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CLIMATIC INFLUENCE ON LIFE-CYCLE INVESTING FOR SUSTAINABLE REFURBISHMENTS IN AUSTRALIA

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ABSTRACT

International research indicates that reductions in greenhouse gas emissions are necessary to mitigate climate change. Australia, in particular, has an urgent need to do so, as it's per capita emissions are among the highest in the world. Building owners facing investment decisions are ill-equipped with information as to the technical necessities that upgrade their particular building to achieve deep emission cuts and the financial impact the decisions have on the net present value and internal rate of return investment criteria. Previous studies lack specificity and provide 'only' generic figures for upgrade costs and do not take into account differences in buildings with regard to their attributes and locations. This research investigates methods to provide greater precision for sustainable refurbishments and their optimal timing. An office building in Melbourne was used to develop sets of improvements using an integrated approach to upgrade mechanical services and the building envelope. Using asset management trigger points the impact on net present value and internal rate of return were calculated, taking into account the capital expenditure required, the energy savings due to the refurbishment, as well as a possible rental increase due to the upgrade and lesser operational energy bills for the tenants. To investigate the importance of the location attribute the upgraded building was modelled in a different climate by using a Brisbane weather file. This research clearly indicates the importance of a refined method for sustainable upgrades taking into consideration building attributes and location as well as the life-cycle approach and timing of asset management decisions. The results show the usefulness of the applied method, the various upgrade technologies, the timing of the decision in regards to investment criteria and how they might differ in different climates.

Keywords: *Asset Management, Climate, Life-cycle investing, Refurbishment, Sustainability,*

INTRODUCTION

The need to reduce energy consumption and greenhouse gas (GHG) emissions in mitigating climate change is clearly shown in international research (Intergovernmental Panel on Climate Change (IPCC), 2007;Stern, 2006). As Australian research shows that its per capita emissions are among the highest in the world (Garnaut, 2008)and that its buildings contribute approximately 23% of the nation's GHG emissions (RAIA, 2008). This is a reason for Australia to aspire to cut GHG emissions by a minimum of 25% by 2020. A 25% cut means that commercial office buildings, on average, will need to achieve an energy rating of 4.5-stars on the Australian National Australian Building Energy Rating System (NABERS) in order to achieve the necessary abatement of CO_2 emissions. While an average of 4.5-stars will produce the required reduction, any new design or refurbishment should aim for greater than that (5-stars) because there are some buildings, for instance, heritage buildings that may not be able to be sufficiently improved to meet the required average. Also, there is some anecdotal evidence that design targets for new and refurbished buildings are not being met in operations.

The NABERS rating tool is a system of measuring only energy efficiency, unlike other systems like GreenStar (Australia) or LEEDS (USA) which include more holistic sustainability dimensions. The original office rating tool is part of an expanding suite of tools for other resources such as water and waste, and other building types. NABERS is important in Australia because it has become a 'default' measure used in recent legislation for compulsory reporting of energy consumption for office buildings. However, there are issues when comparing the same ratings in different Australian states because they use different sources for generating electrical energy. For instance, Queensland (Brisbane) uses predominantly black coal, whereas Victoria (Melbourne) uses brown coal with a greater GHG emission intensity. The current NABERS tool consequently rates Melbourne's buildings at a lower level than comparable ones in other locations. The Australian property owners, via their peak industry body, have successfully argued in a situation where NABERS is the sustainability measure for assessing office accommodation nationally the conversion factors needs to be the same to allow comparison on a like-for-like basis.

BACKGROUND

Approaches to reducing energy consumption

Reduced demand for energy through energy efficiency is under-recognised at present but has very significant contributions to make in economical and effective reductions in GHG emissions (World Economic Forum 2010, 2009). Two approaches to reduce energy consumption (and GHG emissions) are evident:

- 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, though these constitute as little as 3% to the annual increase in building stock (Jones Lang Lasalle, 2005); and
- Altering the existing building stock to increase energy efficiency as these dominate the built environment.

