



# TOWARDS BUILDINGS THAT THRIVE



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Source: greenroofs.com

Our buildings are causing sickness and destroying ecosystems from the pollutants released during material extraction, processing, manufacture and disposal. Serious health concerns are also resulting from poor indoor air quality due to the use of unhealthy materials.

These buildings also demand large quantities of non-renewable resources that are being depleted at a rapid rate. Their construction and operation accounts for more energy use and waste production than any other single sector. The fossil energy being used emits greenhouse gas emissions, affecting urban air quality and contributing to climate change. Healthier, more resource efficient buildings are urgently needed.



**Buildings  
must help  
people  
thrive**



Source: wellbeingchiropractic.nl

Source: Ralph Alphonso

## INTRODUCTION

Buildings are an essential component of almost all cultures around the world, providing shelter, comfort, and security. Yet, their construction and operation requires a considerable amount of natural resources, including energy, water and materials, resulting in significant environmental damage. With the availability of many of these resources rapidly dwindling and the ever-increasing irreversible changes to the Earth's ecosystems, there has never been a more critical time to rethink the way in which we design, construct and use our buildings. The use of unhealthy materials inside buildings, many containing toxic substances, is also making people sick as a consequence of poor indoor air quality. With the majority of people spending most of their time indoors it is essential that we also consider the effect that buildings are having on human health and wellbeing.

This report outlines some of the key problems associated with the way in which we currently design, construct, operate and manage our buildings. The critical areas covered include health and wellbeing, natural resources, fragmented decision-making and economics. It then presents a range of strategies for addressing these problems and

creating buildings that are much more efficient in their use of resources, are healthier places for people to live and work in, and ultimately make a positive contribution to the environment, social wellbeing and building performance. A range of case studies are used to reinforce both the extent of the problems and urgent need to address them as well as demonstrate how suggested strategies can be used to produce buildings that help protect our fragile ecosystems, are healthier, and most importantly, help people to thrive.

While this report draws upon some of the most recent advances in the relevant disciplines, it is written for and targeted towards a lay audience. For a more technical perspective, please refer to the included references.

“With the availability of many resources rapidly dwindling and the ever-increasing irreversible changes to the Earth's ecosystems, there has never been a more critical time for us to rethink the way in which we design, construct and use our buildings.”





Healthier  
buildings  
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## HEALTH AND WELLBEING

Indoor environmental quality (IEQ) is the term used to describe the combined levels of lighting, thermal comfort, air quality and acoustics experienced by people living and working inside artificially created environments. The quality of the indoor environment is an important issue, because of the significant amount of time (80-90%) that people living in developed economies may spend inside enclosed buildings due to lifestyle choices (Klepeis et al., 2001).

In buildings with poor IEQ, people can experience physical and psychological effects, as the receptors in their nervous systems react adversely to environmental stimuli (sounds, smells, light and temperatures) that are beyond the comfort thresholds for the activity they are undertaking (Bluyssen, 2014). In a thriving environment, good IEQ is part of a healthy ecosystem that supports wellbeing and productivity.

Certain buildings are extra sensitive to these factors - hospitals, child care facilities, aged care facilities and schools in particular. Of the different building typologies, it is in commercial office environments where we have the clearest understanding of the minimum performance



thresholds required for achieving good IEQ. For example, inside an office environment, the acceptable threshold levels for indoor pollutants are below 0.05 mg/m<sup>3</sup> of particulate matter (PM10) and 0.5 mg/m<sup>3</sup> of total volatile organic compounds (TVOC), with ambient air temperature in the range of 21 to 24.9°C and relative humidity between 35 to 65% (NABERS, 2010). In a commercial context, our understanding of acceptable IEQ thresholds has been driven by research on the financial gains for businesses which operate inside buildings with good IEQ. In the United States, the financial gains from achieving good IEQ in a workplace are estimated to be up to US\$700 per employee/company/year, as staff generally are more productive and have fewer days off work due to illness (Fisk & Seppanen, 2007). A 2004 report estimated that poor IEQ could cost the

Australian economy \$12 billion/year (Building Commission Victoria, 2004).

Hospitals, child care facilities, aged care facilities and schools are building types where good IEQ must be achieved for social rather than financial gains. Children, the elderly and the sick are particularly vulnerable to environmental stressors because of their growing bodies and lowered immune systems. This means that the 'thresholds' which constitute good IEQ in a commercial context, may not be directly 'transferable' into other environments (Bluyssen, 2014).

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## WHAT IS THE PROBLEM?

### AIR QUALITY AND ASTHMA

The condition of the physical environment can spread or exacerbate illness, which can result in absenteeism from school and work and delayed recovery from other health conditions. For example, the condition of the built environment has been shown by Belanger et al. (2006) to be a probable asthma trigger. They analysed ten years of hospital records from 1991 to 2001 and concluded that the physical indoor environment could exacerbate asthma. It has also been found that people who spend a large amount of their time in spaces with visible mould, inadequate ventilation and vermin were more likely to be absent from school or work due to asthma and other illnesses.

In developed economies, asthma is a leading cause of chronic disease-related school absenteeism (Hsu et al., 2016). Evidence shows that students with asthma miss on average three more school days per year than children without asthma and have an increased risk of suffering a learning disability (Hauptman & Phipatanakul, 2015). A student with asthma may be absent from school on days directly after an attack, or when there is an increased number of asthma triggers present in their environment. In the United States, one in ten school-aged children have asthma, while in Australia this figure is one in nine (AIHW 2009). An asthma attack can be triggered by a number of factors including viruses (cold/flu), exercise, changes in weather, and exposure to pollens, dust, dust mites, pets, moulds, and environmental tobacco smoke (NCA, 2013).

While approximately 70% of children diagnosed with asthma become symptom free by the time they reach adulthood, chronic school absenteeism (where a child is absent from school for more than 10% of the academic year), can have long term impacts on the quality of a child's education, which in turn, may reduce life prospects. The remaining

“Students with asthma miss on average three more school days per year than children without asthma and have an increased risk of suffering a learning disability.”

30% must live with the condition and learn to avoid environments/situations which could be triggers for an attack. A recent review of asthma treatments in the United Kingdom found that despite increasing investment in such medical treatments of asthma (such as therapeutic use of inhaled corticosteroids) progress has stalled in the past 10 years with “preventable [asthma related] deaths continuing to occur with depressing regularity” (Bush et al., 2015). While the cause of asthma attacks can be different for every asthmatic, the quality of the indoor environment can exacerbate the condition, while also spread bacteria and infection that can affect non-asthma suffers.

Health issues related to indoor air quality are also more acute in aged care facilities. For instance, a higher proportion of respiratory discomfort (i.e. wheezing) has been shown to be caused by a high incidence of particulate matter (Bentayeb et al., 2015). There is also evidence to show that breathlessness and coughing increases within spaces with high elevations of carbon dioxide.

