Office buildings and the environment – the increasing importance of ESD

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Abstract:
The links between the built environment and sustainability issues such as fossil fuel consumption and climate change is clear. In developed countries buildings contribute around half of all carbon dioxide emissions and offer considerable scope for a significant contribution to sustainability through ecologically aware design and increased energy efficiency (BRE, 1996). The Australian commercial stock emits 12% of all greenhouse gas emissions however the commercial property market has some inherent barriers to sustainability (DSE, 2005). A substantial proportion of the stock is owned by institutional investors who are unconvinced by the need to improve their stock and pass on running costs to tenants (Callender & Key, 1997). As capital values are not greatly affected by sustainability, owners react by doing little or nothing and the effect is to limit sustainability related investment and undermine efforts to deliver sustainability in the sector.

Furthermore the efficiency of buildings declines over time and whilst energy efficiency is important to new design, the existing stock must be improved if urban built environment greenhouse gas emissions are to be reduced. Much of the property and surveying research has previously adopted an illustrative case study approach advocating the benefits of ESD and energy efficiency in existing buildings. This research adopts a radically different approach and profiles the entire office stock of a global CBD, namely Melbourne, which is seeking to become a carbon neutral city by 2020. The research also employs scenario forecasting to model future changes to the stock over a fifteen year period. This paper sets out the rationale for the research and establishes the methodological approach adopted by the research team.

Introduction

The structure of the commercial property market is such that inherent barriers to energy efficiency exist. A significant proportion of the stock is owned by institutional investors who are not persuaded by the need to improve their stock and pass on running costs to tenants (Callender & Key, 1997). Furthermore capital values are not greatly affected by the amount of energy efficiency within a building and owners react by doing little or nothing to improve their property assets, though recent research indicates this may be changing (RICS, 2005). Other barriers include poor information and professional conservatism (Scrase, 1999); the effect is to limit energy efficiency investment and undermine efforts to deliver energy efficiency in the sector. In an effort to improve energy efficiency many Government lead programmes focused on the domestic sector, which is characterised by a large proportion of owner occupiers who have a vested interest in maintaining the capital value and condition of the property (Scrase, 2001). Consequently, a gap in research exists in the area of office buildings and energy efficiency that this research seeks to address. This research focuses on energy efficiency improvements that can be made during refurbishment of CBD offices to reduce CO_2 emissions.

The research is conducted in Melbourne and there are two reasons for this, with the first related to greenhouse gas emissions levels. Chief scientist, Dr Robin Batterham argued Australia must move to a position where deep reductions in carbon dioxide (CO_2) emissions are made, in the order of 50% by 2050 (Australian Financial Review, 2004). Major technological advances, changes in behaviour and practices are necessary to deliver these cuts and action is needed immediately. Victoria's greenhouse gas emissions were 117 million tonnes in 2002, notably more than the total emissions of many industrialised nations with substantially higher populations such as Austria, Hungary, Portugal, Sweden and Switzerland (DSE, 2005). Furthermore, this figure represented an increase of 9.9% over 1990 levels. At 28 tonnes per capita emissions in Victoria and 24 tonnes per capita emissions in Australia as a whole, per capita emissions are higher in Melbourne than any other developed country including the United States. Subsequently, reductions in greenhouse gas emissions are a priority for all state and territory governments. Melbourne, the largest urban centre in Victoria has a population in excess of 3.5 million - paradoxically, it is ranked second in the world's most liveable cities although it may not continue to enjoy such a status if greenhouse gas emissions are not reduced. The Victorian government have stated that programmes are required 'to drive substantial improvements in energy efficiency' (DSE, 2005).

Second, Melbourne is a global city with a stock of CBD office properties similar to those found in other global cities, for example Toronto, Frankfurt or Boston. This research is applicable and transferable to other global cities and can be seen as a blueprint for policy formation with regard to city wide CO_2 reductions. The CBD is of particular relevance because each major westernised city has a central business district, often with an aging stock of high rise buildings (JLL 2005), with many of which having contributed to the provision of a poorer environmental quality for city workers and, increasingly, city dwellers. As cities expand, improving the quality of the stock is important for all stakeholders, investors, occupiers and policy makers.