Previous studies into ways of improving energy consumption of existing buildings are of two types – technical improvements to and optimisation of occupants' influence on building management (Warren Centre for Advanced Engineering, 2009), or refurbishment of the physical asset.

Issues for building owners

Buildings and properties are idiosyncratic. Differing building uses, building attributes by way of structure, building envelopes, configuration and services technologies, location and resultant climatic conditions are only some of the possible variables. Approaches to investment objectives and outcomes are also complex – within a broad, simple objective for commercial real estate of maximising returns for minimised expenditure at least 23 possible distinct investment objectives have been identified (Jaffe and Sirmans, 1986). For sustainability refurbishments the decision includes not only what technical improvements to make, given the idiosyncratic building, but when to make them, considering the possible triggers that include commercial pressure points such as the end or prospective end of major tenancies, and renewal of aged component assets, like HVAC systems (service-life and component asset renewal pressure points). Much advice to building owners on possible refurbishments is generic by using hypothetical model buildings, for example Davis Langdon (2008&2009).

Clearly, different real-life circumstances for buildings may require different refurbishment and investment strategies, but which to consider and what to do is problematic for building owners in light of generic figures. This necessitates building owners attempting to make their own sense of such information in how it applies to their own, idiosyncratic situation, or, as may be the case, deciding not to make an upgrade sustainable, as it is more difficult and deemed not worth the effort.

AIMS

The overall research project investigated a methodology for more realistic evaluations of refurbishment options and life cycle investment strategies to upgrade buildings to at least 5-star NABERS energy rating. The successful development of such a methodology promises greater precision and sophistication in understanding refurbishment costs and their optimal timing – as a life cycle investment, which is a more appropriate, holistic approach given sustainability issues require a long-term perspective.

The project, as a whole, aims to addresses a number of aspects: 1) Building use; 2) Building attributes; 3) Location and resultant climatic conditions; and 4) Life cycle investment strategies. As part of evaluating the methodology the location aspect was investigated for what happened to building performance and refurbishment options by 'relocating' the building to Brisbane, even though the actual original study was for a Melbourne building. We recognise that this does not capture all the variables of location, which could include things such as topography, orientation provided by the possible street alignments, or urban context, but nevertheless provides useful information on how refurbishments to achieve sustainability may change in different climates.

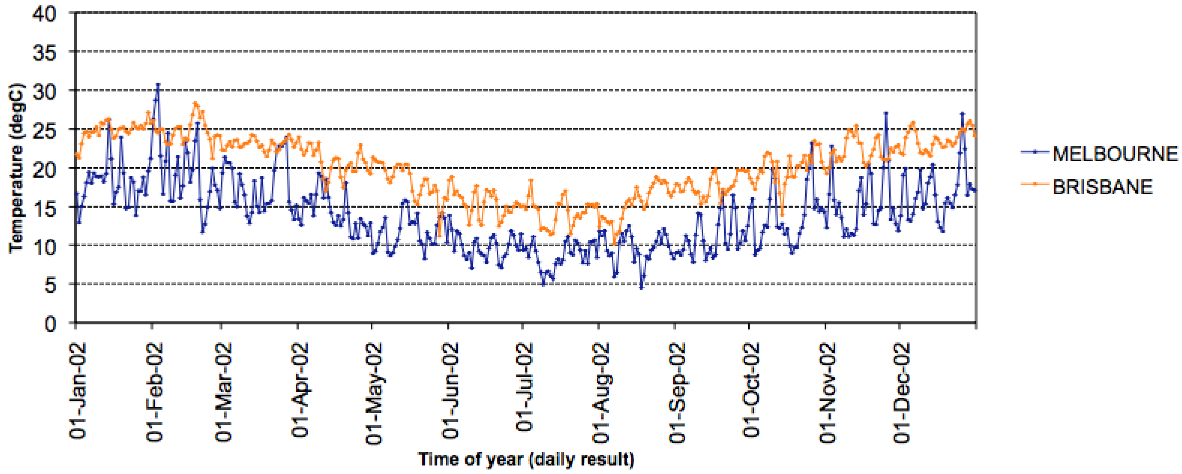
METHOD

Because the researchers were located in Melbourne, one Melbourne office building (21 stories plus a 9-level above-ground carparking podium) was chosen to represent the building use. For this analysis Brisbane was chosen as an alternative location for two main reasons:

