USING MATERIALS FOR SUSTAINABILITY IN INTERIOR ARCHITECTURE AND DESIGN

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INTRODUCTION

"Green," "eco," "sustainable," materials and products are no longer as rare as hen's teeth. There is an increasing market for all things "green," but all the green products in the world won't necessarily create a "green" interior design solution. Understanding the importance of the life cycle of the design for which they are intended is as equally important as the material choice—it's the way the materials are used that will significantly change an ordinary design into a sustainable one.

Much has already been published on reducing the life cycle impacts of products during manufacturing and designers need to be aware of these. However, comparing the life cycle assessments (LCAs) of various manufacturing processes can be complicated, the information opaque, and the results confusing. While the importance of the environmental impacts during manufacture are significant when selecting materials and products for interior environments, equally important are the issues related to consumption, the practice of specification for the use of materials and products, the impacts of indoor air quality, and end-of-life options.

This article will address how interior designers/architects can address some of the greatest environmental impacts of their practice, specifying materials and products, by understanding the life cycle impacts of their designs, rather than just the materials they use, for domestic and commercial use.

RESOURCE EFFICIENCY

What is the problem?

Lifestyle changes, an increasing rate of consumerism, and a first-world society which doesn't seem to be able to keep pace with itself, are all increasingly having an impact on the way interiors are being designed in the domestic and commercial domains.

Interiors are joining other products such as clothes, computers, mobile phones, and cars, which are losing (or have lost) their long-term value and are fast becoming the disposal products we are accustomed to in other forms such as packaging. While iconic and/or well made pieces of furniture, clothes, cars and so on will maintain their value, the mainstream products are rapidly falling to the societal need for constant change.

Evidence of this can be seen in the lifestyle television shows, showing us how we can improve the homes no longer suited to the modern lifestyle we all now apparently aspire to. Out with the old, in with the new—even though the "old" may only be 2–5 years in age. In order to obtain the best financial value in a car, it must be traded in for a new one every 3 years—despite the fact the current one is in perfect working order. One could argue that the newer model will be more fuel efficient, but studies have shown that the embodied energy for creating the car is equal to about a year or more's worth of fuel consumption (Fox and Cramer 1997). So with the maximum savings on fuel efficiency for new cars around 20–25%, one would have to own the car for 4–6 years before these savings outweighed the additional embodied energy. New technologies in computers and mobile phones demand that we update to the newest models to remain in constant contact with friends, colleagues, and family. And of course clothes change with the seasons and the fashions for the year.

As products become cheaper, and our credit larger, so does our consumption. In a recent Australian study *"Wasteful Consumption in Australia"* (Hamilton et al. 2005) it was found that, ". . . the richer we become the more we spend on goods and services that we do not use." These phenomena, according to Hamilton et al., will only increase. And as the countries with the largest populations on the planet, China and India, also begin to aspire to the same standard of living, our need for ever-changing products will boom.

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For interiors, the commercial market has always been an area of constant change. As businesses grow and shrink, so do their places of work—whether that is an office or a retail outlet. The increase in change in the domestic market, however, is a more recent phenomenon.

Recent causes of increased consumption in domestic interiors

Through a growing development of choice, with lifestyles and identities associated with these choices, an increased awareness of aesthetics and technological developments, the domestic interior has now also fallen into an increased consumption pattern (Edwards 2005). Coupled with ". . . a continuing growth in demand based on an increased disposable income, intensified production, revised distribution systems, an increasing social mobility and a growing desire to express individualism, which have all led to consumer acquisitiveness being fuelled by the forces of retailing, fashion and advertising." (Edwards 2005, p. 215) Dolgopolov (2003) also sees this increase in expenditure on homes and home furnishings as "cocooning." "The pervading social uncertainty, the instability of the global markets, the threat of terrorism, teenage gangs and anxiety over an influx of 'strangers' is fuelling the materialistic drive towards making the domestic space more secure and habitable."

How "cocooning" and elements of fear and anxiety also pervade other countries, can be seen through commercial and media responses, such as, a plethora of home styling and renovation magazines and the increased growth in recent years for lifestyle television shows such as *Changing Rooms*, *Room for Improvement*, *Ground Force*, and *Hot Property.* This marketing strategy continues a cycle of promotion, production, desire, and consumption (Dolgopolov 2003) perpetuating and growing the environmental impacts of a consumerist society.

In Australia the per capita overall consumption has risen by 152% from 1960–61 to 2005–06 (Linacre 2007(2)); the consumption of furnishings and household equipment has risen by 3.8% in the ten years from 1994–95 (Trewin 2006), and coupled with this, expenditure on renovations has also increased by 36% (Archicentre 2002). And these consumption trends are not only confined to Australia or other Western style countries such as Britain (Brunsdon 2003) or the USA; as China's urban incomes rise by 14%/year, they too will be and are aspiring to "improved" home environments. (Hua Xu 2007)

According to the Royal Australian Institute of Architects, people on average move or renovate every 7 years with the most renovated spaces being kitchens and bathrooms (Archicentre 2002). In Australia households live in bigger homes, (needing more materials and products to finish and furnish) with fewer people in them, than they did a generation ago (Linacre 2007). Homes are becoming more luxurious with the ownership of more durable goods per person and our waste generation per person has increased by 32% from 1996–2003 (Trewin 2006). The pressures on resources to produce the products bought when households move, renovate, or update coupled with the waste of the materials and products of the old is not insignificant. Yet to date the environmental and sustainable movements have been focussing on energy use and waste generation from packaging and food for the domestic sector but almost ignoring the less obvious patterns of consumption from the acquisition and styling of homes.