Long term research aims

This paper details the early stages of an RICS* funded research project that commenced in 2005 and will be completed during 2006 and has two aims:

1. to profile the energy efficiency of the office stock in a global CBD (i.e. Melbourne); and
2. to scenario plan the impact of varying levels of energy efficiency improvements on that stock.

(*note: the authors would like to acknowledge the assistance of RICS with regards to this project which is funded under the RICS Education Trust Jubilee Award).

Energy efficiency and commercial property

Greenhouse gases emitted over the last 150 years have increased global mean temperatures by 0.6 degrees Celsius and projections indicate that unless global greenhouse emissions are substantially reduced, by 2070 Victoria's mean temperature could increase by 5 degrees Celsius (CSIRO, 2005). In developed countries buildings contribute approximately 50% of all CO_2 emissions (BRE, 1996) and thereby offer considerable scope for meeting emission reduction targets through increased energy efficiency (BRE, 1996). Buildings are substantial greenhouse gas emitters; producing more greenhouse gases than all the cars on Australian roads (ABCB, 2001). In Victoria 12% of all greenhouse gas emissions are derived from commercial buildings alone (DSE, 2005). Previous research concluded although readily available means of reducing energy consumption existed, the 'business as usual scenario' will not deliver sufficient reductions to meet the Kyoto Protocol (Australian Greenhouse Office, 1999; ABCB, 2001). Clearly steps needs to be taken to be done to promote wider acceptance and uptake of measures to reduce CO_2 emissions from the built environment, where there is major scope for improving the energy efficiency of Victoria's existing stock (DSE, 2005).

Much research has focused on the technical ways in which reductions of CO_2 emissions may be achieved while other studies (Fisk & Rosenfeld, 1998; Leaman & Bordass, 1999) set out the social and economic benefits of ESD. The general argument is that energy efficient buildings cost less to operate and have better internal environments for occupants, leading to healthier buildings that contribute to mitigating climate change (Scrase, 2001). Despite awareness of the need for conservation, consumption is increasing particularly in the office sector where CO_2 emissions are relatively high due to high electricity demand for heating, cooling and lighting (Scrase, 2001). The current predictions are that the commercial building sector in Australia is expected to increase its greenhouse gas emissions from 32Mt of CO_2 per annum to 63 MT between 1990 and 2010 under a business as usual scenario ((DSE, 2005. AGO, 1999). Under this scenario Australian emissions will significantly exceed targets established by Kyoto. Australia, though not a signatory to the Kyoto Agreement, is taking action to reduce its rate of greenhouse gas emissions to 108% of their 1990 level by 2008-2012.

In Australia electricity accounts for the largest source of energy in the commercial buildings sector at 65% followed by gas at 25%, petroleum products 7% and coal at 3%. However because electricity results in larger emissions of CO_2 it amounts to 89% of the total greenhouse gas emissions, whereas gas, accounted for only 7% of total emissions. Thus substantial reductions could occur if commercial buildings switched from electricity to gas as a source of energy, however current predictions do not envisage an observed change before 2010 and emissions are predicted to double. The abundance of brown coal reserves which generates the bulk of Australia's electricity makes this switch an unlikely event in the current socio-political climate and the associated reductions in emissions will not be realised.

Thus the focus for emissions reduction must turn to improvements in buildings. Building envelope performance has a substantial impact on the heating, cooling and lighting requirements for commercial buildings (AGO, 1999). There is agreement that improvements in the thermal, daylighting and natural ventilation performance of commercial building envelopes will reduce greenhouse gas emissions. Globally developed countries are increasing thermal standards of new buildings (HMSO, 2004) and new construction has higher levels of thermal efficiency than previously, through improved standards in building regulations (BCA, 2005). Australia introduced mandatory standards for energy efficiency in residential property for the first time in 2005 and in 2006 new regulations will be introduced for commercial property that

are inline with global standards (BCA, 2005). These improvements will deliver a building stock with higher levels of energy efficiency however, as Boardman (1991) demonstrated the replacement of the existing stock of properties is so slow that it will take hundreds of years to bring all the stock up to current standards of energy efficiency. Currently in Melbourne the replacement rate for office stock is less than 3% per annum (JLL, 2005).