- It has a different, sub-tropical, climate from Melbourne's temperate climate (see temperature profile in Figure 1);

- Brisbane and Melbourne represent the climatic extremities of the large majority of the Australian office building stock situated between latitudes 27° 30' and 37° 50' South – Brisbane and Melbourne, respectively. Most of these buildings are located on the Australian eastern seaboard.

Fig. 1. Temperature profile of Melbourne (lower line) and Brisbane (upper line)



The building's owner provided access to energy consumption data, plans, specifications and equipment schedules. From this an electronic building model was constructed to allow energy simulation using 'Design Builder' to analyse the effects of the improvements. These improvements' expenditures were then analysed for changes to Net Present Value (NPV) and Internal Rate of Return (IRR) investment criteria calculated within a life cycle asset management model (LCAM).

This LCAM is a ten-year discounted cashflow (DCF) analysis using an Excel spreadsheet. The DCF inputs were:

- The asset's value at commencement and termination of the analysis period;
- Life cycle investments in renewal of component assets. The component assets were classified using Bromilow's (2000) *Building Property Asset Management Information Guidelines.* A 'life-cycle investment' is one where the component asset is replaced at the end of its service life; for example, the HVAC system's chiller at 20 years, The service lives were estimated based on industry norms and the taxation life under the Australian taxation system. The expenditure was at 'current' prices, that is, current at the date of expenditure. Known 2010 estimates were inflated using a 3.5% Building Price Index (BPI) which is based on historical data from *Rawlinsons* costing guides;
- Operating costs at current prices inflated at a 3.0% Consumer Price Index (CPI). This figure is at the top of the Reserve Bank of Australia's mandated band for the control of inflation;
- Income inflated at the same CPI because this approximates what happens to rental values; and
- Taxation of income and depreciation allowances included in the Australian taxation system for real estate assets. There are two classes of assets in this system – 'depreciable assets' mostly related to occupant amenity; and 'capital works allowances' for everything else.
- A discounting rate of 10% which is between current corporate lending rates and a current real estate investment company's weighted average cost of capital (WACC) of 11% (Ahmedn, 2011). Both figures have been suggested as appropriate discount rates for analysing corporate investments as debt rate theory or WACC theory in modern corporate finance (Golan, 1999).

Seven cases were developed to examine sets of improvements to reduce energy consumption in this single building study. The sets of improvements evolved in later cases to maximise the energy reduction achieved.

The first analysis (Case 1) was a base case example of 'normal' asset investment strategies using the assumptions and framework described above.

The default investment point was at the start of the analysis period because this represents the asset management 'must act now' trigger point, even though other trigger points, such as tenant renewals and service life expiry for major components suggest alternative investment timings. The next six cases were sustainability upgrades. The first of these (Case 2) was an HVAC upgrade. The other five were four façade upgrades (Cases 3 – 6) and a combination of façade and HVAC (Case 7) because of the interconnectedness of these two aspects of building science. The study reported here replicates these cases for Brisbane. It was theorized that the sets of improvements would differ because of Brisbane's sub-tropical climate. Similarly, in a different real estate market with different input variables such as net rentals, operating costs, and construction costs it was thought that there would be different investment decisions about which sets of improvements were best.

