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Title of Paper: **Turning a Red Building into a Green Building**

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Abstract

Commercial buildings consume more energy than other building types in the cities. The number of new sustainable offices constructed each year is far less than the number of existing buildings. Therefore it is important to understand that exploring cost effective ways of modifying existing office buildings into green buildings for the future; is a great challenge for architects, engineers and authorities.

This paper will deal with the question of transforming an existing conventional office building into a sustainable green building and the barriers associated with this transformation. The major differences in design, between office and residential building type will be described in the first part of study. It is more expensive to "modify" an existing building, than to "construct" a new sustainable building. This is an important barrier which will be described in the second part. Despite the barriers for modifying an office building to a green office, there are always opportunities for application of energy efficient design. The third part includes information about methods to minimize energy use for artificial lighting and air conditioning through smart design of building components; in this case study office windows. This review will only include the solar passive design opportunities and innovative design approach of windows, which was missed or ignored through design and the

construction process. The review will be supported by exploring renovations to an example building, and the lessons learned from that experience. It will conclude that modifying an existing building into a green building is not always more expensive than a conventional design approach, but requires knowledge, experience and attention to details.

1- Office Building versus house

The investment and the property values of office buildings are considerably higher than other types of non-residential buildings. It is important to note that considerable parts of buildings that are classified under other building types (eg education, hospitals and so on) are office buildings. According to the 2007 New Zealand statistic report, work on non-residential buildings accounted for 41 percent of the value of all building work undertaken in the year ended September 2006, compared with 39 percent for the previous year in September (figure 1).

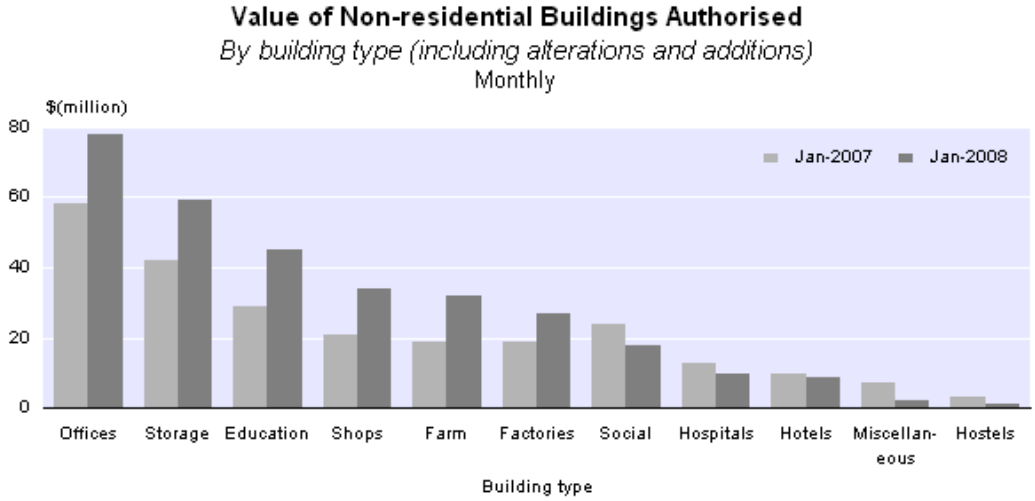


Figure 1*: The trend for the value of non-residential building consents remains at a high level. To reduce distortions, the trend series is estimated after the removal of consent values of $25 million or more.*

Source*: New Zealand Statistics,8 December 2007,Cat 01.500 Set 06/07– 086-http://www.stats.govt.nz/NR/rdonlyres/701056BB-B81E-4E73-ADF2-*

Commercial buildings consume more energy and affect the environment more than other building types in the cities. The number of new sustainable offices constructed each year is far less than existing buildings. This means that even if all new office buildings were designed and built to be sustainable, there remain a large number of offices to be upgraded. Therefore it is crucial to explore cost effective ways of modifying existing office buildings to green buildings for the future.

There are significant differences in design requirements between residential and non residential building types. For example, an office is generally occupied during working hours, from Monday to Friday and a large proportion of energy is consumed for running of computers, heating and cooling. As a result commercial buildings are typically internal load dominated and have different requirements from residential buildings. This means that solutions such as passive solar design and green building materials, for office buildings, are more diverse and demand detailed analysis.

