OFFICE BUILDINGS - THE IMPORTANCE OF "MAKE GOOD", FITOUT AND RECURRING EMBODIED ENERGY

(SCIENTIFIC PAPER)

DR PERRY FORSYTHE

Faculty of Design Architecture and Building
University of Technology Sydney
PO Box 123 Broadway NSW 2007

ABSTRACT

The sustainable refurbishment of buildings is of increasing interest because existing building stock far outweighs new building stock in developed cities. Life Cycle Assessment (LCA) represents a holistic means of measuring the total energy usage in buildings, including the likes of embodied energy and operating energy. This paper debates an apparent gap in the LCA literature, in that much of it only looks at initial embodied energy, and pays little attention to recurring embodied energy associated with the continual refurbishment and repair of buildings. This is particularly relevant to office buildings as many under "*Make Good*" on a regular basis – often as short as once every 7 years. *Make Good* involves the procedure at the end of office space leases, and typically includes the demolition of the outgoing tenant's fitout, followed by the reinstatement of the pre-lease fitout, which may then be further changed by the incoming tenant's specific fitout needs. This very wasteful process generates significant recurring embodied energy. The paper helps identify the scale of the problem, the impact of occupancy churn, and analyses a selection of existing LCA studies. Finally, the paper explores the small amount of literature that focuses on the occurrence of recurring embodied energy in buildings. The study puts forward the case for further research in this area, focusing specifically on *Make Good* and the associated office fitout. This is expressed by way of a structured series of research questions that come out of the paper, and include potential solutions such as the re-think of office fit-out design.

KEY WORDS: sustainability; office building; embodied energy; make good

INTRODUCTION

In a recent study, the building sector was identified as being responsible for 23% of Australia's total greenhouse gas emissions (Larson 2008). Energy usage is clearly a significant part of the greenhouse problem, and to place this in context, the building sector in Europe is said to contribute up to 40% of total energy consumption (Zabalza Bribián et al. 2009). In the Australian situation – being the focus of this paper - a recent Senate Inquiry is considering the introduction of an energy emissions intensity baseline for non-residential buildings, whereby overuse of energy (above the baseline) will require users to buy energy credits (http://www.aph.gov.au/Senate/committee/economics_ctte/energy_efficient_buildings_09/info.htm). Its core interest appears to be in reducing the amount of operating energy used by non-residential buildings. Programmes that focus only on operating energy also exist in countries such as Thailand (Kofoworola & Gheewala 2009). Even so, this paper advocates a more holistic approach that goes beyond a singular focus on operating energy, one based around the principles of Life Cycle Assessment and especially a deeper appreciation of embodied energy.

With regard to LCA, Sartori and Hestnes (2007) note that different proponents have slightly different versions of what is included and excluded in calculations of embodied energy. For instance building materials and products are unilaterally included in embodied energy calculations but more sporadically transport, construction and waste recycling may also be included. Though such issues provide an important backdrop to operational definitions and the interpretation of findings from past studies, there is a need to re-assert the importance of viewing total embodied energy as involving two categories: "initial" and "recurring" embodied energy. The former appears to be used as the main basis for most LCA studies, but more attention needs to be directed towards the under-reported impact of recurring embodied energy (Verbeeck & Hens 2009).

By definition, recurring embodied energy relates to established buildings because it manifests over the life of the building rather than upon the newly built structure. This is an important area of study, because established buildings easily dominate the overall building stock and therefore represent the best area for progress in improved sustainability outcomes (Bullen 2007). Specifically, the focus is on the recurring embodied energy associated with *Make Good* in office buildings. It is argued throughout the paper that this is not appropriately taken into account in the energy calculation debate, and therefore needs to be more fully addressed.

Make Good focuses on the hand back procedure at the end of office space leases, and typically involves the demolition of the outgoing tenant's fitout including partitions, furniture, finishes and stripping out of building services, followed by the reinstatement of the pre-lease fittings, fixtures and finishes (RICS 2009). As part of the overall process, the incoming tenant may undertake their own fitout to meet their specific needs. Cleary, the large open spans of many office buildings make it possible for the *Make Good* process to take place with little impact on the structure of the building. In some ways, the physical fitout component can be conceptualized as a small building being regularly re-constructed within the shell of a larger building. However, a sustainability problem exists because of the overly frequent occurrence of the *Make Good* process. For instance, the Royal Institute of Charted Surveyors make the point that the previously described process includes many iterations of wasted embodied energy (RICS 2009). The lack of attention to this issue is serving to prevent more sustainable solutions and outcomes for office buildings. This paper therefore poses the argument to give greater consideration of recurring embodied energy in office building *Make Good*, and subsequently presents an ongoing research agenda to address this issue more fully.