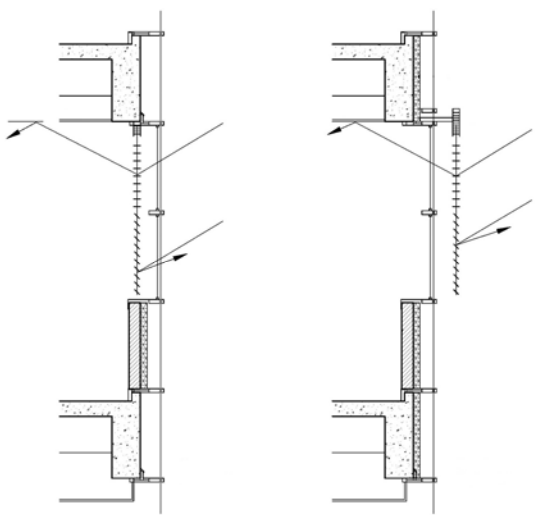
The current building envelope is a fully glazed façade with four equally sized horizontal glass panels per floor, including spandrel panels.

For cost reasons all façade refurbishment options, other than Case 4, can be installed from inside and have a new upstand installed to reduce ingress of solar radiation.

Figure 2 shows the first two cases, 3 and 4, that do not have openable windows. They have a shading system inside (Case 3) and outside (Case 4) that allow daylight penetration through the upper part and sun reflection for the lower part.

Figure 3 demonstrates the façade options Cases 5 and 6 allowing natural ventilation and also including an internal and external shading system with the same properties as Cases 3 and 4.

Fig. 2. Façade refurbishment options (Cases 3 and 4)



Case 3 **Case 4**

Fig. 3. Façade refurbishment options (Cases 5 and 6)

Case 5 Case 6

s ements,’ in this d, on façade technologies, either singly or in combination with consequentially required refurbishment of HVAC, and lighting systems. Energy consumption improvements are possible by changing building elements and technologies such as façade type, lighting and shading systems, heating and cooling strategies and technologies, building material ecology, and more. It is important that, instead of a ‘use as many as possible’ approach to minimize operational energy demand, the minimum number of technologies are used that take advantage of the outdoor environment as much as possible.

Costs related to the case’s sets of improvements (both capital expenditure for the refurbishment and consequential operational expenditures) were then analyzed using the LCAM. While the results presented here assumes an investment in the first year of the analysis period, investment to coincide with other trigger and pressure points could also be analysed but were not for this paper, which concentrates on location and climatic aspects.

RESULTS

The simulation model replicating the studied building showed significant reductions in the operational energy consumption for the various refurbishment options. Table 1 presents the results for Melbourne and Brisbane. As the average temperature is 10 degrees higher in Brisbane compared to Melbourne, Brisbane’s cooling load was higher for the base case – 7,165 MWh (Melbourne 6,409 MWh), and had a significantly lower heating demand of 2,100 GJ (Melbourne 7,057 GJ), as might be expected.

The refurbishments resulted in significant reductions in operational energy consumption. For the best case sets of improvements (Case 7), the energy consumption was reduced by 32.8% for electricity and 87.6% for gas in Melbourne. A similar reduction occurred for Brisbane – 30.9% and 87.8% respectively. Because of the dissimilar units for reporting consumption due to the different energy sources, the only overall measure of reduction is the GHGE for the building, which is 36.6% in Melbourne and 31.9% in Brisbane. Across all the cases, Brisbane’s percentage reductions are less that for the equivalent set of improvement in Melbourne. This results in the best percentage reduction in GHGE emissions for Brisbane’s Case 7 being achieved for Case 6 in Melbourne.

Nevertheless, in both locations external shading and natural ventilation strongly reduces the operational energy consumption for both cooling and heating. The impact of external shading can be seen in moving from Case 3 to Case 4. The impact of natural ventilation can be seen in moving from Case 4 to Case 5.

It also shows that the improvement of HVAC system has a minor impact in comparison with the façade options for both locations. In Brisbane no HVAC improvement is needed to achieve a 5 star rating (see Table 2), which can be ‘easily’ done with the façade Case 5.