Another significant difference between commercial and residential buildings, which affects the entire renovation process, is the ownership of the property. The investment returns required for sustainable buildings will vary depending on the type of building and the nature of the client - eg, public sector or private sector (investment funder, developer or owner-occupier). Private sector buildings represent mainly commercial offices and retail centres. Therefore the key decision-makers involved in the renovation process often have different perspectives on the value of sustainable buildings (Bartlett and Howard, 2000). This fact will affect the office building renovation plan as described below:

- The value of commercial buildings has traditionally been judged in terms of location, quality, function and aesthetics. This is then reflected in the rental return and capitalisation rate. It is difficult to set a value on commercial sustainable buildings until a fully established market exists.
- Developers will have little concern for sustainable building improvements unless there is a marketing advantage, tenant and/or funder requirement and a short-term return. Little or no information is publicly available on the lease rates and resale of sustainable buildings.

- The pay back period calculations for application of sustainable solutions, such as extra insulation, might look interesting and tempting for a house owner (owner/ occupier), but it is not convincing for a developer whose main concern is a fast return on the investment. The higher cost of energy consumption for lighting, heating, cooling and maintenance of a conventional building is paid by the tenant (who is different from the individual users of the building) and obviously will not affect the developer or owner.
- In terms of the renovation of a building, the private sector is more inclined to invest on cosmetic and green washing strategies rather than a comprehensive scientific approach. (www.eeca.govt.nz)

2. Existing Versus New

Modifying an existing office building to a green building is challenging work. The improvement and achievement is based on the existing building conditions, innovative design, strategies and the allocated budget. It is un-measureable and quite different for different cases. However the most important barriers, which are common in most office building renovation, are described below.

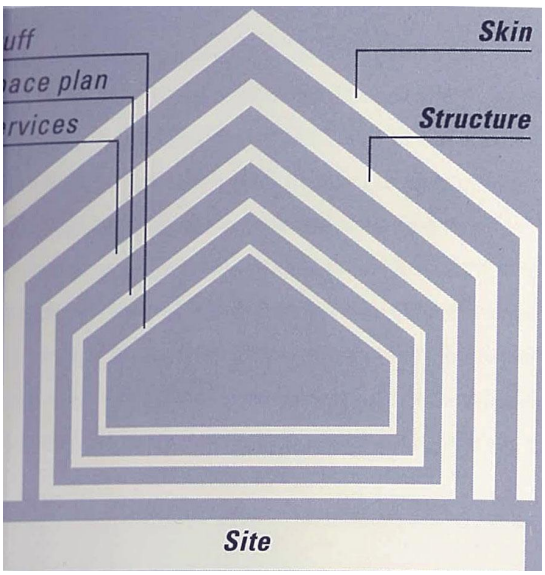
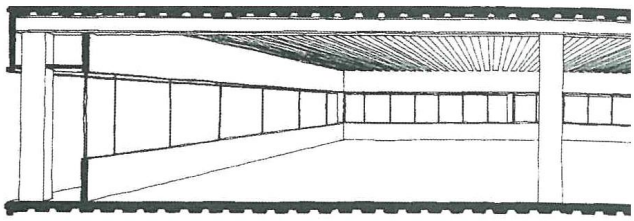


***Figure 2**: This diagram is based on Stewart Brand's reformulation of the idea of the parallel and independent coexistence of different lifespan in the same building.*

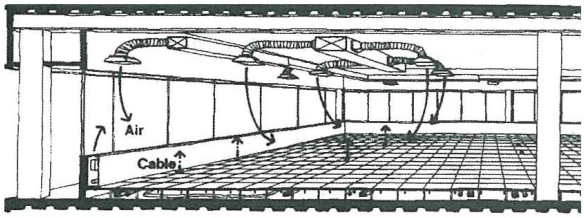
***Source**: (Francis Duffy ed., 1997)*

The key issue for renovating an office building is the life span of the building components and materials. Many office buildings in New Zealand have lasted 100 years while the current Building Code allows for building material life of 50 years. It