HOW OFTEN DOES "MAKE GOOD" TAKE PLACE

If *Make Good* is to be seriously considered as a significant contributor to total embodied energy (i.e. contributed via recurring embodied energy), then there is a need to establish how often it occurs during the life cycle of a building. Here, anecdotal evidence gathered from strip-out demolishers as part of a parallel research study (not reported here) indicates a 5-7 year period is the typical turnaround period for make-good operations. The upper value in this range is supported by a previous study by Tucker and Treloar (1994), who estimated a replacement rate of 5.6 fitouts over 40 years, thus converting to a 7 year average period. In another study, Rousacc et al. (2008) reported a 10 year turn around, though this longer period appears to be on the basis of a property management portfolio with specific sustainability objectives, and therefore may be longer than the norm. Notwithstanding the variance in these figures it is clear that *Make Good* is undertaken on a much shorter time scale than the serviceable life of the rest of the building (which in most studies cited in this paper are calculated on the basis of a 50 year service life period). As a result, fitout is akin to a short term consumable rather than a long term durable. A key concern here is simply that most LCA studies seem to leave the recurring embodied energy (including *Make Good)* out of their calculations. This not only means that the embodied energy of the new fitout is omitted, but the lost embodied energy from the demolished outgoing fitout is also omitted. In order to show the relevance of this latter point more fully, Thormark (2001) found that recycled materials from demolished buildings provided the potential to reduce embodied energy by between 35% and 40%. In addition, the quick cycle obsolescence described above, reduces the feasibility of building in environmental sustainability features which often rely on a longer payback periods to be economically viable. Finally, there is also the question as to why construct fitout for permanency, when it is clear that the short life cycle fitout described above, is better suited to a more temporary or semi-permanent approach.

Given the above points, there is a subsequent argument to re-think the design of *Make Good* and associated fitout to suit a much shorter life, one that allows easy fabrication and equally easy de-fabrication and re-use. This would facilitate less recurring embodied energy over the life of the building and could be designed in conjunction with existing "green" building principles. For instance one option would be to extend furniture design to involve a more encompassing solution for fitout that could make greater use of re-skinable fitout, relocatable fitout and modularisable fitout. Greater use of removable access floors could also help, as could wireless technology in addressing less intrusive service installation needs. Furthermore, concepts used in the temporary construction of theatre sets and event management practices offer potential for improving the speed, flexibility and agility of installing, uninstalling and reusing fitout.

CHURN AND ITS IMPACT ON "MAKE GOOD"

Now that the frequency of *Make Good* has been determined it is worthwhile investigating the reasons why it occurs so frequently. Here the concept of "Churn" is important. Churn primarily concerns the movement of building occupants due to organisational change and this is a large and expensive business. Its occurrence goes some way to explaining the frequency of *Make Good* operations. For instance, Brittain et al. (2004) found a churn rate of 30% of building occupants per year is considered normal in the UK and this relatively high rate of change carries the corresponding need for a high rate of *Make Good.*

Based on a survey of CIBSE facilities managers, churn was found to be one of the highest operating costs for any organization, and the main part of this cost is attributable to fitout and associated building services (Brittain et al. 2004). In overall terms, it is said to cost Britain £2 billion per year (Brittain et al. 2004) and though this cost may be necessary in order to meet business objectives, it is clearly unproductive in meeting sustainability objectives.

Given this, there is a need to manage and improve on the potentially negative impacts of high "churn" rates. Implicit issues in understanding churn include changing temporal and spatial needs, facilities management needs, information management needs, business branding needs and various logistic issues. This is not an exhaustive list and knowledge tends to be limited in mapping the dynamically occurring factors that explain decision making that involves churn and its subsequent impact on *Make Good*. Future research must therefore aim to map and understand the drivers of decision making including the landlord and tenant's perspective, as well as the impact of satellite stakeholders such as property consultants, architects, furniture suppliers and fitout contractors. The outcomes of such research would be useful in facilitating more informed and strategic decision making on *Make Good* in a commercial sense, plus it would also help inform the previously stated call for a re-think of sustainable office fitout design.

THE IMPACT OF "MAKE GOOD" ON THE OVERALL BUILDING STOCK

Where the previous discussion focused on identifying the frequency of *Make Good* and how churn influences it, a separate sensitivity issue concerns how much of the overall building stock is potentially affected by the *Make Good* process. As alluded to previously, it is relevant to distinguish between new and existing buildings because *Make Good* only relates to existing buildings. In this respect, existing buildings easily constitutes the largest proportion of the building stock. For instance, new buildings represent as little as 2% of the building stock and as a result, sustainability improvement in this area only represents a small fraction compared to the existing stock (Bullen 2007). Based on the current rate of new building output, it would take 50 to 100 years to replace the existing stock, hence emphasising the importance of focusing on sustainability improvements to the existing stock (Bullen 2007).

