SUBMISSION NO. 190

Secretary:...

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7 JUL 2004

HOUSE OF REPRESENTATIVES
STANDING COMMITTEE ON
ENVIRONMENT AND HERITAGE

Association for the Advancement of Sustainable Materials in Construction

AASMIC

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AASMIC SUBMISSION TO THE INQUIRY INTO THE SUSTAINABILITY OF AUSTRALIAN CITIES

House of Representatives Committee Inquiry on Sustainable Cities 2025

7th July 2004

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Executive Summary

Our current building stock is constructed using vast amounts of physical material. This physical material is extracted from the earth, and much of the material is eventually returned back to the earth in the form of waste.

In a world of finite resources, the continual extraction of resources and accumulation of waste can not considered sustainable. As a result a new paradigm of materials flow is proposed.

We must explore new ways of building our cities. The sustainable city of the future will not be constructed by extracting and manipulating virgin materials from the earth's resources - as this will never truly lead to a sustainable city. The sustainable city of the future will also not allow for toxins and waste to accumulate, thereby contaminating the earth.

Through understanding the current flawed system of material flow, it becomes clear that society requires a revolution in the way we acquire, manipulate, design, use and finally dispose of materials. Our cities must begin to reflect the physical realities of the materials we use, as opposed to the economic realities our society tries to impose.

Two revolutions are required in the way materials and resources are managed if we are to genuinely attempt to achieve environmental sustainability.

1. A revolution in resource productivity (also called a step change in eco-efficiency), so that materials are used to achieve more than they currently do.

2. A revolution in resource recovery (also called a step change in eco-effectiveness), such that material resources are not lost as waste. This reduces the need for virgin material extraction as well as associated waste.

There is also a third revolution required, that is the development of a sustainable energy system. This aspect of sustainable development goes beyond the scope of this document.

A new theory of resource use is beginning to emerge based on the premise of cradle-to-cradle material flows. It espouses eliminating the very concept of waste by designing our products and materials to be safely returned to nature or to be continuously cycled back into full economic usefulness.

A city that is built to embrace this theory would generate no waste and consume no more non-renewable resources. Our society could then truly begin to say ***"We can be sustained."***

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1. Introduction

The House of Representatives Standing Committee on Environment and Heritage will inquire into and report on issues and policies relating to the development of sustainable cities to the year 2025, with specific reference to;

- The environmental and social impacts of sprawling urban development;
- The major determinants of urban settlement patterns and desirable patterns of development for the growth of Australian cities;
- A 'blueprint' for ecologically sustainable patterns of settlement, with particular reference to eco-efficiency and equity in the provision of services and infrastructure;
- Measures to reduce the environmental, social and economic costs of continuing urban expansion; and
- Mechanisms for the Commonwealth to bring about urban development reform and promote ecologically sustainable patterns of settlement.

This paper makes particular reference to the third, forth and fifth points.

This paper has been prepared to communicate the views of AASMIC on issues and policies related to the development of sustainable cities to the year 2025, and specifically, the development of environmentally sustainable cities.

1.1 Sustainable Cities

The concept of a "Sustainable City" has been spawned from the need for environmental protection as a basis for intergenerational equity. This theory was espoused in the 1987 UN Report, *Our Common Future*, also referred to as the Brundtland Report. The essential premise is that we have a moral obligation to preserve the life supporting and resource-providing environmental systems of the earth for future generations, so that they too have an opportunity for a high quality of life. A sustainable city is one which preserves the current stock of natural resources and in doing so makes these natural resources and ecosystems available for future generations.

The benefits of such a system are obvious for those who inherit an improved environment, but there are also considerable advantages within the current system, as a shift towards reducing traditional resource consumption leads to the development and design of new and improved materials, where environmental impact is greatly reduced.

Air pollution, biodiversity loss, land contamination, increasing landfill levels and a decline in water availability and quality are currently all characteristic of urban development and city living. All of these characteristics degrade amenity and resources available for future generations, and are therefore considered unsustainable.