How can designers reduce the waste of domestic interiors over their life cycle? As has been shown, there is a dual problem in the domestic lifestyle—a social issue (the need for cocooning and feeding this need through consumption) and an environmental issue (the pressure on environmental systems to produce and discard these products). For the designer (and consumer) this poses a conundrum: how can the user satisfy his emotional and social needs and protect the environment?

Designers need to address domestic interiors from a lifecycle viewpoint keeping the products and materials in use for as long as possible and minimising refurbishments and larger renovations. However, behaviour through current factors such as fear and anxiety is possibly the most influential factor to either inhibiting or allowing the success of an improved sustainable interior. Changing the behaviour of others is an almost impossible task; however, influencing behaviour by changing one's own is a more plausible action.

So what can designers control through design and through careful selection, allowing users to also con-

trol their environment, satisfy their needs, maximise resource efficiency, and start changing behaviour. The key factors are:

1. Less is more
2. Longevity/durability
3. Flexibility
4. Reuse, recycling and biodegradability

1. Less is more

Reducing quantity and size. First, address the quantities of materials used for a particular interior design. By reducing the quantity and complexity of materials, the pressure on resources is reduced and the quantity of material at end of life which needs to be accounted for is also lessened.

Designing smaller, versatile, workable spaces and not bigger than required will reduce material need as well as product need, as for example chairs for eating may also double as chairs for working/studying; rooms for sleeping can also double as spaces for working; food preparation and entertainment double as lounge and eating. Too often (in Australia and I suspect in many other countries) dwellings are being designed which have a room for every activity—a games room, a study, a bedroom, a TV room, a playroom. Many of these activities can be brought into the one space and used accordingly. Flexibility in the design also plays an important role here, allowing the space to reconfigure through changed furniture use, storage ideas, and clever planning (See Figure 1).

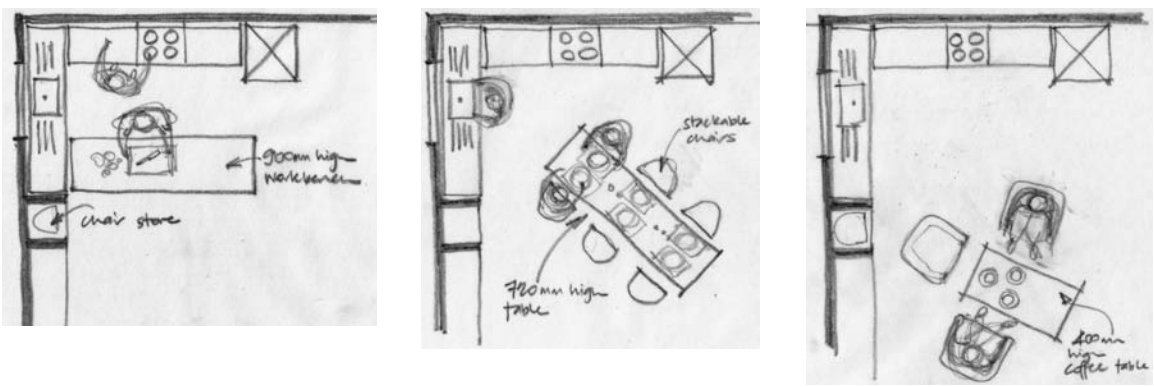
Reducing materials can also be achieved by just using less. When selecting furniture, for example, select a chair for dining that is made from a single material type such as moulded plastic instead of an upholstered version, which may contain twice as much material and a far greater variety, making end of life options more difficult. There are also materials on the market which reduce the overall quantity of material such as lightweight panels. These panels can replace traditional timber fibreboard panels for laminating and veneering. Being virtually hollow in the middle, through complex waffle matrixes using lightweight materials such as paper, the overall material content and weight is significantly reduced. Reducing the weight of a material also minimises energy in transport.

Reducing finishes. Selecting materials that do not require an extra finish can also reduce the need for unnecessary material consumption. A polished concrete floor or timber floor needs no other material to complete it such as carpet or tiling. Where a warmer floor finish may be desired, a throw rug is a good alternative to a broadloom carpet. The softer finish is only used in the desired space, unused carpet is not hidden under permanent furniture pieces, and the overall material use is greatly reduced.

2. Longevity and durability

Investing in quality. Generally for domestic interiors it should be easier to select materials and products that have been designed for longevity as the consumer

FIGURE 1. Flexible meal preparation, eating, and relaxing space through the use of a table which has height adjustment, ease of movement (perhaps castors), and has a foldable or separation component.



has a personal invested interest in (hopefully) keeping the investment for an extended period of time. However, with increasingly cheaper furniture and materials on the market, it can quite often be difficult to convince clients that a more expensive item is the better choice.

Selecting a superior quality piece of furniture designed to last many years can far outweigh the short-term financial benefits of a cheaper piece which may need to be replaced every few years. Through a personal experience, I finally succeeded in convincing a friend to spend the extra money on a chair from a reputable company after he needed to replace the cheaper "bargain" office chair three times in 18 months! (Which I am pleased to say is still in use now three years later) Fashion can also have an impact on why people tend to update their furniture, so not only selecting a piece of furniture that will last but one that will last the test of time is also desirable. Classic pieces, antiques, and iconic items should all pass the test of time and perhaps also become valuable investments.