Poor air quality can also be caused by the use of building materials that off-gas during their use, producing odours and introducing volatile organic compounds into the indoor environment. This can lead to serious health issues for building occupants, including Sick Building Syndrome (SBS). Buildings that are unhealthy to be in and that make people sick are of even greater concern when they are being used for people that are much more susceptible to illness.

### MICROBES

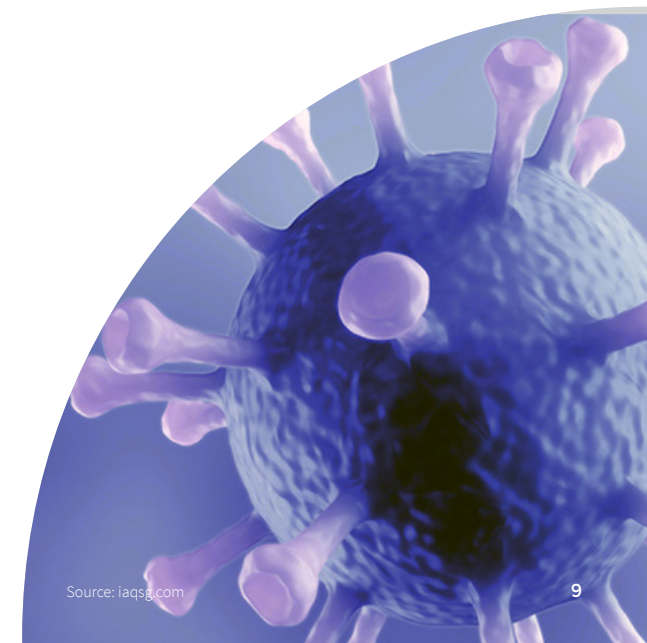
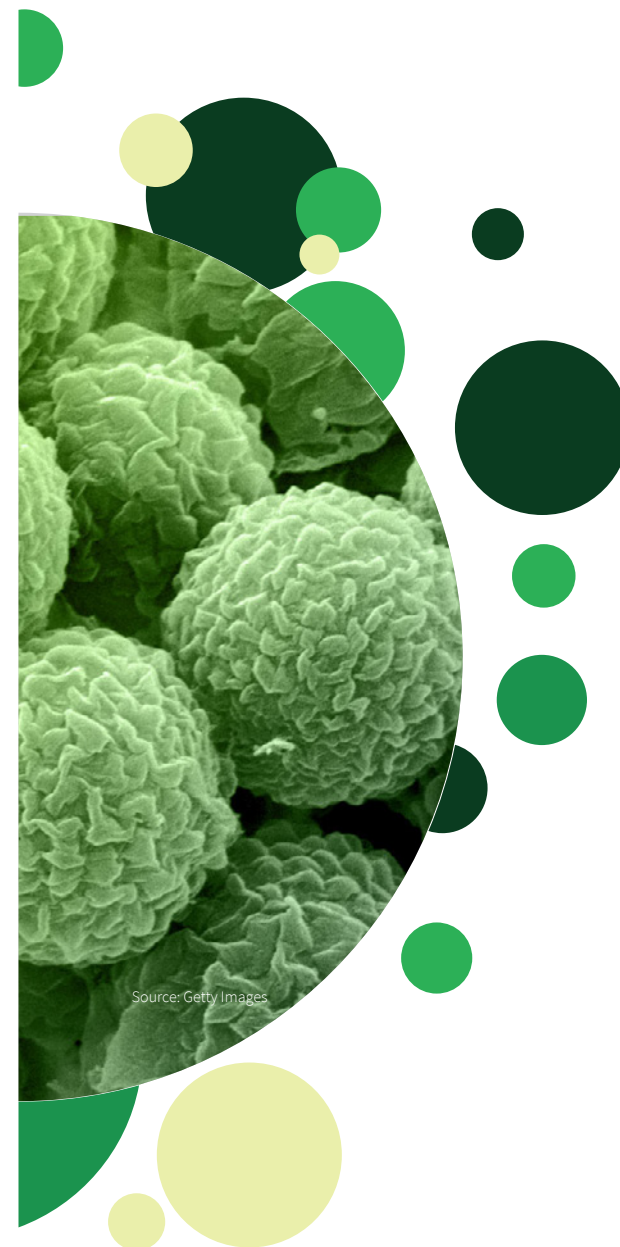
Microbes are airborne microorganisms, commonly known as mould or fungi. Microbes require moisture to reproduce. In the built environment, this may occur near stagnant and dirty water in condensation pans, inside the filters of HVAC units, in wet carpet and on ceiling tiles. Microbes have microscopic spores that may become airborne passively (as people walk past) or mechanically (as they are blown from HVAC units). Airborne spores are also actively discharged from surface moulds.

Research about the specific risks of exposure to airborne microbes is inconclusive. The US Environmental Protection Authority highlights that all moulds have the potential to cause health risks; however the severity of the risk depends on the type of mould, the extent of the exposure, the individual's age and their predisposition to allergies. With this in mind, some of the risks from exposure include triggered asthma attacks; pneumonitis; eye, skin, nose, throat and lung irritations.

### PARTICULATE MATTER

Particulate matter (PM) describes airborne particles that range in size from 0.001 to 100 microns. Particulate matter is made up of both respiratory and non-respiratory particles. Particles that are between 5 and 10 microns in size are non-respiratory, which means they are more likely to enter the upper lung and cause respiratory irritation. Respiratory particles that are <5 microns in diameter can penetrate the lower lung and cause respiratory damage (IPMVP, 2002). The particles can come from indoor and outdoor sources. Common sources of particulate matter are dust (from nearby roads and playgrounds), dead skin cells, fibres (from clothing and soft furnishings) and pollen (particularly problematic during Spring). Having an understanding of the sources of particulate matter is only half of the solution. The other half of the problem can be attributed to how the particulate matter becomes airborne. Typical ways that this can occur include poorly designed, maintained and operated HVAC systems, airflow past infrequently cleaned indoor surfaces and a high volume of occupants moving around a space and in between indoor and outdoor environments.

Volatile organic compounds (VOC) are a class of gaseous pollutants that are emitted from a range of mostly man-made products and processes under normal atmospheric conditions. There are over 900 natural and synthetic chemicals that can each be labelled a VOC (IPMVP, 2002). The reaction that people have to VOCs can vary, depending on the sensitivity of the individual, the nature of the VOC, the length of exposure and the level of exposure (Frumkin et al., 2007). The symptoms generally associated with exposure to VOCs include skin and eye irritation, fatigue, dizziness, headaches, nausea and respiratory difficulties.