Environmental decline is now a well-documented fact and it is not the intention of this paper to explore the various indicators and reported statistics pertaining to this degradation. The objective is to identify an underlying cause and to suggest ways in which action can be taken to improve our current system and assist in the development of cleaner, greener cities.

AASMIC proposes a different perspective on environmental problems. That being: ***All the world's environmental problems are the result of an inherently flawed system of material[1] flow.***

The key environmental problems facing the world today stem from either resource extraction or waste and associated pollution. Both resource extraction and waste occur as part of a system of material flow. This flow of material is what brings us our infrastructure, consumer goods, foods and fuels and is fundamental to our society and our economic system.

The challenge that this raises is for a reconsideration of the current pattern of material flows. What is needed is to redesign the way materials flow through our society and our economy so that we cut down, or even eliminate altogether, resource extraction and waste. We need to use materials more effectively and to ensure that a material flow cycle is developed whereby no material is considered a waste. It is only by doing this that we can preserve and restore the environmental systems on which we depend for the benefit of future generations. It is for this reason that when considering the sustainability of cities, it is vital to understand the flow of the materials to and from our cities.

[1] For the purpose of this submission, the term "material" and "materials" is used to indicate any physical substance that is used by humans.

2. The Material Challenge

Resources usually enter the economy as 'raw materials'. The primary economic sectors add value to them in the process of turning them into material products. These products then generally go into the secondary economic sectors (manufacturing), to be turned into, or embodied in, more complex products, which then feed back into all other sectors - primary, secondary and tertiary (services) - or go to final consumption.

The process of using (consuming) a product subtracts the value from the resources that was added in production. When the product reaches the end of its life, the resources it embodies are likely to have a negative value. Further resources will need to be applied either to recover these resources for use in some other (or the same) application (a process called recycling), or to transfer the product to a place suitable for final disposal.

The flow of materials commences with extraction; either from a mine, field, ocean or forest, continues through the economic sector to the consumer, and then on to a disposal phase. Each of these steps is associated with various environmental impacts, with the degree of impact depending largely on both the size and nature of the material flow.

It is now generally accepted that environmentally sustainable development requires two revolutions in the way resources are managed:

1. A revolution in resource productivity (also called a step change in eco-efficiency), such that value is added to each resource unit during its residence in the economy. This results in higher profits from a reduced resource material flow.

2. A revolution in resource recovery, such that material resources stay in use in the economy for a significantly longer period of time. The environmental implication of this is two-fold. Firstly, increased resource recovery rates result in a given level of resource flow round the economy sustaining a reduced extraction of virgin resources. Secondly, the flow of resources to the final disposal 'waste' phase, and the associated environmental impacts, would be reduced.

2.2 Key issue one: materials are the link between the earths 'biosphere' and the human created 'technosphere'

The term 'biosphere' refers to the biological and geological components of our planet. Environmental decline of the biosphere refers to a reduction in the earth's ability to produce and maintain life systems. This is generally characterised by fewer natural resources, an accumulation of pollution and a reduction of biological diversity.

The term 'technosphere' relates to the human created system of infrastructure and economy, of which our cities are most certainly a part. It is worth noting that the technosphere is primarily made up of material elements that were initially drawn from the biosphere.

The link between the biosphere and the technosphere is physical materials. We take physical materials from the natural system (biosphere), manipulate and use these materials to create and run our cities (technosphere), and then redirect the materials back to the biosphere, generally in the form of 'waste'.

Because of the fragility of the biosphere, it is essential that we take great care in the way we both take from and return materials to the biosphere.

The linear problem – take-make-waste

The problem with this present system is that the flow of materials is a linear one. It can be represented as ***take-make-waste***.

A material flow system that is linear will create imbalance and is likely to lead to environmental degradation and the onset of environmental problems. Currently, nearly all of our materials flow in a linear fashion that can broadly be referred to as 'cradle to grave' or ***take-make-waste***.