Energy use in commercial property

When the proportions of energy use and greenhouse gas emissions are considered in the Australian commercial building stock, 1990 figures showed that heating was the largest single end use at 33% but fourth largest with respect to greenhouse gas emissions. Cooling, lighting and ventilation increase in significance when greenhouse gas emissions are calculated and together account for 71% of total emissions. However, the actual proportion applicable to a specific building may vary considerably from the average. Australia incorporates eight climatic zones within its borders and the breakdown of emissions related to specific operational use will vary across the climatic zones. With a diverse climate such as Australia ranging from below freezing temperatures to hot and humid regions, overall the breakdown of specific operational energy applications principally responsible for greenhouse gas emissions are cooling (28%), air handling (22%), lighting (21%) and heating (13%). Heating ventilation and air conditioning and lighting thus account for 84% of commercial building sector greenhouse gas emissions and it is in these areas that the opportunity to reduce emissions lay (AGO, 1999). Table 1 shows the breakdown for the sector in end use and greenhouse emissions. Clearly the potential for reducing greenhouse gas emissions lies in tackling demand and usage in these areas.

Table 1: Breakdown for the Australian buildings sector in end use and greenhouse emissions.

Use	*Energy share by end use (rank in brackets)*	*Greenhouse gas emission share by end use (rank in brackets)*
Heating	33 (1)	13 (4)
Cooling	21 (2)	28 (1)
Ventilation	16 (3)	22 (2)
Lighting	15 (4)	21 (3)
Office equipment & other	9 (5)	12 (5)
Cooking & hot water	6 (6)	4 (6)

Source: AGO, 1999.

In 1990 Australian figures revealed the largest consuming sub-sector to be public administration and commercial services with 36% of the total emissions. Following closely was the retail and wholesale sector which accounted for 32%. The finance and business sector ranked third at 17%, followed by recreation at 11% and finally communications at 4% of the total. When all building types are considered the largest single source of greenhouse gas emissions in buildings came from offices, and therefore the focus for making substantial reductions of emissions lies with this group. However within the buildings sector the question that is yet to be answered is 'how is greenhouse consumption apportioned amongst different groups?'

Office refurbishment

Office buildings require major refurbishment every 20 -25 years. The primary drivers behind conducting refurbishment are reducing vacancy rates, improving rental levels, upgrading assets (e.g. from Grade B to Grade A) and mitigating against obsolescence; the drivers are financial. In Australia, the Property Council of Australia (PCA) are an influential body representing building

owners, as such they lobby government on behalf of owners and exert considerable influence on the market. The PCA office quality matrix classifies stock according to grade. Premium is the highest grade, followed by Grades A, B, C and D. In summary Premium is considered a 'landmark office building located in major CBD markets', Grade A is a 'high quality space', B is classified as 'good quality space', while Grade C space is 'older style with lower quality finish' and D space is of 'poor quality'. This classification is fully integrated into the Australian market and was adopted in this research as a benchmark of quality. Importantly it is considered typical of grading systems in other global cities. Currently the matrix is under review and the inclusion of Greenstar ESD rating is widely known to form part of the new benchmarking metrics.

Australian office markets are relatively mature and characterised by small amounts of new stock coming into the market annually. In the recent past many Australian owners have opted for a series of minor refurbishments to lower the capital expenditure outlay and avoid access problems (JLL, 2005). This market also has a stock of older properties and higher levels of refurbishment are needed for these properties, hence the scope for improvements to the energy efficiency of the stock is correspondingly higher. For example, the average age of Melbourne CBD office stock is 31 years, Brisbane CBD 25 years and the Sydney CBD 28 years, with the average age since construction or last refurbishment for Melbourne CBD being 17 years, Brisbane 13 years and Sydney 19 years. Many of the office buildings in Melbourne were constructed before 1960, require refurbishment and offer significant scope in terms of improvements to energy efficiency (JLL, 2005).