## THERMAL COMFORT

For humans to operate with normal bodily function they require a constant internal body temperature of 37°C. Coming into contact with a hot or cold environment can increase or decrease a person's body temperature, through conduction, convection and radiation. It is therefore critical to design spaces that provide good thermal comfort. Children and the elderly are particularly affected by thermal discomfort. Children often spend extended periods of time engaged in activities that involve being seated on the floor, which can be cold, leading to thermal discomfort. The elderly are particularly sensitive to thermal discomfort, notably during heatwaves, or during the cold months of winter. It is therefore crucial to design thermally comfortable buildings for these uses, which is not always the case. A Portuguese study assessing thermal comfort across twenty-two aged care facilities found that 42% of the residents find indoor conditions cold (Mendes et al., 2015).

Hospitals are probably the building type which requires the highest levels of thermal comfort as inadequate temperature can not only cause discomfort but can also severely impact the health of patients, resulting in longer healing periods or aggregated sickness.

“Poor acoustics within a building can considerably impair an individual's productivity.”

“A noisy, confusing hospital room might leave a patient not only feeling worried, sad, or helpless but also might raise his or her blood pressure and heart rate and increase muscle tension. In addition, hormones released in response to stress could suppress the patient's immune system, causing wounds to heal more slowly.”

(Sadek and Nofal, 2013)

## ACOUSTICS

The acoustic qualities of a space should be designed considering its use. For instance, classrooms should be designed to facilitate clear communication of speech between the teacher and students. The acoustic properties of a classroom impact the effectiveness of good pedagogy, through directly impairing the development of students' comprehension and skills. Reverberation and background noise can lower the speech to signal ratio, reducing the level of speech intelligibility between students and their teachers and/or peers, which in turn decreases student engagement in the task and understanding of the lesson (Pohl, 2011).

In hospitals, the space should be designed to minimise sources of background noise to provide a peaceful environment for the patient to recover. Sources of background noise can include any means of transport (road traffic, railway, aircraft), plant and equipment (required for heating and cooling), noise from adjoining rooms (scraping chairs and movement) and outdoor activities that are either on the grounds or on neighbouring sites.

Reverberation time is a measurement of how much time it takes for a signal to decay. In a room with exposed surfaces, such as brick and tiles, the sound will be reflected. Inside a room that reflects sound, the energy from that sound will continue to bounce around the space and become weaker, until it finally diminishes. Sound made inside a room with soft finishes (carpet or vinyl) will be absorbed. Sound absorption allows the individual signals that make up speech to be heard, providing greater clarity for listeners.

## IMPROVING HEALTH AND WELLBEING

Good indoor environmental quality performance inside a building is the product of how it has been designed, constructed, maintained and/or operated by occupants (Vittori, 2002). Design professionals can influence the performance of building IEQ, through making well-informed decisions during the design phase that reflect how a space will be used. The following strategies are recommended, particularly for those buildings with a sensitive population, in order to improve building IEQ.

### Washable surfaces

Specify floor and wall surfaces that are washable, which do not contain fibres that can hold particulate matter or support microbial growth. This will help ensure that disease is not as easily spread and occupant illness from airborne particles is minimised. Respiratory problems, such as asthma, may also be reduced.

### Low VOC materials

Specify building materials, including finishes, furniture and fittings that off-gas no or low levels of volatile organic compounds. This will help to minimise the occurrence of Sick Building Syndrome, creating a much healthier indoor environment and may reduce instances of absenteeism.

### High sound absorption materials

Specify finishes with high levels of sound absorption. This will help to control noise within indoor environments leading to higher levels of speech intelligibility, greater student engagement, and more comfortable environments, especially for those highly sensitive to noise.

### Thermally comfortable materials

Consider the radiant temperature of any materials that people may be in direct contact with. Ensure these materials are not able to get so hot or cold that being in contact with them causes thermal discomfort. This will help to ensure that building occupants, even children sitting on the floor, are comfortable.



Source: thenatpath.com



# CASE STUDY: Schools

Receiving an education inside schools with poor IEQ can be particularly challenging for children compared with adults (Faustman et al., 2000; Landrigan, 1998; WHO, 2006). Children are in a dynamic state of growth where environmental contaminants can cause irreversible damage to their nervous, immune, respiratory, endocrine, reproductive and digestive systems.

Children have a higher risk of being exposed to contaminants as they spend long periods of time closer to the ground - where most contaminants will settle. As they are still developing their hygiene behaviours, they are more inclined than adults to end up with these contaminants in their mouths.

In addition to the potential effects of contaminants on the health and wellbeing of children, their learning process can also be negatively affected by noise. As children are still developing their comprehension skills they can find it more difficult to recognise speech signals and comprehend sentence structure in classrooms with poor acoustic performance. They are also more inclined to become distracted by noise.

The students considered the most at risk of learning difficulties and disengagement from school, are those who are absent for more than 10% of the school year (approximately 15 to 18 days). Balfanz and Byrnes (2012) define students who miss more than 10% of the school year to have “chronic absenteeism”. The specific impact of absenteeism on academic progress can vary with subject matter. For instance, progress in mathematics is more sensitive to absenteeism, compared with progress in reading (Aucejo & Romano, 2016). In a report about Equity and Quality in Education, the OECD (2012) highlights that educational failure can impose a high cost on both the individual and society. There is a high likelihood of fewer life prospects for students once adults, who miss out on developing the knowledge and skills that come with gaining an education.

To address these concerns and create school environments that are more susceptible to learning, student engagement and improved student health, classroom design must be based on well-considered design choices that align with their function and consider the unique needs and characteristics of growing bodies.

“High quality indoor environments with well-considered material choices are essential for reducing the instances of asthma and other illnesses resulting from poor air quality within schools.”

## FIVE REASONS TO PROMOTE HEALTHY SCHOOLS

1. Many childhood illnesses and deaths are greatly influenced by the built environment.
2. Children are more susceptible to environmental diseases than adults and therefore need healthy schools.
3. Children’s health can be improved with low-cost interventions at schools.
4. Implementing changes in the school physical environment can improve children’s health.
5. Improvements in the physical school environment can increase school attendance.

(WHO, 2006)



Source: UNICEF





# CASE STUDY: Hospitals

Traditional and institutional hospital architecture treats the building design as a shell constructed to accommodate the scientific knowledge of human bodies and the range of technologies required to care for them (Helminski, 2014). Hospitals can be uncomfortable environments for patients to navigate as they face psychological fears about their illness, procedure and/or being in isolation; along with physical complaints caused by poor indoor environmental quality.

Our current and developing understanding of health care facilities elevates the importance of hospitals as places of healing, where the environment should be complementary to the medicine.

Improving the quality of the indoor environment inside a hospital may contribute to reducing errors, falls, and infections, while enhancing patient privacy, comfort, and control (Huisman et al., 2012). “Healing environments can be considered as smart investments because they save money, increase staff efficiency, and reduce the hospital stay of the patient by making the stay less stressful” (Huisman et al., 2012 citing Ulrich, 1992).