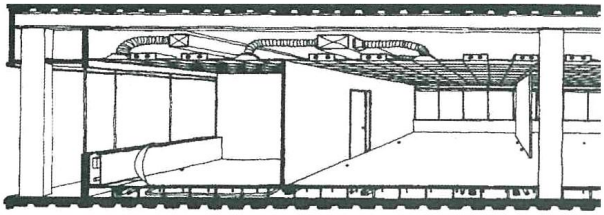
is environmentally preferable to reuse or renew existing buildings rather than building from scratch. The appearance of a building (skin); structure, services and fit out have different life spans. The typical life spans are shown in diagrams 2 and 3. The most important elements of environmental services such as elevators and air conditioning are usually expected to last about 15 years. Therefore, to minimise the environmental impact of the renovation plan, it is important to decide which building component to keep and which to remove, reuse or recycle.



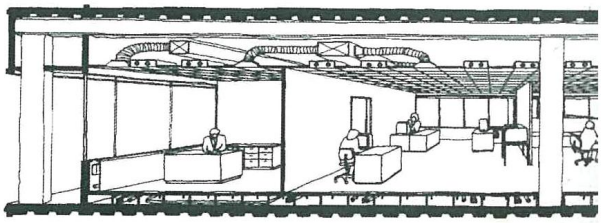
❶ The building shell. Lifespan: 50–75 years. Structure, cladding (skin).



❷ Services. Lifespan: 15 years. Heat, ventilation, light, power.



❸ Scenery. Lifespan: 5 years. Fixed interior elements – ceilings, pa
finishes, infomation technology equipment.



❹ Settings. Day-to-day rearrangement. Office furnishings.

Figure 3*: Stewart Brand in his book, how the building learn, has distinguished between the office components; site, structure, skin, services, space plan and stuff*

Major refits of office buildings are now very common and it is generally the upgrading of environmental services that attracts the greater part of the budget. Of all the money spent on an office over its lifespan, by far the greater part is spent on what is often but wrongly considered to be the more trivial features of interior design (Duffy Francis, 1997). For example, refurbishment of banks and government offices often induce in changing the carpets and fit-out for the sake of fashion and appearance and or aesthetics only.

The other important barrier for modifying existing office buildings to green buildings is the lack of information on rating systems. Most rating tools are designed for new buildings. There is no Guide to provide straightforward recommendations and "*how to*" guidance to facilitate its use by anyone in the construction process who wants to modify an existing building into a more energy efficient building.

The most common rating system used in New Zealand is The Green Star-Office Design tool, which is being expanded to assess both the design and built forms of new and existing office buildings. Through the Green Star system both new and existing buildings are able to achieve a Green –Star Office Design/Built rating. The design and built forms of an existing building will be rated independently of how it is operated, in the same way that new buildings are. The manner in which the building performs will be addressed separately through the development of a performance or in-use rating. The Green Building Council has now realized the need for developing a tool for existing office buildings undertaking upgrade planning. (Green Star New Zealand, 2008)

Making the renovation sustainable is a complex process than perhaps it would seem at first, with a wide number of competing issues. For example is it more sustainable to buy a product that is more efficient from overseas, or a less "eco-tech" product made locally? To make this process easier and to try to keep the decisions consistent, an environmental renovation policy should be developed at the first stages of design. It is crucial to discuss this policy with all of the relevant parties working on the various aspects of the renovation plan, as it does affect the work plan and finances.

3. Window Design for Thermal Conditions

It is cheaper to save energy than to generate it. For this reason, in any building renovation, high priority must be given to energy efficient design. From a global, national and individual perspective, it makes a lot of sense to turn existing New Zealand offices into energy efficient ones now. Therefore any upgrade of an office should lead to a reduction in energy use. It is important to note that the energy used to operate a building (eg heating, cooling and etc.) is significantly higher than the energy bound up in the construction, maintenance and disposal. Moreover a modern open plan office needs more energy for heating and cooling of the internal space. This means major renovations must incorporate sustainable design methods, such as passive solar design, which allows the energy gain and cross ventilation during the day time at all seasons.

The following study indicates the exemplary methods to minimize energy use for artificial lighting and air conditioning. This study is limited to the office building renovation in the Auckland climate. It investigates the improving the energy efficiency of the building through smart design of only one building component: *the windows*.