It is vital to examine existing stock (RICS, 1993), and over decade since 1995 refurbishments accounted for 60% of all completions in the Melbourne CBD (JLL, 2005). As energy efficiency was introduced only in 2005, the overwhelming proportion of stock is relatively inefficient. It is not possible to deliver sufficient reductions in CO_2 emissions to meet targets or effect climate change through reliance on building regulations, and consequently the onus is on those who influence stakeholders and professional consultants to deliver the message that improving energy efficiency in the existing stock is of paramount importance. Though there is a convincing rationale for energy efficiency in refurbishment, much improvement in energy efficiency in refurbishment is fortuitous (improvements in technology) or imposed (required by legislation) and the minimum to satisfy the building code (Croxton, 1994) rather than intentional (Cook, 1997). Thus, research into office property refurbishment in the CBD, energy efficiency and the scope for CO_2 reduction is relevant and vital.

Energy efficiency measures

Owners can consider the performance of the façade and either incorporating shading devices or low 'E' glazing where appropriate. The incorporation of Building Automation Systems or Building Management Systems also provides an opportunity to increase the efficiency of the building management system to operate plant and services more efficiently with less waste (JLL, 2005). High efficiency chillers and variable speed drives on pumps or fans offer a further opportunity to increase efficiency and reduce consumption of energy. The current view is that owners need to achieve AGBR (Australian Greenhouse Building Rating) ratings in the 3 – 3.5 star rating bracket in order to remain competitive in the market, however substantial amounts of the stock are believed to fall below this level.

Another driver in the refurbishment of offices is that government and public administration and major corporate tenants are seeking buildings that demonstrate ESD principles. In Victoria government tenants will only lease buildings with 4.5 star ratings under the 'Greenstar' rating system, and in New South Wales the figure is set at 3.5 stars. By 2007 owners wishing to sell office buildings will have to disclose to potential purchasers the energy consumption of the

property as part of the due diligence process and this measure will increase pressures to provide energy efficient buildings.

Promoting the uptake of energy efficiency in the sector

AGO (1999) concluded voluntary measures in the commercial building sector have the potential to produce higher levels of abatement than any of the current government led policies or measures such as the building regulations. The reason being, that in the commercial sector there were low levels of penetration and application in the marketplace of policies and Government measures. Voluntary measures that focused on cost benefits, such as short pay back periods and reduced running costs, were likely to enjoy a higher uptake in the market. The greatest opportunity for greenhouse gas emission abatement occurred in the area of lighting, which showed a potential reduction average of 70% of total emissions. This conclusion is consistent with BRE (1997) findings in respect of the UK office sector. Refurbished buildings can achieve reductions of 50% of greenhouse gas emissions on average, however, in order to maximise effectiveness voluntary measures have to run alongside education programmes and awareness raising.

One priority area for abatement is the public administration sector, for example, approximately 30% of the Melbourne office stock is taken by government and public bodies. Within buildings a focus on reducing demand for electricity will result in the greatest levels of reductions. When building systems are considered, it is the lighting systems that offer the greatest potential for reductions within less than a 2.5 year payback period (AGO, 1999). Equal priority should be given to new build and refurbishment as both offer the same potential for reductions however, given that most building activity occurs in the refurbishment and maintenance of the existing stock and the emphasis should be placed on existing buildings.

The City of Melbourne has set ambitious goals to mitigate climate change by establishing a roadmap to achieve zero net greenhouse gas emissions by 2020 (City of Melbourne, 2003). Rather than a threat, the municipality perceive the zero net emissions strategy as an opportunity for economic growth, environmental improvements and social cohesion, advocating adopting a triple bottom line business approach. The city felt the opportunity had to be seized imminently, otherwise the chance to present the city as a leading centre integrating economic growth and benefits with environmental and social gains would be lost. The strategy uses ‘market mechanisms and appropriate regulations’ to influence business investment that occurs in buildings, plant and power generation and it is at this level that this research project profiling the baseline CO emissions from CBD offices dovetails with the strategy. This research project underpins the city’s target setting process and also allows the municipality to benchmark the likely savings or reduction in carbon emissions that will occur along a business as usual approach and also a best practice approach in CBD office refurbishment. The forecasting and modelling of the emissions will facilitate the targeting of effective policy making to meet business needs and wider social goals.
Set in a wider context, Melbourne and the broader Australian community is conscious of the Asia Pacific setting, where there is rapid growth of cities creating major economic, environmental and social change. For example a city the size of Perth is added to Asia every week (Neilson, 2000). The consequences of globalisation and urbanisation are profound in terms of environmental problems, greenhouse gas emissions, opportunities to export skills and technologies and in the nature of international competition.