“The new broader perspective in medicine requires that the psychological and social needs of patients be strongly emphasised along with traditional economic and biomedical concerns, including disease risk exposure and functional efficiency, in governing the care activities and design of healthcare buildings”.

(Ulrich, 2001, p.49)

“Research has shown that green design principles such as improved ventilation, natural light and a connection to nature can lead to an 11% reduction in secondary infections and a decrease in nursing turnover rates.”

(GBCA, 2009)

Improving IEQ in hospitals involves the use of views of nature and nature images, indoor plants and landscaping, way finding and orientation of the space, pleasant colour schemes, the presence of coordinated art objects, furniture layout, air quality and freshness, daylight, thermal comfort, and acoustic quality. This can help to reduce pain amongst patients, sleep disturbance associated with excessive noise, delirium and agitation, post-surgical complications, hearing loss amongst premature babies, patient mortality, risk of medical error, and length of hospital stay.

Source: Tarkett





# NATURAL RESOURCES

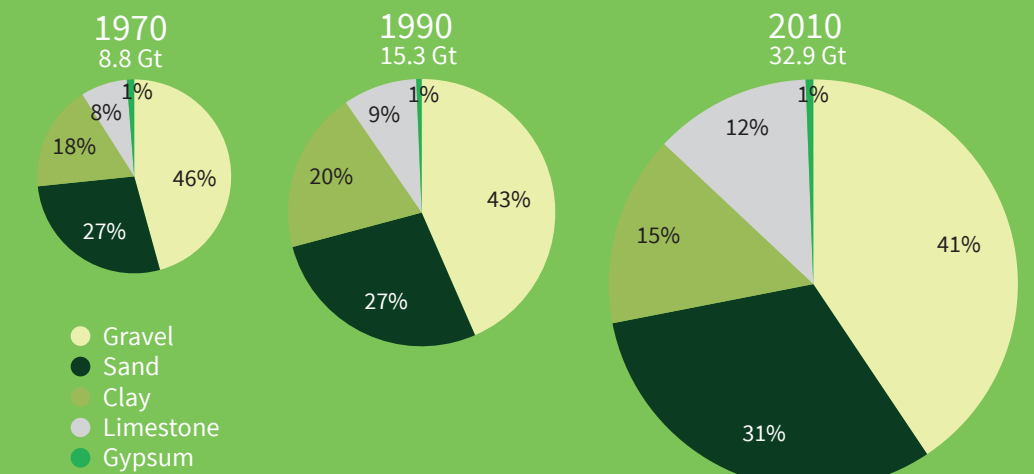
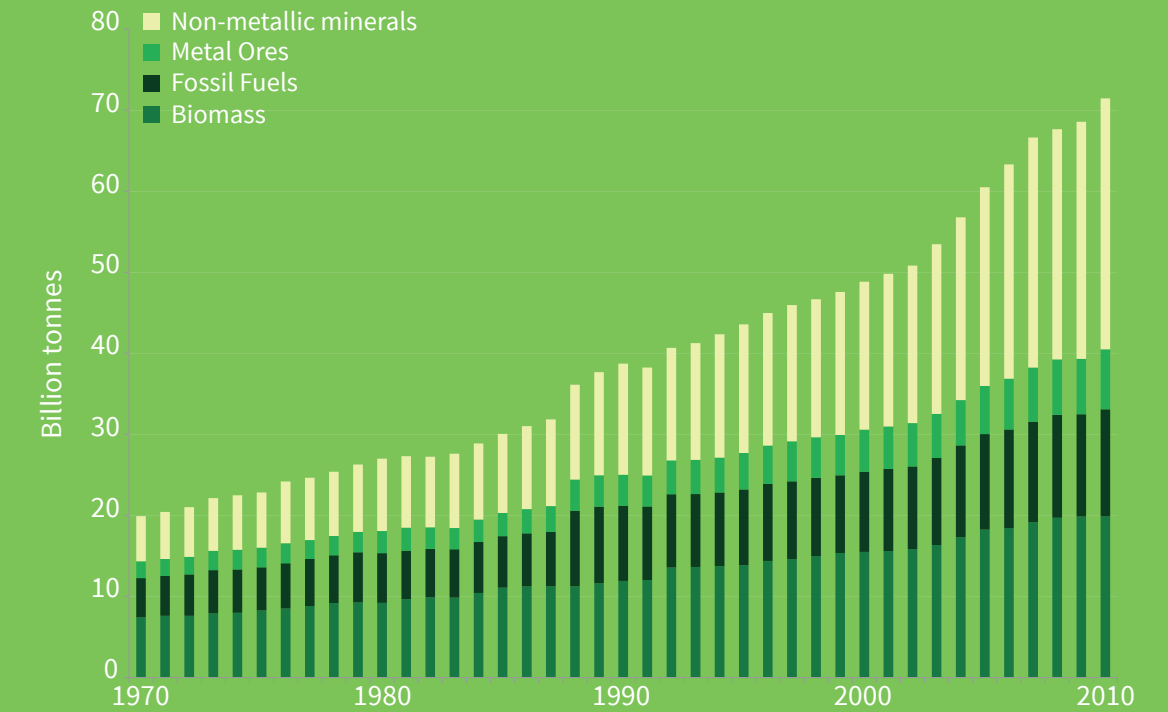
The construction and on-going use of buildings demands a considerable amount of the earth's natural resources. These resource demands occur across the entire life cycle of a building and include fossil fuels, water, and raw materials, such as metals, non-metallic minerals and biomass. Raw materials (such as sand) are used to manufacture building materials (like concrete) and products. Energy and water are used in these manufacturing processes as well as during building occupancy for the provision of heating, cooling, lighting and other operational needs.

Over 70 billion tonnes of materials are extracted from the earth on an annual basis, which highlights the scale at which these natural resources are being used. This is enough to cover the surface of Tasmania by half a metre, every year. In the 40 years from 1970 to 2010, global materials extraction tripled. In addition to this, the rate of extraction has grown faster since the start of the present century than at any other time in recent history. The extraction of non-metallic mineral products has driven much of this growth, accounting for the fastest rate of increase of any natural resource. Of the total volume of resources extracted, non-metallic minerals, i.e. gypsum, limestone, clay, sand and gravel, represent around 44%, growing at a rate of 4% per year on average since 1970.

## BUILDING SECTOR

The building sector is responsible for at least 80% of non-metallic mineral use, accounting for over 25 billion tonnes per year, mainly for the production of concrete and bricks. Buildings also account for over one-third of global energy use (IEA, 2013) and 32% of greenhouse gas emissions (IPCC 2014) and represent one of the main users of metal ores.