Fixed non operable windows were in fashion during the late 70s and are still used for high density and high rise office buildings. This type of design relies heavily on Mechanical ventilation, which is expensive to run and maintain. Architects and Engineers who are conscious of sustainability are attempting to work with, rather than against nature. The aim of green building “window design”, is to drive down energy costs while allowing users more choice in controlling their working environment. There are new and innovative ways of designing or modifying the building skin and windows to prevent solar gain in summer, while attracting as much day light and solar gain in winter, as possible. Moreover adjustable/reflective shades and louvres are becoming critically important.

The green office building’s window design is becoming architecturally and environmentally far more interesting. Today’s offices accommodate a large number of computers, printers and machines which consume energy for their operation. They

generate large amounts of heat and need artificial air cooling. Many office workers dislike air conditioning and want natural and easily controlled ventilation and cooling. Mixed-mode office building is designed to meet the conflicting demands of people and machinery. The resolution would be to draw cool air through the building by convection, without the use of fans, pumps or other machinery. This can be done through special design of windows/glazing or special towers, staircases and the heavy (concrete) structure of the roof.

3.1 Window Design For Ventilation - Operable Versus Fixed Windows

Operable windows offer the advantage of personal comfort control and beneficial connections to the environment. However, individual operation of the windows that are not in coordination with the HAVC system setting and requirements, can have extreme impacts on the energy use of a building's system. Advanced energy buildings with operable windows should strive for a high level of integration between envelope and HAVC system design. Firstly, the envelope should be designed to take advantage of natural ventilation with well-placed operable openings (figure 4). Secondly, the mechanical system should employ interlocks on operable windows to ensure that the HAVC system responds by shutting down in the affected zone if the window is opened. It is important to design the window interlock zones to correspond as closely as possible to the HAVC affected by the opening windows. (Advanced Energy Design Guide, 2004)

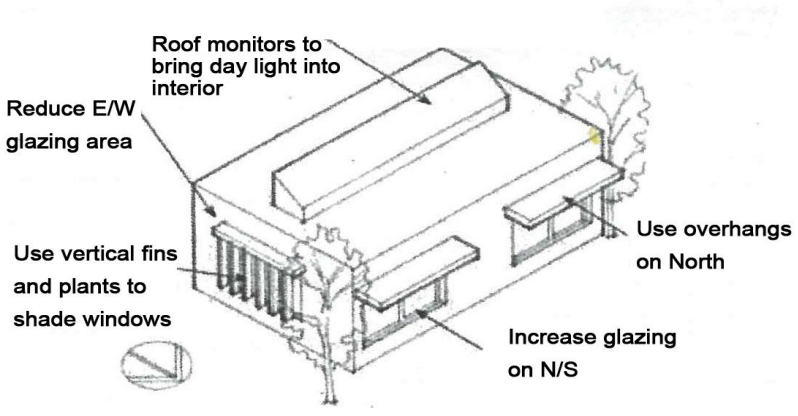


***Figure 4** : Window design principals for thermal conditions*

3.2 Window Design for Daylight - Glazing Versus Glare

Application of passive solar energy saving strategies is generally limited to non-office spaces. This is to prevent unwanted glare and solar overheating, particularly on the North facing side of the building. Adjustable blinds should be used to control intermittent glare conditions that are variable.