Research methodology

Initially the team had to define the CBD for the purposes of the research and to establish a framework whereby an appropriate data set could be selected and collected. A tri-stage approach was adopted, using parts of existing databases supplemented by survey information. The research project database was assembled after consultation with various data providers who collect information on the Melbourne CBD for different purposes. Listed below are the primary data providers and an overview of the type of information provided. This data is aggregated and identification of individual lessees, property owners and related sensitive property information was not possible due to ethical constraints.

The Melbourne CBD office market

In the Melbourne, the CBD office property market comprises of various regions commonly known as; Western core, Eastern core, Flagstaff, Civic, North eastern, Spencer and Docklands. Other office property is located in three other precincts referred to as 'St Kilda Rd', 'Southbank' and 'suburbs'. This research focused on the Melbourne CBD area and excluded the newer areas of Docklands as the majority of the office stock is extremely new, having been completed within the last 5 years and not requiring refurbishment in the short to medium term. The total stock comprises 3,383,709 square metres in July 2005 (CBRE, 2005).

CLUE (Census of land use and employment)

CLUE is an information system about land use, employment and economic activity across Melbourne (www.melbourne.vic.gov.au/clue). It is produced by the City of Melbourne Sustainable City Research Branch and updated every two years. The most recent update was in 2005 and accordingly is the version used in this analysis. For the purposes of this research, the team are interested in the data relating to property. The CLUE database contains information about floorspace, employment, car parking, property use including retail, recreation and office land use. The database also holds information about the nature of the space, for example whether it is under refurbishment, demolition, vacant, leased but not used and so forth. Using the PCA grading systems all office properties are ranked according to the quality of space. The aggregate information in CLUE has been instrumental in collecting data for the forecasting and modelling process for the Melbourne CBD.

Cityscope

Cityscope provided both a historical and spatial perspective in relation to the data collection and analysis of the CBD stock. It is a commercially available database and provides detailed, accurate and extensive CBD property information throughout Australia (Cityscope, 2005). The types of data held on the database include, street frontage, zoning information and site area, detail of development applications, building progress and completion, complete title details and property details such as building services. Over 3000 Melbourne CBD properties are included on the database and updated annually. The database is available in paper, CD and an online version. Cityscope is used in conjunction with CLUE to provide data for the modelling and forecasting of baseline carbon emissions and energy efficiency for the CBD. This research is supported by the 2005 version of Cityscope.

Survey design and implementation

The third component of the data collection for the research is a detailed survey of building owners. The survey provides supplementary information to support the data not included in the