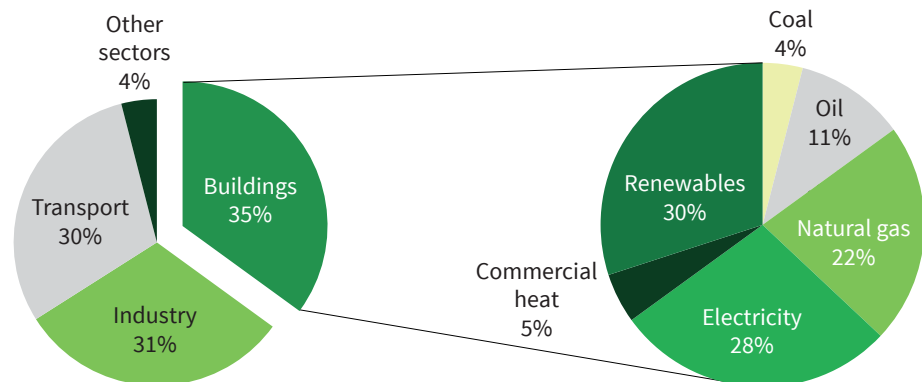
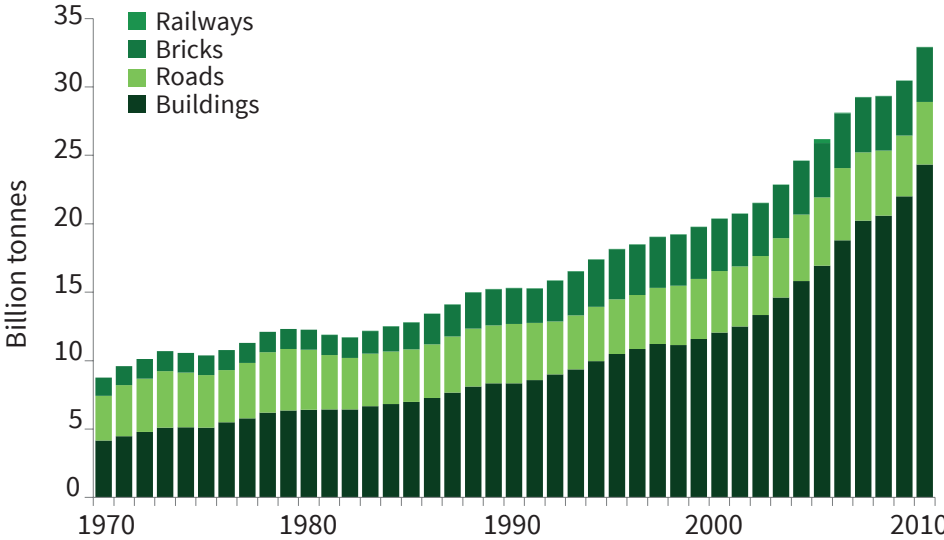
“The building sector is one of the largest consumers of natural resources and thus has a critical role to play in reducing the environmental effects associated with their extraction and use.”



Global annual material extraction by material (top) and breakdown of non-metallic minerals (bottom)  
Source: UNEP (2016)



“Resource use has grown dramatically over recent years, driven by population growth, higher incomes and increasing standards of living.”



Global annual material extraction (top) and energy use (bottom), by sector

Sources: UNEP (2016) and IEA (2013)



Sand and gravel are the most extracted materials

Source: Rochelle Peabody

## WHAT IS THE PROBLEM?

The extraction and use of the Earth’s natural resources contributes to a broad range of consequences for the natural environment and on human health and well-being.

The continued use of non-renewable natural resources will inevitably lead to a reduction in their availability and eventually at some point in the future, their depletion. Any growth in the rate of resource use, as is currently being experienced, will lead to an even faster rate of depletion. With global economies so heavily reliant on the Earth’s non-renewable resources for the provision of energy, food and shelter, this poses a serious concern for our future unless alternatives are found.

The process of extracting, consuming and disposing of resources also results in other pressures on the environment. Mining and harvesting of resources results in land disturbance and degradation, through erosion, salinisation and acidification. It can also lead to the destruction of habitats and the loss of flora and fauna. Processing of raw materials and the subsequent manufacture of commodities, such as building materials and products, contributes to the release of greenhouse gases, pollutants and waste. The potential effects of global warming resulting from increasing concentrations of

greenhouse gases in the atmosphere are well documented, including rising sea levels, more frequent extreme weather events and species extinction. Lower awareness exists of the indirect consequences of the release of ecotoxic (toxic to nature) and anthropotoxic (toxic to humans) pollutants into the soil, waterways and air. These can have a direct effect on human health, through water contamination and reduced air quality for example, as well as an indirect effect as these pollutants are passed along food chains and accumulated in organisms at the top of these chains.

Even during the use of buildings there is a considerable demand for resources, in the form of energy, water and replacement materials. These indirectly result in the production and release of additional greenhouse gas emissions, pollution and waste. All resources extracted from the Earth are eventually sent back to the Earth in one form or another, most of which as waste. A range of mechanisms for controlling the effect of this waste on the environment and human health are in place. However, for the vast majority, a lack of controlled release into the environment, and the rapid pace at which this is occurring, is causing irreversible damage and considerable consequences for human civilisations.

Natural resources are being depleted at a rapid rate

“Demand for resources is creating irreversible and detrimental consequences for the environment and human health.”

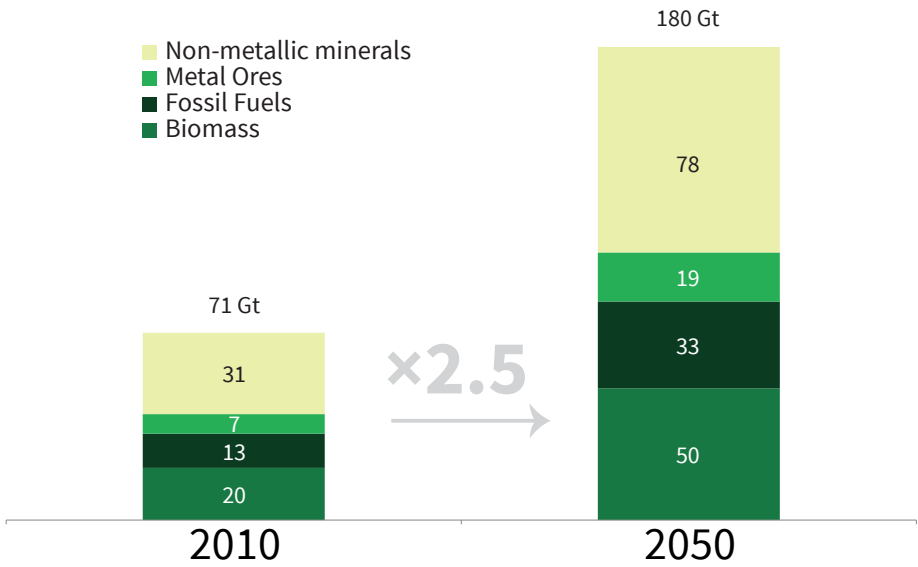


# CASE STUDY: What does the future hold?

Increasing population is a key driver for growth in demand for resources, with the need for more housing, infrastructure, food and fuel. While there is an obvious link between population growth and demand for resources, higher incomes and increasing standards of living, particularly in developing economies, are also driving up the demand for resources.