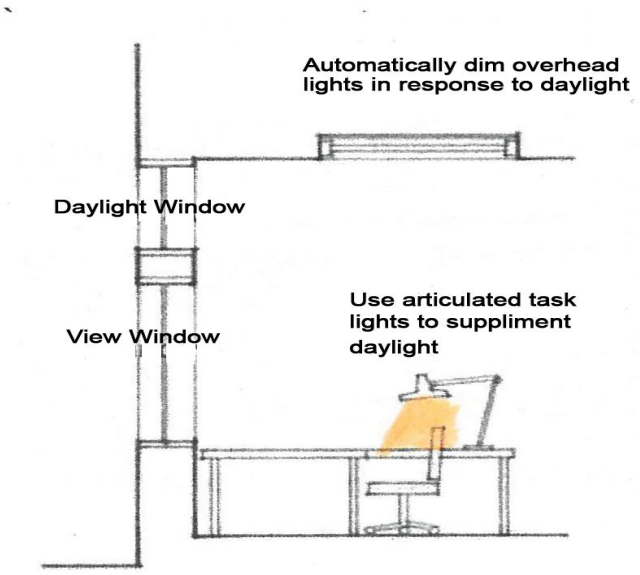


***Figure 5**: Window design for Daylight*

Adjacent taller buildings and trees, shrubs, or other landscaping features are effective to shade glass on south, east, and west facades. For North facing windows, the sun is higher in the sky in the summer, so that shading plants should be located with proper height to effectively shade the glass. The solar reflections from adjacent buildings, shading devices with reflective surfaces (metal, reflective curtain walls) should be considered in the design.

3.3 Case Study

This part of the study will give practical information on how to make the renovation of an office building a greener process, by explaining how the exemplary office building windows were modified.

The selected building for the case study is the East wing of two-storey office blocks in

Newmarket, which is under major renovations. The building was constructed in the mid 70s and has been renovated and upgraded many times during the last 20 years. The owner decided to remove all the interior walls, partitions, windows and mechanical systems. The existing operable windows were replaced with large fixed glazing. As a result the building will rely heavily on mechanical ventilation after renovation. The glare and overheating during summer time will be a problem. Obviously the cost of operation of mechanical systems and maintenance of the renovated building will be considerably higher than the existing building.

The following are the diagrams and photos that explain:

- How the existing building's windows were operating (3.3.1)
- Tips and recommendations for upgrading the window performance (3.3.2)
- How the renovation design ignored the minimum design standards (3.3.3)

It is interesting to note that most of office renovation plans follow the same pattern and produce buildings that are more environmentally un-friendly than they were before! They consume more energy and are more expensive to operate or maintain.

3.3.1 How the existing building's windows were operating

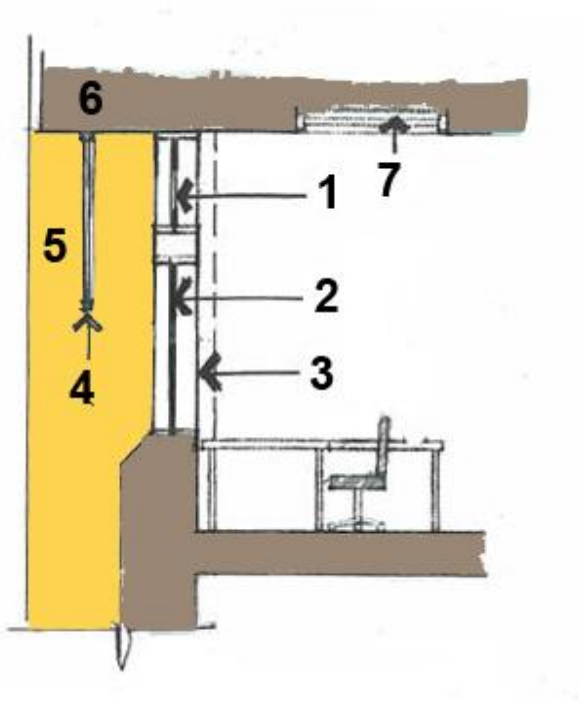
Continuous operable windows including:

1- The top window located close to the ceiling for daylight

2- The bottom window for view (at eye level) with the sill above the work station bench top height.

3- Window venetian curtain for manual controlling the glare

4- The Glazing panel in front of the windows for controlling the glare and



light, which is not working as it was designed for.

5- Vertical panels

6- Window overhangs for exterior sun control on both West and East side of the building