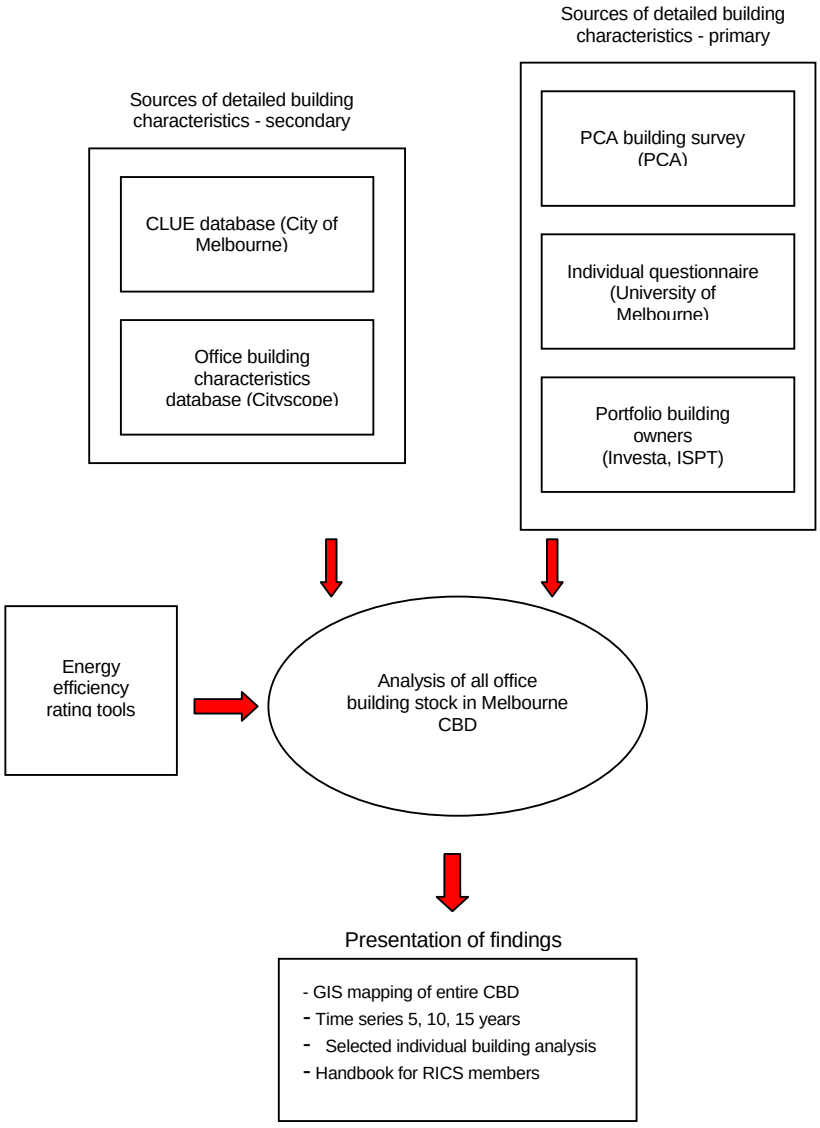
CLUE and Cityscope databases. When conducting research there are challenges in accessing data, especially for property information that is perceived to be sensitive. Sometimes researchers have to compromise on the depth of information collected in order to obtain any data at all. At other times researchers are confronted with response rate issues and negotiating with 'gatekeepers'. Gatekeepers are organisations or people through whom the researcher needs to go in order to gain access to the respondents and to maximise return rates. In this case the PCA are a gatekeeper for building owners. The researchers considered it to be highly unlikely building owners would divulge sensitive information about energy consumption, especially if there was a possibility that their building could feature as an 'energy guzzler'. Although energy efficiency is not currently highly affecting property value, there is an acknowledged perception this is changing in the market place and owners are unwilling to risk having their property stigmatised. The survey requested information that some owners may have some sensitivity concerns about becoming public knowledge. PCA are a strong supporter of the research and agreed to send out the survey to their members with a covering letter explaining confidentiality of data supplied, reassuring participants that only aggregated data will be published about Melbourne CBD property for this research, and importantly no individual buildings will be identified. After extensive consultation the survey has also been sent out to two major property owners in Melbourne, Investa and ISPT who have agreed to complete the surveys for the research.

Computation of carbon emissions

Since 2001 the Australian Building Greenhouse Rating (ABGR) has been used to benchmark buildings energy ratings and CO_2 output and is a recognised metric in Australia. ABGR provides market recognition and a competitive advantage for low greenhouse emitters and energy efficient buildings; and, it encourages best practice in the design, operation and maintenance of commercial buildings. The scheme is administered nationally by the NSW Department of Energy, Utilities and Sustainability (DEUS) and locally by State greenhouse agencies. ABGR rates buildings from one to five stars with five stars representing exceptional performance and current market best practice is three stars. ABGR is voluntary and a rating can be initiated by a building owner, manager or tenant; and it can be used for the base building (central services), whole building or individual tenancies. The AGBR standard was adopted as a benchmark of performance for this research.

Once the data has been collected the research team analyse the collected office building information in terms of the converting energy consumption into tonnes of carbon emissions. This is achieved via the online rating tool at the ABGR website (www.abgr.com.au). Using the two databases and the survey the completed research will have a comprehensive sample of buildings which will produce a statistically significant representation of carbon emissions for the office stock. This data is used to profile the stock in terms of age, size, use, location and so forth. From the new database collated by the research team, the modelling and forecasting process will be undertaken as outlined below. Figure 1 overleaf illustrates the relationships between the various stakeholders and data sources.