Reduce the need for change. When selecting items for longevity, be sure that these are items the client will not wish to change in a few years' time through need (a childless couple has a family and the prized designer lounge suite will only get ruined) or fashion (the sixties style orange kitchen). These items should obviously also be durable to stand the test of time. Address items which could potentially be costly such as floor coverings, which if selected appropriately can last a lifetime. Materials such as timber, cork, slate, linoleum, and concrete are all very durable, long-lasting materials able to be sustained for generations. Softer floor coverings are obviously not as durable, and their selection should be carefully chosen for the lower impact areas, where reduced wear and tear will increase the life of these materials.

With items possibly in need of change on a more regular basis, select them on the basis that they will have a life beyond this first phase (can be reused, refurbished/repaired, disassembled and recycled, or can be safely biodegraded), or have come from a second-hand/recycled source.

Low maintenance materials will also endure the test of time and have a reduced environmental impact. Materials which require continuous maintenance and upkeep to remain in an optimum condition will not only be a nuisance for the users, but if additional materials such as paints are required to maintain this material, there is an additional environmental impact.

3. Flexibility

As has been indicated, there are many reasons why homes are changed, updated, or renovated. These include changing lifestyles, household sizes, fashion, or as is currently the case in many western countries, this need for cocooning. Designers have no control on when, how, or why these changes will occur through the life cycle of a domestic interior but design ideas can be built in to assist these changes to occur with the least amount of impact on resources and waste through flexibility.

Flexible spaces and or products can

- Perform more than one function
- Change to suit developing needs and styles
- Increase or reduce in size
- Reduce waste and resource impact through reuse

Chairs that function as dining chairs and workspace chairs perform more than one function. A room can function as a family entertainment area for all family activities, not just one. A table can be changed to downsize when not required or be transformed into tables of various heights—side table, dining table, work table—performs many functions (see Figure 1). Movable walls can create bigger or smaller spaces as required, and modular furniture and building systems mean that even whole buildings can be changed to suit changing needs.

There is a growing market for modular building systems throughout the world capable of being easily erected, disassembled, and reassembled. Shigeru Ban, a Japanese architect, took the concept of flexible interior design to a new height in his *Naked House* in Tokyo where a large barn-like structure is divided by large rolling box shaped "spaces," rooms on wheels, which can be moved throughout the space to suit varying needs, climatic conditions, and light changes. Designing for permanence where constant change is the reality, will only further environmental impact.

Modular systems allowing the user to easily translate an existing configuration into a new one with the least amount of effort, energy, and waste, can be a

sound solution to the social and environmental needs of changing households. Particularly in areas such as kitchens and bathrooms, which have been highlighted as the most renovated spaces within a home, using modular systems could allow the flexibility of change, without the environmental impacts of waste. Even the plumbing can be integrated as flexible items that don't have to be adhered to in fixed positions—it's a matter of material choice (flexible piping and plumbing) and clever planning.

More traditional ways flexibility can be incorporated into domestic design are through minor refurbishments. Changing the upholstery on a chair to satisfy a new look will have a lesser environmental impact than purchasing an entirely new chair, for example. In this instance the durability of the structure of the chair will need to outperform and accept changing upholstery.

It may be that interior spaces should be thought of as spaces of constant change, with restricted life spans and opportunities for new ways of living every say 10–15 years. However to be able to achieve this and reduce environmental impact, considerations for resource efficiency become vital, and reuse, recycling, and biodegradability, paramount.

4. Reuse, recycling, and biodegradability

Reuse options. The ability to reuse items in a domestic design should not be difficult. There are many opportunities to buy second-hand furniture over new from opportunity shops to antique showrooms. Refurbishing already owned pieces should also take preference over buying new. And when old items are no longer wanted or needed, there is an increasingly large market such as *eBay* to sell second-hand goods.

Of course the value of second-hand items relates directly to the initial purchase. Cheaper, poorly made pieces will not have the same resale value as pieces purchased for superior durability and longevity. The cheaper pieces are piling up at landfill sites, while the higher quality items are obtaining sometimes even profitable resale values.

Recycling and biodegrading options. While reuse should always take preference over recycling or biodegradability, sometimes there is no worth or value left in a material or item for reuse. At this point in the life cycle the most should be made of the resources contained within the product for recycling into a new material or biodegrading to form compost or earth for plants to grow. William McDonough, in his book *Cradle to Cradle,* explains how materials should belong to one of two cycles—either the technosphere, where materials and products remain technical nutrients to an industrial cycle, returning for example plastics, back into plastics or the biosphere, where biological nutrients are returned to a biological cycle.

When selecting materials and products, it is important to consider not only the expected life of the item(s) but also end-of-life options. Materials with a shorter use by date generally fit better into the biological nutrient category as the energy required to turn the material back into food for the biosphere is generally much less than the energy required to change a material into a technical nutrient for industrial use. Hybrid materials (materials belonging to both material cycles) should also be avoided as their worth in a "second life" is largely devalued. Particularly when addressing materials available in large varieties such as plastics, it is also important to maintain the purity of the material, always ensuring that at end of life it is up-cycled into a better or as-good-as product. Many plastics, for example, are recycled to form amorphous materials, which at the end of *their* life are difficult or impossible to identify and continue within the technological cycle and then become waste.

Selecting materials based on their expected lifespan within the interior and the cycle they belong to (industrial or biological) can greatly reduce their environmental footprint. However, it is equally important for systems to exist which will allow for the collection, manufacture, and redistribution of these recyclable or biodegradable materials. A manufacturer claiming the recycling qualities of a product for which no system exists is as good as landfill.