If we assume that the world is moving towards a system of production and provision of major services, such as housing, mobility, food, energy and water supply, that matches those enjoyed by developed economies, nine billion

people would require 180 billion tonnes of materials by 2050, almost three times the current demand (UNEP, 2016). In many areas the global economy is already surpassing the ability for the environment to cope with the pressures being placed upon it. This means that the level of well-being experienced in developed economies cannot be extended globally based on the same system of production and consumption unless large improvements in resource efficiency are achieved, and lifestyles are potentially adapted.



Global annual material extraction is expected to grow to 180 billion tonnes by 2050  
Source: UNEP (2016)



Source: Donald Ytong

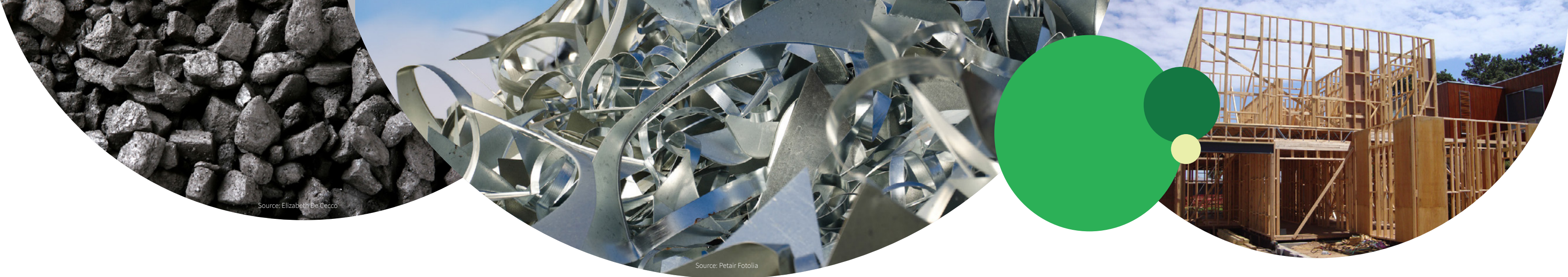
180 Gt  
The expected amount of materials humanity will extract from the ground in 2050



Iron ore is one of many materials that will see an increase in demand

Source: Agence France-Press / Getty Images





“Finishes, such as flooring, account for the greatest demand for energy and water over the life of a building.”

### AN UNSUSTAINABLE APPETITE FOR RESOURCES

As the rate of resource extraction and use increases, especially as a result of growing incomes, standards of living and population, the effects on the natural environment and human health are further exacerbated. The effects of climate change will become more pronounced, air quality will decline, availability of fresh, clean water will be reduced, rates of acidification and eutrophication of soils and water bodies will increase, habitat destruction will become more widespread, materials will become harder to source and subsequently more expensive, waste production will increase and people and animals will suffer from more frequent and severe health issues.

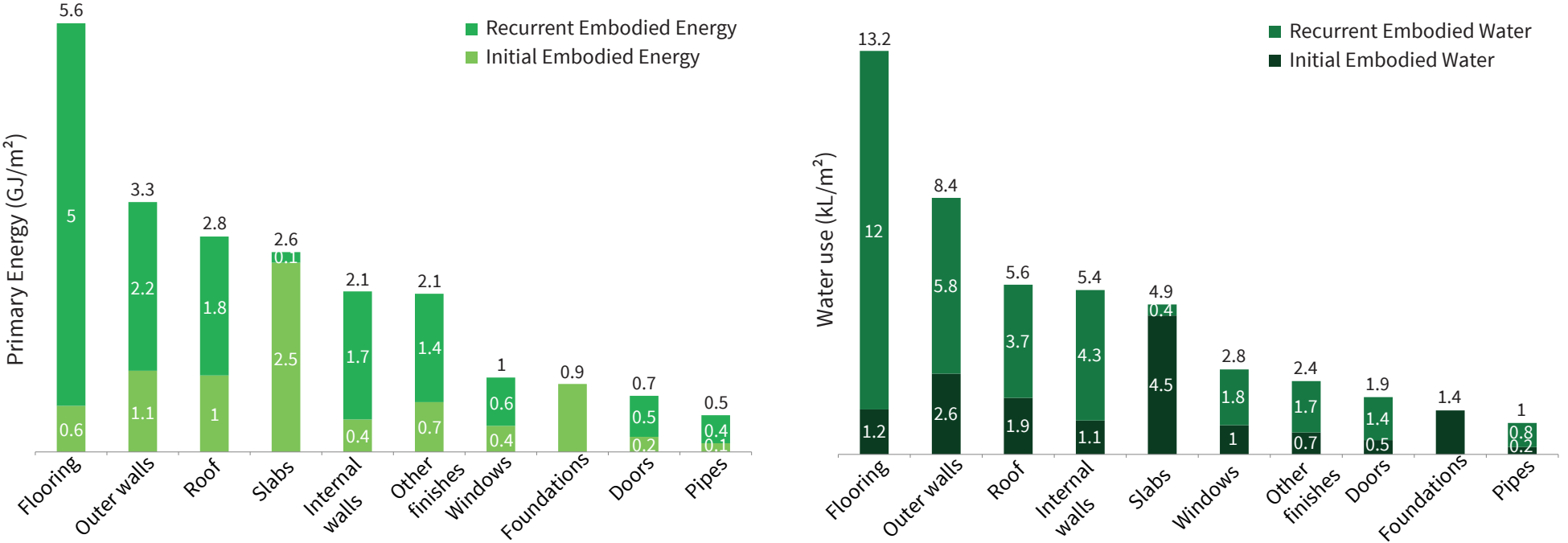
Increasing the use of non-renewable resources thus leads to an even less sustainable situation. This is happening at a time when we should, as a minimum, be focused on creating buildings that not only use resources sustainably, but also help in undoing much of the damage to the environment and human health that has already occurred. Given that the building industry is a key driver of resource demand, more efficient means of extracting, processing, manufacturing and utilising the materials that are endemic to this industry is of critical importance.

“Waste from the construction and demolition of buildings accounts for the greatest single source of material sent to landfill.”

### CASE STUDY

A typical detached house in Melbourne requires a significant amount of materials, energy and water to construct and operate. It is also responsible for large amounts of waste at the end of its life.