Consistent with this trend, office buildings represent an estimated 22 million square meters of floor space in Australia - 83% of this being more than 5 years old (Roussac et al. 2008). As a result, it is clear from the previous discussion that the majority of office space will soon be impacted by the need for *Make Good*. In terms of the potential for improvement, Roussac et al. (2008) make the comparison that over a 30 year service period, a new building with strong energy saving credentials, would use up to twice as much energy as an existing building upgraded to a similar level of operational energy efficiency. Along a related line of inquiry, Moe (2007) established that it will take approximately 65 years for a new green and energy-efficient building to recover the energy and resources lost in the demolition of an existing building, even if 40% of the building materials from the demolition are recycled. In further support, recent research suggests that refurbishment of existing buildings use 23% less energy than new construction (Mickaityte et al. 2008).

Based on this data, there is a clear need to focus more on existing building stock, than new stock, and by inference, there is a need to focus on improving outcomes associated with *Make Good*.

USEFUL FINDINGS FROM PAST LCA BUILDING STUDIES

Much has been written on LCA analysis and although only a small proportion of this relates directly to office buildings, coverage of the extant literature is useful in showing the variables that influence the validity and generalisability of LCA findings. For instance embodied energy is of central interest to this paper and even though it is often said to be a lower contributor to total LCA energy, it is relevant to point out that this varies significantly according to the type of building involved. For instance, Sartori and Hestnes (2007) found that embodied energy in low energy consumption buildings can vary between 9 and 46% (of total energy) of the building, and that the embodied energy in conventional buildings can vary between 2 and 38%.

To place this in further context via a series of potted examples, the Zabalza Bribián et al's (2009) study found that embodied energy represented more than 30% of primary energy during the life of a typical house in Spain, while other studies concerning low-energy housing show that embodied energy can account for as much as 40–60% of total energy use (Winther & Hestnes 1999; Thormark 2002). Thormark (2001) also found that in low energy apartment buildings in Sweden embodied energy can account for as much as 45% of total energy. Still further, Huberman and Pearlmutter (2008) found that in a desert environment in Israel, embodied energy accounted for 60% of total energy. In contrast, Sheuer et al (2003) found that in a six storey university building embodied energy, only accounted for 2.2% of total energy.

A small number of studies have dealt directly with office buildings. Here, Cole and Kernan (1996) compared their results - based on three different types of construction for a model building – with the results from previous studies in New Zealand (Buchanan & Honey 1994), Australia (Tucker & Treloar 1994), Japan (Oka et al. 1993), United States (Stein et al. 1976) and United Kingdom (Gardiner & Theobold 1990) and found that there was a significant difference in the estimated values for embodied energy. For instance, the lowest amount of embodied energy in an office building was 3.35GJ/m² and the highest was 18.6GJ/m², thus representing 5.5 times the difference between lowest and highest. Looking at more specific examples, Dimoudi and Tompa (2008) found that the embodied energy of office buildings varied between 13.05% and 19.24% as a proportion of total energy consumption. Kofoworola et al. found that embodied energy represented 17% in a Thailand based study.

Clearly broad ranges exist in the above findings and so it is pertinent to explore why this occurs. Since embodied energy and operating energy make up the vast majority of total energy in a building it is worth exploring how the two relate to each other, if at all.

EXPLORING THE RELATIONSHIP BETWEEN EMBODIED ENERGY AND OPERATING ENERGY

Authors such as Sartori and Hestnes (2007) and Zabalza Bribián et al. (2009) assist in explaining the relationship between embodied energy and operating energy, by making the point that a common way to reduce operating energy is to spend more on things like improved passive solar and thermal design, which have the effect on increasing embodied energy. In this context, more embodied can mean less operating energy. A good example of this is apparent in the role building design can play as seen in Feist's (1996) "passive" house. Here Feist compared three houses with different low energy designs and found that an 18.7% increase in embodied energy in his "passive" house could achieve a threefold decrease in operating energy.

However this is not the only issue that affects the relationship. For instance, Sartori and Hestnes (2007) found a strong correlation between operating and total energy, but they also note that this may be an indirect consequence of variables such as climate, which influences operating energy demands. So in a favourable climate, operating energy may be low, whilst in a less favourable climate it will be high. Since embodied energy remains stable, it occupies a larger proportion of total energy in the favourable climate and less in the unfavourable climate. Sartori and Hestnes (2007) also make the point that embodied energy results can vary greatly due to other factors such as the country involved and the efficiency of materials production.

While this discussion provides a degree of insight into the relationship between embodied and operating energy, the cited studies focus almost entirely on initial embodied energy rather than recurring embodied energy. As mentioned previously, this apparent omission is an area of concern and as a result, it is now important to turn attention onto this under-reported part of the energy calculation puzzle.