Whatever the solution was to improve resource efficiency for one domestic interior it will nearly always be different for the next. There is no exacting formula, no list of right and wrong materials, dos and don'ts. Each project will have its own sustainable brief just as each client will have his own individual brief. The task for the designer is to steer the way through a path that will change with each client but leave the smallest footprints behind.

What are the impacts of commercial interiors?

Resource use occurs at all stages of the life of an office tenancy, retail or food outlet during relocation, use, and refurbishment. While office tenancies have an average life span of around 5–7 years, shopping centres last only around 5 years. These short life cycles create a variety of waste issues including unwanted furniture, fittings, fixtures, and finishes, construction waste on site, as well as manufacturing and production wastes off site (Máté 2003). Construction waste worldwide accounts for 40% of landfill.

In 1999 Treloar et al. undertook a study to assess the embodied energy contained within the continuously changing interiors of the commercial world. What he and his team found was that the impacts of "churn" every 5–7 years in commercial interiors can have a substantial environmental impact throughout the life cycle of a commercial building. The effects of refurbishment, replacing the furniture, floor finishes, walls, and ceilings of commercial interiors can, due to the embodied energy contained within the manufacture and production of these items, outweigh the overall operational energy of the building during a lifetime of 40 years. This was a significant find as until that point designers had been concentrating only on the building envelope to reduce environmental impact.

FIGURE 2. 5 Star Green Star Rated (Australian Green Building Council) office fitout for Investa Property Group (Designers Hassell, Photographer Tyrone Branigan).

Of course the importance of issues concerned with energy and water efficiency should not be reduced; however, this study has revealed a major contribution to life cycle impacts of commercial buildings for which interior designers/architects are largely solely responsible.

While the key factors are the same for commercial interiors as for domestic interiors, the approach can be slightly different. Let us reconsider these differences in each of the four key areas:

1. Less is more
2. Longevity/durability
3. Flexibility
4. Reuse, recycling, and biodegradability

1. Less is More

Management. Planning to use less in commercial interiors can be dealt with through reassessing management design as well as physical design. Changing management culture to introduce notions of hot-desking, increasing opportunities for staff to work from home, and/or the increased use of laptop computers with wireless Internet connections, can assist in reducing the need for permanent, fixed, office environments with all of the physical requirements they demand. Likewise, increasing online shopping options for customers may decrease the need for physical retail outlets or provide opportunities to reconsider new ways of physical shopping experiences to reduce environmental impact.

Leasing options. With such a high and frequent turnover the ownership of physical items for commercial interiors also comes into question. Alternatives such as leasing options can therefore be considered. This can place the responsibility of end-of-life options back onto the producer to deal with reuse, recycling, and biodegradability. While leasing furniture

is not a new concept the leasing of other items such as carpet is. Interface, the world's largest carpet manufacturer is currently exploring this concept with its customers worldwide, the aim is to maintain the responsibility of their product through its entire life cycle. By leasing the carpet tiles (carpet tiles are also a more efficient material to use for particularly commercial interiors as damaged tiles can be replaced easily, as opposed to broadloom carpet, significantly reducing waste and can be removed more easily for future reuse, recycling, or composting depending on the material type). Interface can maintain the condition of the carpet throughout its use and at the end of the lease retrieve the carpet for reuse or disassembly, material separation, and recycling.

It is important to consider that while leasing items can be a better option than buying with the probability of future disposal, consideration needs to also be given to leasing companies and their responsibilities to their products over the duration of their life cycle—how are they manufactured, transported, and packaged; how are they maintained, refurbished, or upgraded, and what happens to the items at end of life?

Shell and Core. In many office and retail tenancies, landlords or building managers require lettable spaces to have base building fitouts installed for new tenants including floor finishes, ceilings, and occasionally partitions. Often these finishes are removed to be replaced by other new finishes that better suit the incoming tenant. When assisting a client to select a new tenancy advising the selection of tenancies that are shell and core only, i.e., no floor or ceiling finishes or partitions, can save waste in replacing them for their new design. This also provides the designer with the option for example of not including ceiling panels to the entire fitout or only in areas where they may be required for acoustic or lighting control.

Reducing materials and materials waste. Smart planning can greatly affect the amounts of materials used for a new commercial fitout. This can occur by reducing the amount of materials required for a particular product (see domestic interiors) or reducing their requirements. For example by ascertaining where full-height workstations are required for visual or acoustic privacy, other workstation partition wall heights may be reduced from full height to just above desk height. By reducing wall heights even by 900 mm in an office with 200 workstations, hundreds of metres of fabrics, metal plates, boards and steel/aluminium framing can be saved in production and has added benefits of increasing the ability of natural light to penetrate further into a space. Similarly, office wall heights can be reduced to meet needs rather than wants or conform to norms (Máté 2003).

While reducing the size of our living quarters reduces material needs, so too does the reduction of floor space in office or retail space, subsequently reducing rental costs, decreasing energy requirements for lighting and air conditioning, and reducing the demand for the construction of new commercial buildings. Look to see how particularly areas used only intermittently can be reduced in size or functions doubled. For example, a corridor may "balloon" in size to accommodate a coffee area or casual meeting space, while still functioning as a circulation space (See Figure 3).