Based on data from a recent study on the City of Melbourne, every new house built since 1960 required, on average, 3.1 tonnes of materials for every square metre of gross floor area, including 650 kg of concrete, 23 kg of steel and 640 kg of timber. In addition, these houses required 10-15 GJ/m<sup>2</sup> of embodied energy and 17-20 kL/m<sup>2</sup> of embodied water for their construction. The water needed to construct a building is equivalent to around 10 times its volume.



Life cycle embodied energy (left) and water (right) demands of houses in the city of Melbourne built from 1960 until today and projected until 2100

Source: Stephan and Athanassiadis (under review)



# TOWARDS THE SUSTAINABLE USE OF NATURAL RESOURCES

## Dematerialisation

Reduce the quantity of material used to meet a particular function. This may be as significant as reducing the size of a building with a more efficient use of space or reducing material use in the structure, ductwork, finishes, cladding and/or piping. Smaller buildings create a multiplying effect, requiring less materials for furnishings, ongoing maintenance and refurbishment, and less energy for heating, cooling and lighting. Furthermore, smaller buildings result in less land use and a more efficient use of infrastructure.

## Manufacturing efficiency

Improve the resource efficiency of manufacturing, using less water and energy, and producing less waste – create more with less. Maximise the value of resources by producing more materials and products with less resource inputs. The use of renewable energy sources is also important in reducing the energy-related effects of manufacturing. However, these sources of energy should, in turn, be produced sustainably.

## Renewable materials

A renewable material has the potential to be available indefinitely into the future. Their use can reduce or even avoid the chance of resource depletion. However, even some materials considered to be renewable, such as timber, are in such high demand that their availability and status as a renewable material may be under threat. Moreover, the environmental effects of renewable materials should be carefully monitored to ensure that they do not damage the ecosystems from which they are extracted.

## Recycled materials

Utilise available non-virgin resources where possible to replace virgin materials used in manufacturing. This can significantly reduce the demand for virgin materials as well as other resources. For example, aluminium made from recycled material can use up to 95% less energy to produce.

## Recyclability

Produce materials that are easily recyclable, reducing reliance on virgin materials and the energy and water used in production. Design buildings that use recyclable materials in order to reduce landfilled demolition waste and demand for virgin resources.



## Material reuse

Recover materials for reuse in new or refurbished buildings offsets the demand for virgin materials, energy and water, much the same as using recycled materials. An added advantage is that it implies less reprocessing and thus can achieve even greater reductions in resource use.

## Design for disassembly

Consider the end-of-life stage of buildings and maximise the ability for materials to be easily disassembled, separated and recovered. Avoiding permanent fixings (such as glues), ensuring fixings are accessible, minimising the number of different materials, and avoiding the use of composite materials can maximise the opportunity for materials to be recycled or reused easily.

## Sustainable materials

Producing and using materials that have no long-term effects on the environment. While a material may be renewable it isn't necessarily being extracted/harvested, processed, manufactured and/or used sustainably. If non-renewable resources (for example, energy from fossil fuels) are being used in any of these processes or the associated environmental effects are irreversible then the material itself cannot be considered to be sustainable. A variety of aspects, such as monocultures, soil contamination, ecosystem degradation, local and global modification to climate and others should be considered to ensure that materials are produced and extracted sustainably. Certifications can help inform the selection of more environmentally friendly materials.

## Durability

Designing materials and buildings to last as long as possible can reduce the frequency of repair and replacement. This reduces demand for natural resources associated with the production of replacement materials and building components. Durable materials are most critical in high use areas of a building in order to minimise premature wear or damage. Avoid the over-specification of materials - where a material's expected life is much longer than its anticipated in-service period - as this may result in excessive use of resources, especially if no consideration has been given to design for disassembly to facilitate recyclability or reuse.

## Design for adaptive reuse

Designing buildings that can be easily adapted for different uses is essential. This helps to maximise the value of the resources embedded within a building by providing greater opportunity for building reuse and ongoing refurbishment. Flexible layouts, accessible and upgradable services, easy building access, energy efficient design, durable materials, appropriate location and high floor to floor heights should be key considerations.

Achieving  
more with  
less





We need  
to think of  
buildings  
as part of a  
system

## A SYSTEMS APPROACH

The current societal approach to problem solving in developed economies is anchored in the linear thinking of the industrial revolution. This approach has led to the advent of separate disciplines with clear boundaries which often results in a fragmented process to problem solving. This can deliver under-performing solutions which favour certain aspects to the detriment of others. For example, a building could be designed not to use any energy for its operation but this could result in the choice of materials that require significant amounts of energy to produce and potentially resulting in disastrous social effects elsewhere, such as exploitation of child labour.

In order to move beyond this compartmentalised perspective, a more holistic approach is needed. Considering a product or a building as part of a larger system allows designers and users to reflect on the repercussions of decisions made to improve one part of the system on others. A regenerative approach to systems thinking focuses on ensuring that all parts of the system are taken into account and are designed to provide benefit for the system, so that they all thrive. This helps remove the barriers between disciplines and aims to deliver healthy and interconnected built environments.



## WHAT IS THE PROBLEM?

Current business as usual approaches in the built environment tend to rely on a linear thinking paradigm, where each discipline is responsible only for its part of the job. This leads to suboptimal built environments where the linkages between buildings and the natural and socio-economic systems on which they depend are neglected. Such manner of thinking, focused on one particular aspect only, e.g. building height, can have severe consequences on the urban system, such as the loss of street life, overshadowing of entire neighbourhoods, loss of identity, environmental damage for material extraction elsewhere, lack of connectivity and others. Another example is focusing on just durability at the cost of recyclability, or just aesthetics at the cost of durability of a product.

Considering a product's whole life cycle and its ability to contribute along this life cycle avoids shifting impacts; and in turn, supporting innovation creates opportunities.

As long as certain parts of a system are favoured while others are neglected, it will be extremely hard to ensure that the environmental, social and economic aspects of a project or building are all working together. A systems-based perspective is therefore needed to move beyond the current piecemeal approach and to ensure interconnected, resilient, healthy and thriving systems in the built environment.



# REGENERATION AS A SYSTEMS APPROACH

Regeneration can be defined as creating benefit for the systems interacting with a product, across its life cycle and well beyond the product itself. Though not quite regeneration, the concepts of circular economy and cradle-to-cradle support whole of life thinking, being wise with resources and removing concepts such as ‘waste’ from the system. A key innovation in this area is the idea of buying a service rather than a product. In the case of a printer, you pay for each page printed and not for acquiring a printer. Similarly, finishes could be provided for their use – covering the floor for example, for an annual rate. In this case, the flooring provider is in charge of maintenance and other operational aspects. This ensures

it is in the manufacturer’s best interest to create the best product. Furthermore, they have control over its whole of life potential. Regeneration moves further towards the benefit of the product for the system and all involved.