Table 1. Operational energy consumption and (raw) GHG emissions for Melbourne and Brisbane (actual consumption data in brackets) - simulation results

	Melbourne					Brisbane				
Reduction in	energy consumption				GHGE	energy consumption				GHGE
	MWh p.a.	%	GJ p.a.	%	%	MWh p.a.	%	GJ p.a.	%	%
Case 1 *(Base case)*	0 (6,409)	0	0 (7,057)	0	0	0 (7,165)	0	0 (2,100)	0	0
Base 2 *HVAC-based*	669	11.5	1,527	0.3	11.0	550	7.7	83	4.0	7.6
Case 3 *Façade Option A*	859	14.4	1,527	14.0	14.4	463	6.5	286	13.6	6.6
Case 4 *Façade Option B*	1,164	19.1	3,843	50.0	20.4	560	7.8	914	43.5	8.4
Case 5: *Façade Option C*	1,790	28.8	6,368	89.3	31.0	1,941	27.1	1,776	84.6	28.1
Case 6: *Façade Option D*	1,939	31.1	6,207	86.8	32.2	2,091	29.2	1,844	87.8	30.2
Case 7: *Case 6 with improved HVAC*	2,052 (4,356)	32.8	6,257 (800)	87.6	36.6	2,215 (4,950)	30.9	1,841 (259)	87.8	31.9

Although the percentage reductions in operational energy consumption are similar in both locations, the NABERS ratings are quite different (Table 2). The best case (Case 7) gives a 4.5 star rating in Melbourne and a 5.0 star rating for Brisbane due to the different conversion factors. If the Melbourne conversion factor were to be applied to Brisbane, the same Case 7 would achieve only a 4.0 star rating which actually shows the 'true' comparative energy consumption.

Table 2. NABERS rating for the sets of improvements

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Melbourne	2.5	3.5	3.5	4.0	4.5	4.5	4.5
Brisbane	3.5	4.0	4.0	4.0	5.0	5.0	5.0
Brisbane equivalent to Melbourne	3.0	3.0	3.0	3.5	4.0	4.0	4.0

It also indicates areas of further discussion and attention. For instance, if a building owner only aimed to achieve a rating of 5 NABERS stars to attract specific tenants, the building in Melbourne would need further or a different set of improvement as the current cases have not fully met this requirement. The same building in Brisbane has already achieved 5 stars with the refurbishment option Case 5.

The refurbishment's necessary capital expenditure and the investment criteria – Net Present Value (NPV) and Internal Rate of Return (IRR) – are calculated for both locations (Table 3).

The differences between the locations are illustrated most clearly in Cases 1 and 2. Case 2 illustrates the construction cost differential (13% higher in Melbourne) (Rawlinson, 2010) which affects both the refurbishments and renewals of component assets at the end of their service lives that are included in the LCAM. Other differences between the locations are:

- Net incomes 16.6% higher in Brisbane;
- Capitalisation rates higher by 0.75% (average);
- Operating costs 10% higher in Brisbane (Colliers International, 2010a&b); and
- Energy costs 3.5% higher in Brisbane (Australian Energy Management Organisation (AEMO), 2011).

Table 3. Capital expenditure, investment net present value (NPV) and investment internal rate of return (IRR) for Melbourne and Brisbane - simulation results

	Melbourne			Brisbane		
	Capital expenditure	Investment NPV	Investment IRR	Capital expenditure	Investment NPV	Investment IRR
	AU$ ('000s)	AU$ ('000s)	%	AU$ ('000s)	AU$ ('000s)	%
Case 1 *(Base case)*	0	-$6,646	11.0	0	-$5,197	12.2
Case 2 *HVAC-based*	$492	-$6,319	11.2	$428	-$5,135	12.2
Case 3 *Façade Option A*	$10,811	-$14,200	7.2	$9,405	-$12,077	9.3
Case 4 *Façade Option B*	$15,800	-$17,736	5.4	$13,746	-$19,768	5.7
Case 5: *Façade Option C*	$5,321	-$8,996	9.9	$4,551	-$7,230	11.3
Case 6: *Façade Option D*	$6,611	-$9,980	9.4	$5,751	-$8,046	11.0
Case 7: *Case 6 with improved HVAC*	$7,103	-$10,236	9.3	$6,179	-$8,924	10.6

Other notable points in interpreting Table 3 are the NPV and IRR values. Without the space for detailed discussion of investment decision-making, the IRR needs to meet organisational investment hurdle requirements and negative NPVs would usually preclude an investment. However, in this building's LCAM analysis the inclusion of high capital expenditures for renewing component assets early in the 10-year analysis period impacts on the Base Cases' values. What matters most here, is how the investment criteria change because of the refurbishments. It must be noted that for all the current input variables in the LCAM the requirement for immediate refurbishment investments only increases the already negative NPVs.