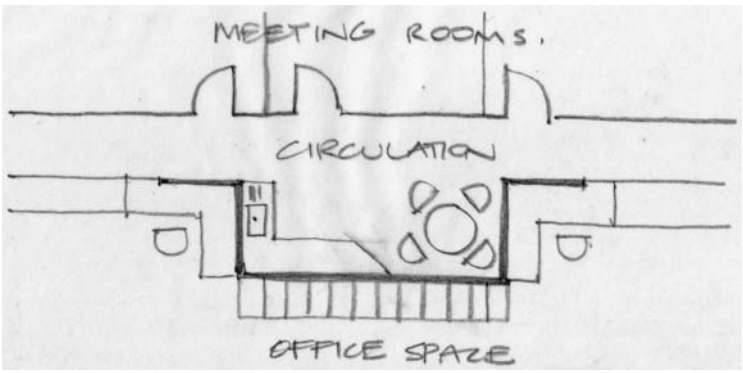


FIGURE 3. Planning an office circulation space to also include a break out area.

During construction waste can be reduced or avoided by ordering exact quantities of materials and/or designing to conform to manufacturers' production sizes. Packaging can also play a major role in waste production for a commercial interior fitout, particularly furniture pieces delivered covered in plastic bubble wrap and similar. Many manufacturers now consider this impact by using reusable and/or recyclable packaging or avoiding packaging all together.

2. Longevity/Durability

In an environment that is constantly changing, selecting items for durability have different considerations than for a domestic situation. With high churn rates in commercial environments, durable items need to be considered for those items that will have a long use and for which needs will not change radically over a 10–15 year time frame. Identifying with the client the items most likely to be retained until the next refurbishment or move and the time lag expected for these activities will provide valuable information on the longevity and durability requirements of materials and products. Once this has been established, materials and products can be selected based on these expected life cycles.

Decisions can then be made addressing the following questions based on short- or long-term life expectancy of the materials/products:

Short life materials and products (under 5 years or will not be retained over next refurbishment or move)

- Can the material/product be reused and/or upgraded by a secondary user? If so, is a leasing arrangement available for this particular material/product or are there genuine markets available for resale or donation?
- Can the material/product be recycled? What systems are available for the recycling of this material/product? Is the material up-cycled (made into an equivalent or better material) or down-cycled (made into an inferior material with no further end of life options)?
- Does the material/product have options for biodegradability? What systems are available for the biodegrading of this material/product?
- Does the material/product come from a manufacturer/producer that takes full life cycle responsibility for their product?

FIGURE 4. Council House 2 (CH2), Melbourne Victoria, the new council building for the City of Melbourne is a 6 Star Green Star rated building with the Australian Green Building Council, the highest rating available in Australia (Designers DesignInc).

- Does the material/product have a low embodied energy and/or come from a renewable or recycled resource? (High embodied energy materials should be avoided for short-term life expectancies.)

Longer life materials and products (over 5 years with a minimum useful life of 10 years or will be retained over next refurbishment or move)

- Can the material/product be sustained/maintained over the duration of its expected life in use?
- Can the material/product be upgraded, refurbished or remanufactured to prolong its life without the need to replace the whole item?
- What are the sustainable implications for maintaining a material/product for the duration of its use? (I.e. cleaning, repair, regularity of maintenance required, energy and water requirements, other durables associated with the product such as toner cartridges)
- How flexible is the material/product to alternative or similar functions for the same client?
- Does the material/product come from a manufacturer/producer that takes full life cycle responsibility for their product?
- Are long term leasing options available for the material/product?

FIGURE 5. Council House 2 (CH2), Melbourne Victoria, materials have been minimised by eliminating secondary ceiling finishes using undulating precast concrete beams and chilled beam thermal control systems. Storage systems double as wall systems, reducing material quantities.(Designers DesignInc, Photographer David Hannah).

- What systems will be put in place to ensure the material/product remains in use for the longest possible time frame? (This is particularly relevant for materials/products with higher embodied energies) Storage may also be a consideration here.
- As all materials and products ultimately have a use by date, what reuse, recycling and or biodegradability options do the materials/products have?
- During a move what will the transport, packaging and storage implications be for the material/product? How easily can the material/product be reused in an alternative setting?

3. Flexibility

With commercial spaces that in our current culture are changed and churned with high frequency, flexibility coupled with longevity and durability can play a vital role. Spaces designed to be flexible can offset the need for economically and environmentally costly moves to suit changing needs and even fashions. As with domestic interiors, flexibility in commercial interiors can

- Perform more than one function
- Change to suit developing needs and styles
- Increase or reduce in size
- Reduce waste and resource impact through reuse

FIGURE 6. Hassell Studio, Melbourne, circulation, meeting, and breakout spaces are all integrated into one open plan area. The space also makes use of iconic furniture such as the Herman Miller Eames Lounge Chairs, which should retain their value and therefore use over many years (Designers Hassell, Photographer Earl Carter).

FIGURE 7. Council House 2, Melbourne Victoria low height, open plan workstation layout provides flexibility and reduces materials use. Carpet floor tiles also facilitate flexibility, reuse, and possible recycling (Photographer David Hannah).

Workstations are generally more flexible than enclosed office spaces. While the layout of workstations may not be changed on a regular basis, the possibility of this happening quickly and economically is far greater than for moving around fixed walls for an enclosed office space. However, increasingly available are demountable wall systems for creating enclosed spaces and/or temporary spaces for placement within an interior, on the market, offering further flexibility. Nevertheless, it is advisable to check how versatile the system is and how easily these adaptations can be

made. Factors to consider include how smoothly a system can be reconfigured, dismantled, and reconstructed and how readily various items can be upgraded, e.g., textiles changed, framing systems modified, surface finishes altered, or technologies adapted (Máté 2003).