Therefore, in order to protect the environment, greater emphasis needs to be placed on minimising resource use, (minimising the ***take***), and on minimising ***waste*** by directing the material back into society and the economic system, (maximising the ***make***).

The ***take*** at the beginning of the ***take-make-waste*** path will continue to grow every time there is economic demand for a product. Take often comes in the form of forestry, mining, fishing and farming and depletes resources from our biosphere.

The problem with ***waste*** materials is twofold. Firstly, the materials are often not in a form that can be easily assimilated back into the biosphere, and secondly, the 'wasted' materials represent a lost resource for society and the economy.

In order to reduce both the rate of resource extraction (***take***) and the levels of ***waste*** introduced to the biosphere, we must integrate our ***take*** with our ***waste*** to create a closed loop of material flow. This requires smarter material design to minimise the refining and distortion of materials, so as they can be readily reused when they reach the ***waste*** phase.

This is not an easy thing to do. Unfortunately, during our current ***make*** stage we combine and distort materials to levels that makes them difficult to reconstitute into their original form by the time they reach the ***waste*** stage.

What is required is a ***make*** process that allows for us to ***take*** from our ***waste***.

A classic example of an environmental problem stemming from poor material flow is climate change. Climate change is one of the most pressing issues facing the world today and is largely caused by an imbalance in material flow. In this case, a raw material (e.g. oil or coal) is extracted from the ground, burnt to generate energy with the waste material, carbon dioxide, disposed of into the atmosphere. It is now well documented that climate change is the result of increasing carbon dioxide levels in our atmosphere. The flow of molecules through this system is linear, creating a significant imbalance whereby natural resources continue to be depleted while waste, in this case a damaging greenhouse gas, carbon dioxide, continues to accumulate.

Our dominant linear model of material flow was spawned during the first industrial revolution over 150 years ago, a time when natural resources were plentiful and waste and pollution were at levels that could be ignored. Times have changed and there is a need for a new paradigm in the way we use materials. A sustainable city and society can only occur when we 'close the loop' on material flows.

The use of more sustainable materials is fundamental to our survival on the planet. The choice of materials that we use to construct our cities and infrastructure (the technosphere) ultimately controls emissions, lifetime and embodied energies, maintenance of utility, recyclability and the properties of wastes returned to the biosphere. To reduce the destructive impact of the current take-make-waste system, it is important that we think about the materials we use to construct our built environment and the molecules they are made up of.

2.3 Key issue two: construction materials; the building blocks of the sustainable city 2025

The make-up and composition of construction materials is imperative to the development of sustainable cities. The extraordinary mass and volume of these materials that are used in the construction of our cities simply dwarfs that of any other industry.

There has been large growth in consumption of construction materials over the last 50 years. A 'boom period' at the end of WWII was sustained for almost a quarter of a century[2]. In 1997, Australia produced 98 million tonnes[3] of construction materials, 99% of which were consumed within Australia. This amounted to an average of just over 5,200 kg per person. It is estimated that around 3 billion tonnes[4] of materials are used annually to construct buildings worldwide.

Unfortunately, the 3 billion tonnes of construction materials that are used globally every year have inherent deficiencies when considered in the scheme of environmental sustainability.

The key issues that prevent sustainability of construction materials and products are:

- They often consist of large amounts of virgin natural resources such as minerals, timber, natural gas and oil based polymers;
- They are often combined in a fashion that makes them difficult to reconstitute into their individual components at the end of their useful life meaning large amounts end up as waste;
- There are many toxic elements included in the make up of construction materials; and,

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[2] http://www.abs.gov.au/Ausstats/abs@.nsf/0/17a5995c5d55bbbdca256cae0015f653?OpenDocument
[3] Dr Peter Newton, CSIRO
[4] Hawken, Lovins, Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* http://www.natcap.org

- The energy that is required to drive the take-make-waste system of material flow is produced through another take-make-waste system; that being the take-combust-waste system associated with fossil based fuels.