For Case 7, the change in the investment parameters over the Base Case are almost identical in the two locations with NPVs of -\$3,590k (Melbourne) and -\$3,727k (Brisbane) being a 3.8% difference, and IRR reductions -1.7% and -1.6% respectively. For the Melbourne set of improvements offering the same percentage GHGE reduction as the best case for Brisbane (Cases 6 & 7 respectively) Brisbane's negative change in NPV is 11.8% higher and the change in IRR is the same (1.6%).

The change in investment parameters to improve the NABERS star ratings is also important in the Australian context given their utility as a measure of sustainability. Façade Option C gives the maximum uplift in stars for both locations – 2 stars (from 2.5 to 4.5) for Melbourne and 1.5 stars (3.5 to 5.0 stars) for Brisbane (Table 2). This uses the current NABERS energy consumption conversion factors that recognise that Melbourne's electrical energy comes for brown coal and is subsequently more GHGE intense that Brisbane's black coal sourced electricity. As previously noted, NABERS is moving to its conversion factors being the same nationally to allow comparison on a like-for-like basis. When this principle is applied to this building and the NABERS stars are calculated for Brisbane on the same basis as Melbourne, that is, as if Brisbane's building energy was from the same sources as Melbourne's, then the best achievable uplift in rating from the improvements in Brisbane is 1 NABERS star (Table 2). This is also for Case 5 Façade Option C. However, to achieve the same star uplift in Melbourne Case 2 HVAC only is sufficient.

The capital expenditure to achieve that one star uplift is as follows:

- Melbourne AU\$0.492 million (HVAC only); and
- Brisbane AU\$4.551 million (Façade Option C)

This shows that if a building owner would pursue the same uplift in NABERS rating from the existing Base Case, it would require higher capital expenditure in Brisbane (9.25 times) and must include façade upgrades in the set of improvements.

CONCLUSION

This paper presented the results of a study that explored location differences – both climatic and investment-based – in energy efficiency refurbishments. The study corrected building attributes being different in a changed location by using the same building and simulating building and investment performance for two locations – Melbourne and Brisbane – in the same way.

The results show that the sets of improvements had very similar effects in both locations with regard to percentage reduction in GHG emissions (though Melbourne had a 4.7% better improvement). This was unexpected. This similarity was not so for the NABERS ratings where the same improvements produced different ratings and different changes in ratings between the two locations. This is a result of the conversion factors employed in the different locations to convert GHG emissions to star ratings. This confirms that for building owners and users to make efficiency comparisons between buildings in different locations they need to be on the same basis, whether this is within a country (as here) or a market (like Europe or North America).

For the investment criteria, the two locations showed very similar changes for the same sets of improvements in the different locations as a result of the capital expenditure required for those refurbishments. This was also unexpected. When NABERS stars were sought the maximum one star uplift in Brisbane (on the same energy source basis as Melbourne) required 9.25 times the expenditure in Brisbane as required in Melbourne to get the same one star uplift. This was also unexpected.

The study shows that the performance of the sets of improvements was independent of latitude (and related climate), and the investment criteria were also independent of location. Whether the same results apply in the northern hemisphere real estate markets over different latitudes needs to be tested. The approximate Australian latitude differences are those between Cairo, Egypt, and Athens, Greece, or Tampa Bay, Florida,. and Washington DC, USA. Also, whether these types of results apply to buildings with other attributes, particularly façades needs to be tested.

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