Modular, flexible products are generally more available than in domestic interiors that can also be simply and efficiently upgraded and refurbished without the need to replace the whole item. Modular flooring systems, carpet tiles, office chairs, workstations, ceiling panels, modular display units are all products and materials designed for flexibility and control available for the commercial interior industry.

FIGURE 8. Office fitout for Investa Property Group, reception area uses FSC (Forest Stewardship Certified) timber products and reconstituted stone floor which has been integrated into the raised floor panel system for ease of reuse at end of the current fitouts life cycle (Designers Hassell, Photographer Tyrone Branigan).

4. Reuse, recycling, and biodegradability

The issues of reuse, recycling, and biodegradability are similar to those for domestic interiors; however, the practice of reuse is not as widely used by designers as it is for domestic interiors. The cultural practice of starting a design from new in commercial interiors is an activity that needs to be readdressed. As has been discussed previously, leasing and modular systems are one way of addressing reuse as an alternative to buying new. However, the purchase of second items for new fitouts and the reuse of existing furniture is environmentally and also economically viable.

Sometimes reuse is not a viable option, and where this is the case, systems to support recycling and biodegradability are a necessity to minimise long-term environmental impact. With commercial interiors where it is known that the design will have a short-life term, designers could, for example, design the whole interior for recycling or biodegrading—all material choices are therefore based on the availability of supporting recycling or biodegrading systems. It would then be a simple disassembly and sorting process.

MATERIAL USE IN INTERIORS

While the selection of materials and products for interiors based on their own life cycle processes is vial to the success of a sustainable interior fitout, so is the

FIGURE 9. Office Fitout for Sustainability Victoria, breakout space uses cardboard, a biodegradable or recyclable material, as a dividing wall (Designers Hassell, Photographer Trevor Mein).

importance of the selection of materials based on the life cycle of the interior they are selected for. Without taking this into account one is still able to design an interior with inferior sustainable qualities, even when using green materials.

However, another important factor in the selection of materials and products for interiors is the impact these same materials have on indoor air quality.

THE IMPORTANCE OF MATERIAL SELECTION ON INDOOR AIR QUALITY[1]

Why?

In our modern, urban society, we can spend up to 90% of our time indoors and yet while there are plenty of regulatory systems in place to monitor the quality of the outside air, the internal air we breathe can be up to 100 times more polluted than the external air, with the US EPA calling ". . . indoor air quality one of the top five environmental health risks of our time" (Conlan, Carey 2000). And if this alone is not reason for concern, read on.

The effects of poor IAQ result in a:

- reduction in the quality of life for occupants
- loss of productivity for employees
- potential for costly legal action

Risks to human health from poor IAQ include:

- asthma
- allergies
- cancer
- reproductive and developmental problems
- general respiratory irritation

A 1996 study performed in Victoria's Latrobe Valley by Monash University looked at formaldehyde emissions in 80 homes. In households where formaldehyde emissions were greater than 40 parts per billion there was an increase in incidence of asthma in children. This study alone shows that exposure to formaldehyde levels may increase the risk of allergy and asthma among children (Environment Australia 2001) and yet our homes contain a huge variety of formaldehyde content products.

And of course it is the most vulnerable in our society who are at the greatest risk of the affects of poor IAQ—children, the elderly, the infirm, and the unborn babies of pregnant women. A recent CSIRO study has found that 500,000 Australians are living in homes containing air with a level of toxicity 20 times above the national limits set by the National Health and Medical Research Council (NHMRC).

The World Health Organisation (WHO) estimates that as many as 30% of new and refurbished buildings are subject to complaints about internal air. Other research indicates that Sick Building Syndrome (SBS) occurs in 40–60% of office environments. An excess of chronic poor health symptoms that can't be traced but which dissipate when leaving the affected building indicates SBS.

Sick Building Syndrome effects include:

- Irritated, dry, or watery eyes
- Irritated, runny, or blocked nose
- Dry or sore throat
- Dryness, itching, or irritation of the skin occasionally with a rash
- Headache, tiredness, or lethargy

However, as stated by the NSW State of Knowledge Report 2001, "Health impacts resulting from exposure to individual chemical substances in building materials are not well understood." This is because all of the chemicals found in our internal air (and these are known to be around 5,000) have not yet been thoroughly evaluated and so little is known about long-term health effects or when different chemicals are combined—the synergistic effect.

As our health is being affected, so too is our productivity. "Results of hundreds of studies and reports have demonstrated a significant and causal correlation between improving the indoor environment and gains in productivity and health" (AERLAS Air Quality Sciences IAQ Resource Centre). Costs to business and society for this loss in productivity is in the billions of dollars. In the USA estimated costs due to SBS symptoms is around US$60 billion (Fisk 2002) and in Australia it is estimated to be around Aus$12 billion (CSIRO 1998). While money is now being spent (and well spent) on saving energy, the real savings are yet to be made by improving productivity that could outweigh the energy costs by 100:1.

[1]The information contained in this section was first published in InDesign Vol 20, February 2005, "Indoor Air—Take a deep breath," by Kirsty Máté.

In extreme cases, other financial costs can include:

- evacuations
- investigations
- lost productivity
- lawsuits
- workers compensation
- medical costs

Legal action has been taken against numerous people for cases associated with IAQ, predominately in the USA but also in Australia, and, it seems, no one is safe. In the USA employers, building owners, landlords, architects, engineers, contractors, HVAC manufacturers, interior designers, carpet manufacturers, pesticide applicators, and maintenance personnel have all had legal action taken against them through cases involving IAQ.