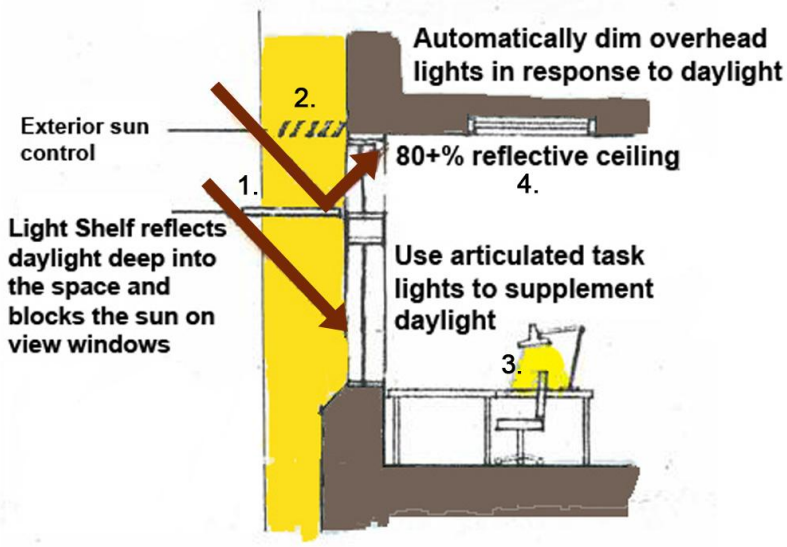
7- Sensor overhead lights (in response to movement)

- Use of “manual on” occupancy sensors in day lit spaces saves energy as electricity is not automatically consumed unnecessarily.
- Use of manual switches for the areas such as kitchens, small meeting rooms and toilets.

3.3.2 Tips and recommendations for upgrading the window performance

1- Consider exterior light shelves between the daylight window and the view window. These are effective for achieving greater uniformity of delighting and for extending another level of light onto the ceiling and deeper into the space.

2- Retain the existing window overhang or replace it with exterior sun control



3-Use of local articulated adjustable task lights (eg desk lamps) in day lit spaces increases occupant satisfaction and is an effective supplement for day lighting.

4- Implementing a Lighting system that can be adjusted, both in intensity and quality and switched on and off according to changing individual or group preferences. Use of automatically dim overhead lights in response to daylight

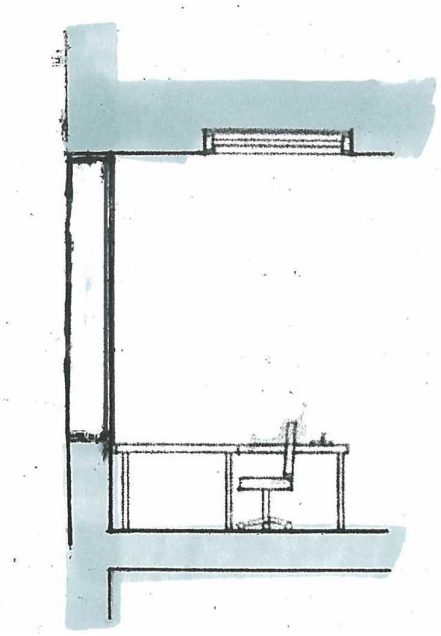
5- Use of lower partition or translucent partition, which is more energy efficient for both daylight and electrical light.

6- Using reflective light colours for the interior walls in depth.

(Evans, Benjamin. 1997), (IESNA. 1997)

3.3.3 The Renovation Design

- All the operable windows are replaced with continuous fixed windows
- All the overhangs and vertical fins are removed
- The building is completely relies on Mechanical ventilation now



Conclusion

Green Building concepts have been applied in New Zealand for many years and environmentally friendly houses and buildings can be found across the country. However, despite the necessity for upgrading existing buildings to be more environmentally friendly, very few attempts have been done to modify/improve existing office buildings into green office buildings. Existing regulations and rules, prevailing technologies and building materials, general level of expertise and training, and conventional investment considerations have not been conducive to achieving high levels of sustainability. As Johann Bernhardt mentioned:" Apart from a few notable exceptions, the level of sustainability we have achieved in New Zealand so far can be classified as a light shade of green! The time has come to accelerate and aim to a deeper shade of green! (Dernhardt, Johann. May 2008)

Modifying an existing office building to a green building is challenging work. The improvement and achievement is based on the existing building conditions, innovative design, strategies and the allocated budget and is un-measureable and quite different for different cases. There are very few records of modifying existing office buildings to sustainable offices, in New Zealand. This is a challenging area that requires architects and engineers to address and to share their experience and achievements with others.

If the building industry is to develop in a way that does least harm to the environment, the sustainable techniques applied to the buildings should be the norm rather than the exception. To be truly effective, sustainability needs to be managed across the industry on an integrated basis.

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