Figure 1 – Sources of Information



Forecasting and Modelling techniques

The task of profiling the office stock requires an analysis of all factors that affect the office market, both at a detailed level and from a broader economic perspective. In other words the decision to undertake a refurbishment will be a higher priority to a property owner if the timing is suitable and there is an observed benefit to be realised. For example if a property market is experiencing high tenant demand with low vacancy rates, owners will have little incentive to spend additional capital expenditure to attract tenants. On the other hand a building owner in a marketplace with high vacancy rates will have to actively compete with other buildings, both new and refurbished, for buildings. Clearly an older building with higher obsolescence will struggle to effectively complete in this type of marketplace.

Forecasting trends in office markets in an integral part of cash flow analysis and there are various indicators that need to be considered. Property professionals in Australia are focused on addressing this need, and the project is well supported by market analysts from global firms such as Jones LaSalle, CB Richard Ellis, Colliers International and Knight Frank. Furthermore there are industry bodies (e.g. Property Council of Australia) and professional organisations (e.g. Access Economics) who also contribute to this body of knowledge. For this project the models for the Melbourne CBD office market are based on 5, 10 and 15 year timeframes will focus on the following indicators:

- Office market vacancy rates (Premium, A, B, C and D grades);
- Leasing rates per m^2 (Premium, A, B, C and D grades);
- Supply of white collar workers;
- Changes in the area per m^2 for each worker;
- Supply of new office stock;
- Removal of office stock from the marketplace (demolition or conversion rates);
- Factors that influence depreciation and obsolescence levels;
- Variations in government legislation towards energy efficiency;
- Level of operating expenses including effect of inflation;
- Government policy towards leasing CBD office space;
- Gross domestic product and overall confidence in the broader market;
- Trends in other competing investment (e.g. share market, cash);
- Returns from property investment including growth of listed property trusts.

This research is accessing a cross section of data sources as well as undertaking primary data collection via surveys, within a short timeframe. Accordingly there are limitations and constraints to be acknowledged. A large proportion of the data is being sourced from respected property organisations and is of the highest standard. Considerable efforts are being undertaken to ensure the final dataset is both reliable and complete, including an ongoing validation process during the data collection phase.

Aim 1 of the research is to be achieved by profiling the stock and examining the variables in terms of age, size, location, energy consumption per square metre and so forth. This will enable the team to determine the characteristics of the stock in the baseline year 2005. The fulfilment of aim 2 will then occur through modelling the data and predictions will be made based on all of the information available, such as vacancy rates and the length of the construction cycle. This process is ongoing at the time of writing. Whilst every care is taken to ensure these assumptions are correct, there is no certainty about long term future predictions over periods up to 2020. Thus a degree of caution should be exercised and some flexibility must be incorporated into any modelling process. Furthermore, forecasts concerning financial decisions are influenced other investment classes such as the share market and interest rate levels where predictions on a short term basis are often difficult.

Conclusions

This paper has presented a rationale and a format for undertaking research into CO_2 emissions and office buildings, with the emphasis placed on a CBD office market that is representative of a global city. The research is unique in that it profiles a whole CBD over a 15 year time frame to establish potential and likely reductions in emissions rather than a narrow focus on individual exemplar case study buildings. The data collection process presented the many challenges that were overcome, given the sensitive nature of property information and data availability and it was agreed to aggregate the data so individual property owners and tenants could not be identified. The combination of different datasets and surveys provided an opportunity to build a unique and comprehensive dataset that would accurately profile the stock both at present, and also using 5, 10 and 15 year timeframes.

All building owners and managers will undertake measures to improve levels of energy efficiency in their buildings if they perceive there is a gain to be made or a loss to be avoided, either financial or some other form. It remains challenging to predict exactly how and when the perceptions of building owners and managers towards energy efficiency will change over time. The increasingly high profile of rapid climate change and building sustainability has undoubtedly raised the profile of the environment of society at large, including shareholders of organisations who in turn are embracing and calling for corporate social responsibility. Nevertheless, benefits such as increased awareness of the environment by building owners that affect modelling in this research may be a relatively small limitation for a comparatively large positive contribution to the environment.