RECURRING ENERGY AS A MISSING PIECE IN EMBODIED ENERGY CALCULATIONS

Virtually all of the studies cited previously in this paper assume a 50 year service life for the building and with regard to this, Verbeek and Hens (2009) make the point that time is often cast as a fixed variable. The point here is that many LCA studies do not take into account the renovations that most buildings go through before reaching end of life.

The main study that could be found that addressed recurring energy in detail was Cole and Kernan's (1996) account of life-cycle energy use in office buildings. Though somewhat dated, it still provides valuable insight into the analysis of embodied energy as two dimensional construct. For instance, they report that even though internal finishes only constitute 12-15% of initial embodied energy, internal finishes are the most regularly replaced items over the life of the building, and often involve high embodied energy components. Subsequently, fitout will eventually outweigh high initial embodied energy elements, such as the structure of the building, when taken over a full life cycle approach. In addition to this, they found that building service represent 20-25% of the initial embodied energy of the building, but as Zabalza Bribián et al. (2009) point out, such services are intimately linked to internal refurbishment work and therefore will also add to significantly to the recurring embodied energy over the full life of the building.

Further to the above, Cole and Kernan (1996) assert that for a typical building with a 50 year life, the recurring embodied energy will end up equaling the initial embodied energy of the building. As alluded to above, the building services and interior finishes are the most significant components of the recurring embodied energy. In order to extend this point further, Cole and Kernan (1996) utilise data from a study by Howard and Sutcliffe (1994) to make the point that basic, medium and top grade fit outs can vary significantly in embodied energy depending on how often the fitout is replaced. For frequent replacement over a 60 year period, the data indicates recurring embodied energy rates of 0.17, 0.23 and 0.34GJ/m²/year respectively. For infrequent replacement, the same figures drop dramatically to 0.10, 0.13 and 0.17GJ/m²/year, thus giving some indication of the improvement possible, under improved *Make Good* practices. Even so, they go on to compare these figures with initial embodied energy figures for the same fitout (based on averages) being 0.08, 0.09 and 0.1 GJ/m²/year respectively. From this, they make the point that recurring embodied energy may ultimately be higher or lower than initial embodied energy, depending on the life expectancy of the building. Such findings reinforce the belief that recurring embodied energy is a significant problem that needs to be more fully dealt with in office buildings.

CONCLUSION AND ONGOING RESEARCH AGENDA

Office buildings represent a large slice of the commercial property sector. Indeed, more office buildings are refurbished than built new but in sustainability terms refurbishment has passed relatively unnoticed as an issue that needs to be addressed. LCA has served to articulate this point in a quantifiable way. Of note, the *Make Good* process, including the linked issue of fitout, represents a considerable chunk of refurbishment works and the study presents the case that *Make Good* is currently a wasteful process that generates significant recurring embodied energy.

These issues set up the basis for an important research agenda which aims to quantify and better understand the problem of recurring embodied energy associated with office *Make Good*, and the ability to develop design and business-led solutions to provide improved sustainability outcomes.

Key research questions that help define the agenda include:

- To what extent does recurring embodied energy - as generated by *Make Good* - impact on the total embodied energy of an office building (including fitout and building services components)?
- To what extent does recurring and total embodied energy, impact on the total energy of an office building?

- To what extent could the above issues be moderated by saving embodied energy at the demolition stage of office fitout (including re-use and recycle options)?
- To what extent does churn impact on the extent and rate of *Make Good* in office buildings?
- As appropriate to the above findings, what potential exists to reduce the impact of churn by developing a greater understanding of the business, social, environmental, legal and temporal factors influencing churn?
- To what extent can design led solutions reduce recurring embodied energy i.e. occupancy designs that reduce the need for churn, and designs that improve the reuse, upgradability and relocatability of fitout?
- Consistent with the previous point, to what extent is there potential to develop new leasing arrangements that reduce the wastefulness of current *Make Good* practices and can this include new business-led models for *Make Good*, such as leasable fitout?
- To what extent do green building leases reduce recurring embodied energy from *Make Good*?

The closing objective of this paper is to implement the above agenda and in undertaking this there is a clear need to provide generalisable findings, hence impacting on the size and method of sampling and the need to adopt an LCA methodology that suits the nature of office *Make Good.* As Zabalza Bribián et al. (2009) point out, there are quite a few different LCA methods, with many carry considerable complexity and a lack of fit with building projects. As such, the need for a simplified methodology is important especially where encouraging accessibility and uptake from industry stakeholders such as property developers, building owners, contractors, consultants and interior designers. In ensuring that a well balanced and suitable methodology is developed a multi-perspective approach is merited. To this end, collaborators in undertaking the above agenda are welcome.

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