In a landmark case in the USA in 1999, a woman was awarded US $400,000 from her employer after she was forced to keep working in her newly renovated office even though she had been rushed to hospital with chest pains and vomiting from fumes from the carpet. While many have been settled out of court, it is believed that these court cases are on the increase with two, more recent cases involving IAQ, resulting in settlements of [US] $25.9–$35 million (AERLAS Air Quality Sciences IAQ Resource Centre).

What?

The major impacts of poor IAQ are due to the quality of the external air, the building materials (particularly internal materials), people, HVAC systems, level of ventilation and clean fresh air intake, cleaning chemicals, level of humidity, and equipment—particularly office equipment but also gas stoves and unflued gas heaters in a domestic environment. While all of these issues are of concern, for interior designers, the choice of material is the most significant and has been highlighted as the most important. "The opportunity to guard against poor IAQ in a building, therefore, lies not only in its design, but in its fitout and choice of materials" (Report on Sick Building Syndrome, NSW Legislative Assembly 2001).

There are four important factors associated with the health effects of materials:

- Emissions
- Toxicity
- Quantity
- Proximity

Emissions. Emissions are gases and other volatile organic compounds (VOCs) which emanate or offgas from certain materials. VOCs are organic (carbon containing) compounds that are converted into gases at low temperatures and so can take several years to be liberated in typical indoor environments. Over 5,000 VOCs have been identified to date in indoor air. They originate from building materials, furnishings and equipment such as adhesives, carpets, paint, and manufactured timber products. While VOCs outgas over time and this level of outgassing dissipates over time, some can still occur over a number of years.

Toxicity. While most materials offgas some type of compound, not all are dangerous to human health. Materials that have toxic ingredients have harmful or poisonous effects on people, and the level of toxicity may be relevant in certain materials. Acute toxicity has immediate effects, while chronic toxicity has long-term effects.

Quantity. As the type and toxicity of materials are important, so is the quantity of the emissions. Low emissions from large quantities of materials such as walls, floors, and ceilings can result in high total amounts of chemicals in the internal air. A synergistic effect is when the sum of emissions from a combination of different materials is greater than their individual effect.

Proximity. Materials contained within an interior are more likely to have an effect than those outside. However, materials that are situated outside an internal space can affect some people. VOCs may also spread from one space to another through diffusion through walls and ceiling spaces or in commercial environments through HVAC systems.

Some building materials:

- have higher emissions than others
- are enhanced by an increase in temperature or humidity and therefore increase the VOC emission
- have higher VOCs in newer products
- have VOCs that are greatest during curing and drying of "wet" materials

- can adsorb pollutants and re-emit or desorb them over an extended time—this can prolong the presence of a compound in the internal environment but can also act as a temporary buffer (Meininghaus et al 2000)

Generally, in any building between 50–150 different VOCs can be detected (Environment Australia 2001). While little is yet known of the health implications due to the synergistic effect, research has indicated that individuals may suffer irritations if the sum of all individual volatile chemicals or TVOC ranges from 0.2mg/m^3 to 3mg/m^3.

Some of the toxic chemicals found in internal materials include the following:

- Formaldehyde
  —Paints, particleboards, carpets, glues, drapes, plastic resins, furniture and insulation foams, fire and shrink proof fabrics, paper products
- Xylene/toluene
  —Paints, glues, carpets, polyurethane
- Vinyl chloride monomer styrene
  —Vinyl flooring, blinds, textiles, synthetic rubber underlay, 2 part fillers and paints
- Isocyanates
  —Polyurethanes, glues, fillers
- Glycol Ether & derivatives
  —Solvents in water based paints, varnishes, glues
- Epoxy resins
  —Tile, wood and metal glues, cement and surface binder, terrazzo
- Benzene
  —Paints

While formaldehyde has been listed a *probable* human carcinogen until recently, it has now been listed as a human carcinogen and yet it is the most commonly identified VOC in indoor environments and is a major component of indoor air pollution. Exposure to other chemicals listed can cause asthma, damage to lungs, liver, blood, and the central nervous and reproductive systems.

How?

Specifying for a project with low VOC emissions and better indoor air quality can be problematic due to the limited amount of information currently available, including zero or low VOC emitting products. However, there are ways of improving the current situation and begin to instigate change, especially among manufacturers and government.

It has been mentioned that a high quantity of even a low emission material can have detrimental effects on the quality of the indoor air. Therefore, when specifying low or zero emission products, these are the areas that should be concentrated on:

- walls
- floors
- ceilings
- furniture (particularly in large office fitouts)

We have also mentioned that certain people are more susceptible to poor IAQ conditions, thus, zero/low VOC products should be a top priority when designing kindergartens, schools, pre-schools, hospitals, accommodation for aged care, medical clinics, mother care, nursery rooms, and so on.

Key steps in reducing the levels of VOCs in an internal environment are:

To Eliminate

- Substitute materials with those of the lowest possible emissions.
- Prioritise zero/low emission internal materials.
- Control of emissions should be the most important strategy rather than trying to clean continually polluted air.
- Avoid use of solvent glues—specify screw/nail fixings.
- Minimising material types also minimises synergistic affect.
- Always ask for an MSDS (Material Safety Data Sheet) which should list any dangerous chemicals.
- Maintenance and cleaning solutions should be water-based not solvent—check maintenance of especially flooring materials when specifying.
- Minimise applied finishes by selecting materials which do not require a finish for durability or longevity.
- Minimise textiles, carpets and ceiling tiles that can be major absorb/desorbers of VOCs.
- The addition of indoor plants may also assist in eliminating some VOcs and adding a fresh source of oxygen to the internal environment.