It is important to not just be ‘less bad’ through efficiency, but to create actual benefits (reforestation, upskilling of workers, up-cycling, and increasing educational opportunities for families, or those using the products). A concrete floor may still have a significant environmental impact, along with the other finishes, but the key lesson is the investment of that impact into a greater whole, a whole of wellbeing, story, history and connection

(see the Venny case study on page 30-31). Also, over time the thermal mass of a concrete floor will contribute to keeping the thermal conditions of the building comfortable which helps reduce energy use for heating and cooling, creating a long term energy benefit. All finishes have the potential to be more than just a colour, a cover, a hard wearing surface; depending on the context, they can contribute through strategic initiatives throughout the life cycle or in the case of the Venny, being part of supporting its key role.

Beauty is integral to human wellbeing. For example, the use of colour in hospitals tends to improve patient wellbeing.

However, our current understanding of which colours to use for which purpose is still limited as highlighted by studies such as Tofle et al. (2004). More research is needed in this direction and the application of colour for particular purposes should be undertaken with caution.

Like the Venny, it means understanding the context/culture/function enough to make the right choices. Biophilic design would suggest that a key way to think about colour is by connecting to the local environment – local flora, soils, timbers, rocks, sunsets and so forth. Our finishes can thus bring nature inside, connecting people to place.

Colour supports wellbeing

Colour in hospitals is a factor supporting health and wellbeing as well as quicker healing. Recent research has found that colour used strategically in operating theaters and recovery rooms can reduce the stress of those being operated on, and on those performing the operation.  
(Dalke et al. 2006)

The use of colour in hospitals has been shown to support better health ad wellbeing and quicker healing  
Source: Tarkett



# CASE STUDY: Regeneration in action

The Venny is an after-school and weekend place for children from South Kensington, Melbourne to come and be supported. It was set up to provide children growing up in low income high rise apartments to have a backyard and social support, as many of these children are at risk. These are vulnerable children for whom the Venny is a second home, their safe place. When it was proposed to knock down their 30 year old asbestos filled

shack and build them a new facility, it was key for the Venny staff and designers to protect the children and support a gentle change to the new building. This was done through involving the children in the design process and getting their input into what they felt was special about the old building they wanted to keep. They shared with the designer what they loved about the old Venny and what they wanted for the new building. In

short they wanted to save the walls, floor, ceiling and door; everything. In response to this, the staff, architect and children started to capture ‘loved elements’ which were embedded in the new floor. They made models of the old building, drew, painted, made prints, and wrote stories about the Venny. The floor became the holder of this history. Through this process the design team held the children safe through the design process.



One of the most powerful stories told to me by one of the staff, was about one of their boys, a boy with a lot of problems and stresses in his life, and his reaction on coming into the new building. “He came in with an attitude of distrust, he took two steps, went quiet, then sighed and lay down on the floor, arms spread wide. He was hugging the photograph of the old Venny door, which had been embedded in the floor at the entrance, complete with all the locks that kept them ‘safe’”.

## Venny

Melbourne, Australia

A risk-taking playground







## ECONOMICS

Indoor environment quality (IEQ) is critical to the success of a building design and happiness of its occupants. Green Star, the leading Australian green building assessment methodology categorises nine factors that contribute to a green building and awards the most points in the IEQ category. However, IEQ is somewhat intangible economically which leads to misunderstandings about its benefits. Despite this, a significant amount of work has been done looking at the economics of IEQ in green buildings, and in general there are two competing considerations to consider:

1. Economic benefits to building owners from IEQ-related productivity benefits linked to tenant happiness and productivity (e.g. the contribution of IEQ to green buildings)
2. The cost of achieving high IEQ (for example low VOC paints in place of normal paints)

## HAPPINESS AND PRODUCTIVITY

A landmark US study by Eichholtz, Nok and Quigley in 2008 titled ‘Doing good by doing green’ has shown that buildings with green ratings on average commanded a 3% higher rental return and a 16% higher selling price, suggesting that the IEQ requirements which are significant in rating tools contribute directly to this outcome. In Australia, Davis Langdon (2007) has conducted research emphasising how important staff satisfaction is, as 80% of a business’s costs come from staff. Their studies found that investment in green building can increase staff productivity by 1 to 3%. Based on this data IEQ has come into sharp focus as proponents of green buildings try to develop a business case for going green.

Sick Building Syndrome (SBS) has a significant effect on staff productivity and absenteeism, affecting a business’s economic performance. SBS is usually attributed to poor maintenance and operation of the building’s fresh air supply, material off-gassing, mould and inadequate ventilation of internal equipment (such as photocopiers). SBS can occur in both old and new buildings. The most common complaints of SBS are eye, nose and throat irritations, asthma and asthma-like symptoms, as classified by the World Health Organisation. Solutions to SBS are usually focused on ventilation rates (Wargocki et al., 2000) but this can be masking underlying issues with building materials.

“As IEQ has evolved from a ‘nice to have’ into a key feature of both green and standard buildings, both design and material choices, and operation and maintenance issues are brought into focus. Tenants knowledge has increased to the point where productivity and happiness are translating into financial rewards for building owners; a trend that is only set to increase as green buildings and productivity are increasingly valued.”





## Kroon Hall

Yale, USA

This university building combines resource efficiency with natural systems. Built on the site of an old power plant, it maximises daylight and natural ventilation to provide a very high indoor environmental quality. The landscaping comprises a range of indigenous plants that help restore the local ecosystem.

## BUILDINGS OF THE FUTURE

There has never been a more important time to carefully consider the way in which we build the world around us. Now is the time to start planning for a future that is filled with beautiful buildings that not only thrive both inside and out, but also help the systems on which they so heavily rely, to thrive as well.

One of the keys to achieving this vision is through exemplar projects that demonstrate alternative thinking and prove that better buildings are feasible. This will help pave the way for the buildings of the future and give hope to building designers, users and all other stakeholders, that there are solutions waiting to be built. Our current buildings may not yet be the answer, but they are stepping stones on this forward journey.

Exemplar  
projects are  
needed

Today's buildings are often unhealthy, resource intensive and tend to result in significant environmental damage.

The buildings of the future will rely heavily on sustainably sourced renewable materials. They will be manufactured, constructed and operated using renewable energy sources. The materials and components from which they are made will be infinitely reused, turning waste into highly valued resources and cities into urban mines. They will enhance the health and wellbeing of their occupants, creating places in which people can thrive.





### 5x4 Project

Melbourne, Australia

This in-fill house has a tiny footprint, uses renewable materials where possible, relies on 100% renewable energy, has a simple floor plan with minimal finishes and uses plants for improved indoor air quality. It is an example of how we can densify and retrofit our cities.



### The Royal Children's Hospital

Melbourne, Australia

The RCH was designed for children to connect with the natural environment, with inner courtyards, natural ventilation and views from all rooms. Artwork, colours and meerkats contribute to their wellbeing.



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