishment plan for older buildings. Also, newer technology available at replacement means that energy efficiency improvements may be possible when this normal asset replacement occurs simply due to the constant development in technology;
- Another reason for the clients to focus on the technologies mentioned above may simply be because they can be accessed from within the building. Any façade or geo-thermal upgrade, for example, might need external access, which increases

the difficulty of such refurbishments and would obviously increase the refurbishment costs; and

- The rating systems themselves may encourage focussing on particular areas through the rewards they provide thereby ‘distracting’ from other issues that target especially the operational energy consumption. This may be seen by looking at the nine areas in the *Analysis Framework for Green Building Strategies*.

To achieve an overall rating above the 4.5 stars target required to achieve the 25% GHGE reduction it is likely that all of the nine areas of improvements in the *Analysis Framework* that affect energy consumption may need to be utilised. These include: use of geo-thermal energy, efficient lighting, passive cooling, efficient HVAC, daylight use, façade upgrade, heat recovery and building automation system.

Out of the most important areas noted immediately above, Melbourne refurbishments use all but geo-thermal; Brisbane sustainable upgrades have incorporated only 50% of the possible options (efficient lighting, HVAC, façade upgrade and building automation). This indicates that Melbourne uses more areas of improvements for a sustainable upgrade than Brisbane; not just in regards to the overall number of areas but also the ones that have a major impact on the operational energy consumption of the respective building (and therefore on GHGE). This may also be a reason why Brisbane buildings have a much lower average rating than Melbourne’s have.

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Comments on data availability.

This research was undertaken before the requirement for compulsory reporting of energy performance, though its implementation is imminent at the time of writing. As a result, the research is based on publicly available information only therefore the resultant building analysis is not be complete in all technical details, as noted above. Nevertheless, the results still shed light on the key areas of upgrade and refurbishment, though there are a number of qualifications about the building data that need to be noted.

First, buildings with the most readily available information on their sustainability refurbishments tend to be higher-profile Premium and A-grade buildings. Refurbishment work for B and C-Grade buildings is not well documented. It is important to note this because, while Premium and A-grade buildings comprise the largest percentage of Australian office floor area, B and C-Grade buildings are the most numerous buildings. Also, the latter are more likely to be owned by small investors who may have constrained technical capacity to know how to undertake sustainability refurbishments. They will be even more reliant on the relatively limited environmentally sustainable consulting expertise noted above.

Second, information about office building refurbishments in Brisbane is scarcer than that in Melbourne suggesting the ESD refurbishment market may be less mature there. Third, the detail of the information available for specific building refurbishment is limited and biased according to focus of specific author, for instance a number of buildings were sourced from a ‘green building’ grants website. This really only contained information about the funded upgrade works and not the ratings achieved.

Conclusion

This research examined the recent refurbishment strategies adopted in Melbourne and Brisbane buildings to improve their energy efficiency as indicated by their NABERS rating. Whereas it was thought likely at the outset that different refurbishment strategies would be adopted because of the different climates this was found, generally, not to be the case. There were some instances where different strategies were adopted. However, there were enough instances where beneficial climate-based strategies were not adopted to suggest that sustainability improvements that were being adopted were not selected on the basis of climate. Instead, a common ‘normal’ refurbishment strategy was identified that focussed on HVAC systems, building automation and management systems, efficient lighting and electricity metering. While these are also most likely to be replaced in a normal life cycle they can also make quite significant improvements in rating tools’ assessments.

The survey of the respective buildings did provide information on the areas of improvement but, unfortunately, not detailed material on what precisely was done within these areas; for example, what sort of upgrade the HVAC system received. More precise information could further indicate a focus within a particular area of refurbishment and therefore enable more precise comparisons.

The result rating levels are quite good for those that report them. However, it is likely that a much lower figure would be achieved if more of the buildings’ ratings were available. This suggests that more needs to be done if deep GHGE cuts (25% for the purposes of this paper) are to be achieved.

More can be done by way of use of possible low GHG emitting energy technologies that impact on operational energy use and resultant emissions which were often absent in the refurbishment strategies adopted in the study’s buildings though these can be said to represent current best commercial asset management practice in Australia.
It was found particularly interesting that the building envelope, that has a proven and very significant impact on the operational energy consumption, seemed rarely approached when sustainable refurbishments are currently implemented. Misperceptions in regards to overall costs for the upgrade and/or the general strategies

portfolio managers come up with might hinder tackling this important building element.

However, an integrated approach to refurbishments where the inter-relationship between façades, HVAC and lighting systems are not just possible but provide opportunities for making deep cuts to GHG emitted as a result of building energy use. This approach was seems absent in the buildings studied here due to the infrequent use of façades upgrades and the quality of the information available, but this work suggests that such an approach to refurbishments to improve sustainability may be fruitful and require testing for its application to asset management decisions.

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