To Separate

- Use air barriers or seals to separate problem materials and products from other areas.

FIGURE 10. Office Fitout for Sustainability Victoria, the use of planting to improve indoor air quality and double as dividing screens (Designers Hassell, Photographer Trevor Mein).

- During refurbishment or construction on a multi unit or commercial site, ensure no pollutants are being carried through the HVAC system.
- Conduct pollutant-producing activities during non-occupancy or separately ventilate.
- Wet finish trades completed before installation of absorbing materials.
- Materials which have similar cleaning regimes should be placed next to one another, i.e., cork/linoleum next to carpet as all have a dry maintenance regime.

To Ventilate

- Provide fresh air through open windows (if this air is not contaminated).
- Use mechanical systems that are designed to remove pollutants and provide fresh air.

In America "bake outs" have been implemented in new buildings before occupation to literally heat up the building to high temperatures and bake out the

FIGURE 11. Office fitout for Investa Property Group, break out area uses FSC (Forest Stewardship Certified) timber products and a linoleum floor to minimise the VOC emissions including formaldehyde (Designers Hassell, Photographer Tyrone Branigan)

VOCs. This procedure is, however, energy intensive and the VOCs are just released into the external atmosphere instead and should be a last resort technique in reducing VOCs. Another solution to already problem areas is the use of plants that can reduce the level of VOCs in the internal environment. Recent research at the University of Technology Sydney has indicated that plants can remove certain problematic toxins.

Some preferred materials for a better IAQ include:

Floors

- Linoleum
- Cork—without a polyurethane finish
- "Grass" soft flooring: sisal, coir, sea grass—with a *natural* latex backing
- Solid timber—without a polyurethane finish
- Concrete—without a polyurethane finish
- Tiles and stone products

Walls—paints (for more information see product section):

- Low VOC paints
  —VOCs less than 700 ppm
  —Limited to flat, eggshell, and semi gloss in whites and soft pastels
- Plant or mineral paints
  —Naturally occurring VOCs
  —citrus-based solvent d, l-limonene, turpentine, tung oil, or pine resins

- Milk paints
  —least toxic
  —made with milk proteins, earth pigments, lime, and clay
  —may need to be painted more frequently
- Whitewashes
  —lime paste, water, salt
  —best used on plaster, cement, or stucco walls

Furniture—compressed timber fibreboard

- Select solid timber cabinets and furniture instead of compressed timber
- Select second-hand furniture—where most if any VOCs will have been "off-gassed"
- Completely laminate compressed timber products to capture VOC emissions within product
- Low formaldehyde products are now available on the market; however, be aware that recent USA research has shown that formaldehyde is only *one* of the VOCs found in compressed timber fibre boards—others include small straight-chain aldehydes such as hexanol, pentanal, heptanal, octanal, and nonanal and generally exceed emissions of other compounds and accounted for more than 50% of the total VOC emissions (Baumann et al. 2000)

FIGURE 12. Office Fitout for Sustainability Victoria, minimal material usage, reducing product with formaldehyde content and the use of planting to improve indoor air quality and double as dividing screens (Designers Hassell, Photographer Trevor Mein).

What now?

While the importance of IAQ is still filtering through our society, there are some excellent resources now being made available to assist designers to select appropriate materials both internationally and in the Asia Pacific.

These include:

- Blaue Engel www.blauer-engel.de—most comprehensive listing of eco labelled products—710 companies and over 3,800 products from building material made with waste paper to wallpaper. Includes very detailed information concerning standards for chemical inclusion.
- European Eco Label http://www.eco-label.com—not as comprehensive—relevant categories include paint, hard floor covering and textile products.
- GreenGuard www.greenguard.org—American database of independently tested interior products/materials tested specifically for good IAQ.
- Global EcoLabelling Network includes IAQ as criteria for relevant products including paints, wool carpet, and recycled plastic.
- EcoSpecifier www.ecospecifier.org—a subscription based resource of ecologically superior products that includes information on IAQ issues.

The USA appears to be making the most advances in this area (perhaps due to the high legal implications) and standards are being developed which could be adopted in other countries where no local standards exist, including a list of recommended emissions for commercial buildings:

- Floor materials/coatings 600µg TVOC/m^2/hr
- Wall materials/coatings 400µg TVOC/m^2/hr
- Movable partitions 400µg TVOC/m^2/hr
- Office furniture 2500µg TVOC/hr/workstation

CONCLUSION

Key factors for reducing the environmental impact of interior design

While other ecological building issues such as energy and water are important, waste and the quality of our internal air are major challenges for the interior designer. Increased consumption in domestic interiors will continue to have increasing impact on resources and waste as has already been recognised in commercial interiors.

The importance of reducing environmental impact through material selection, together with the understanding of the individual impacts of those materials and products, should not be diminished. However, the recognition of the life cycle of the interior design these products and materials are intended is of equal importance in reducing the overall impact of interior designs and improving the health and well-being of the people for whom they are intended.

To minimise this environmental impact:

- Reduce the amount and variety of materials used.
- Ensure materials and products are selected which have reduced their own life cycle impacts and are selected to best reduce the life cycle impact of the design.
- Reuse materials and products as much as possible.
- Select recyclable and biodegradable materials particularly when reuse is not an option.
- Select materials which do not add to poor indoor air quality.

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