This paper has stated the important contribution that office buildings, and the refurbishment thereof, makes towards sustainability and the overall reduction of CO_2 emissions and the need to examine large amounts of stock as well as individual buildings. This research format can be extended to other global cities such as Auckland, London, Singapore and Sydney, as well as to other land use types including retail and industrial. Dramatic changes in weather patterns have been observed globally with devastating consequences including floods, droughts and hurricanes. Whilst there is little argument that global climate change is occurring, research into the contribution buildings towards climate change has never been more important. This paper presents the initial steps in profiling the sector of CBD stock to examine the potential for reductions in CO emissions over a given time frame and further research is vital to evolve the knowledge base and theoretical frameworks.

References

Australian Buildings Codes Board, 2001 Energy Efficiency in Building Directions Report. www.abcb.gov.au (date accessed 10th May 2005)

Australian Greenhouse Office, 1999. Australian Commercial Building Sector Greenhouse Gas Emissions 1990-2010. Executive Summary Report. The Australian Greenhouse Office, Canberra, ACT. ISBN 18 76536 195.

Australian Financial Review, 2004 Dr Robin Batterham. 9/9/2004.

BCA. 2005. Building Code of Australia 2005. Australian Building Codes Board Canberra, ACT. ISBN 1 74134932X.

Bennett, M. & Newborough, M. 2001. Auditing energy use in cities. Energy Policy. Vol. 29. pp 125 – 134. Elsevier Science Ltd.

Berenson & Levine. 1992. Basic business statistics. pp 668 – 673. Prentice & Hall.

Boardman, B., 1991. Fuel poverty: from cold homes to affordable warmth. London ; New York Belhaven Press

BRE, 1996. Potential carbon emission savings form energy efficiency in commercial buildings, by S.A. Moss. Building Research Establishment IP3/96.

Callender, M. & Key, T, 1997. Value of the UK commercial property stock. Presented at the 6th Investment Property Databank Investment Strategies Conference. Brighton, 27-28 November.

CBRE 2005. Market view: Melbourne Office. Third Quarter. July 2005. www.cbre.com.au

Chandler, I. 1991. *Repair and Refurbishment of Modern Buildings.* B T Batsford Ltd, London.

City of Melbourne 2003. Zero net emissions by 2020. A roadmap to a climate neutral city. City of Melbourne, February 2003.

Cook, S.J. 1997. Thermal improvements in commercial refurbishment: An international comparison. RICS Proceedings of COBRA conference University of Portsmouth.

Croxton, R. 1994. *Audubon House. Building the environmentally, responsible, energy efficient office.* John Wiley & Sons, New York.

CSIRO, 2002. Energy & Transport Sector: Outlook to 2020. www.csiro.au (date accessed 10th May 2005)

DSE. 2005. Victorian Greenhouse Strategy Action Plan Update. VICTORIAN Goverment Department of Sustainability & Environment, Melbourne. ISBN 1 74152 109 2

JLL, 2005. Building refurbishment – repositioning your asset for success. March 2005.

Fisk, W.J. & Rosenfeld, A.H. 1998. Potential nationwide improvements in productivity and health from better indoor environments. Proceedings of the American Council for an Energy efficient Economy Summer Study on Energy Efficiency and Buildings, **8**, 85-97.

JJL. 2005. Building Refurbishment – Repositioning your Asset for Success. Jones Lang Lasalle March 2005.

Moss, S.A., 1994. *Energy consumption in public and commercial buildings.* BRE IP 16/94. BRE, Garston, Watford.

Neilson, L. 2000 Asian urbanisation and the impacts on Australian Cities. PCA Brisbane.

PCA 2005 Benchmarks 2005, PCA Sydney Australia.

Robinson. J. & Reed, R. 2003, *The significance of depreciation and obsolescence in the assessment of long term property values* presented at the 19th Annual ARES Conference, 2-5 April 2003, Monterey.

RICS. 1993. *Energy appraisal of existing buildings. A handbook for surveyors.* Surveyors Holdings Limited, London

RICS Foundation. 2004. Sustainability and the built environment – an agenda for action. October 2004.

RICS 2005 *Green Values. Green Buildings Growing Assets.*October 2005.RICS London. www.rics.org/greenvalue

Scrase, J.I., 2001*Curbing the growth in UK commercial energy consumption.* Building Research & Information. (2001) **29**(1), 51-61