As a result of utilising a take-make-waste system, and constructing our cities from materials which are both unsustainable and resource exhaustive, we significantly impact on our finite environment. The following are characteristic of the current system of linear material flow;

- Depletion of natural resources;
- Generation of large volumes of waste;
- Loss of biodiversity;
- Air pollution and the associated human health risks; and,
- High energy consumption and resultant climate change.

The key to designing a system that sustainably utilises materials involves acknowledging and understanding the molecular flows throughout the lifecycle of the materials we use. The question needs to be asked, "How will the material be reconstituted into a new useful product when its primary function has been realised?"

Picture 1: A typical example of the real life '***waste***' side of the material flow equation. This is just one day's collection of waste from a new house development involving *no demolition work.* Most likely all this material will go to landfill.

Material eco-efficiency and eco-effectiveness

The World Business Council for Sustainable Development (WBCSD) coined the term eco-efficiency in 1996. This phrase refers to the efficiency at which materials maintain utility and usefulness to humans. It is often referred to as doing more with less and is the cornerstone for de-materialisation of our economy. In other words, it refers to the amount of usefulness we get from materials between the 'take' and the 'waste'.

There is also another school of thought that is beginning to emerge regarding materials that has been coined eco-effectiveness. This term advocates materials that satisfy a specific purpose or need as effectively as possible, rather than simply being efficient. Eco-efficiency is often used to describe an improved system whereby less waste is produced, but the premise is based around the idea that there is always going to be waste. The objective is to minimise impact, rather than to eliminate it. Eco-effectiveness is quite different, as it does not set out to improve a flawed system, but rather to design a more intelligent system where waste is not even considered.

The two concepts are defined by their outcomes; eco-efficiency almost always refers to a legacy, with any improvement in performance assessed against a reduced impact. Although this results in better environmental performance, the shift must be towards changing the activity so as the legacy, "waste" becomes redundant. The focus must be on the action rather than the result. The changes are required at the design phase, with a push to smarter thinking. This is an attempt to move away from simply looking at the quantity of material used for a particular purpose to looking at the type and design of the material that is used.

For example, using thinner cement blocks to build a wall may increase eco-efficiency by reducing the amount of cement that is mined and processed, but using very thick locally available adobe bricks may be far more eco-effective as they would cause far less damage to the environment through extraction and processing despite the extra material used, and at the end of its life, the adobe block can be completely reconstituted into a new block with little added energy.

Being ***efficient*** isn't always the best answer, as becoming more efficient doesn't often change the paradigm we work from. There are significant gains possible through rethinking what we are actually trying to achieve, and in doing so, by making some fundamental changes to become more ***effective*** and to benefit not just the environment, but also society and the economy.

2.4 Key issue three: take-make-waste, materials and embodied energy

As previously stated, the process of take-make-waste construction material flow is powered almost entirely by fossil fuels, themselves moving in a take-make-waste fashion. It is for this reason that embodied energy is an important aspect when considering the environmental effects of various materials.

The importance of embodied energy reflects the fact that the take-make-waste system that brings us our materials is powered by a flawed energy system. When considering a fossil fuel based energy system, embodied energy represents a certain amount of non-renewable natural resource (oil or coal) taken out of the ground and an equivalent amount of carbon dioxide discharged into the atmosphere.

The energy embodied in existing building stock in Australia is equivalent to ten years of the total energy consumption for the entire nation[5]. The choice of material and design principles has a significant, but often unrecognised, impact on energy required to construct a building. Embodied energy is considered a key measure of the environmental impact of construction and the effectiveness of any recycling, particularly carbon dioxide emissions.

The reuse of building materials commonly saves about 95% of embodied energy, which would otherwise be wasted. The savings realised through recycling of materials for reprocessing varies considerably with savings up to 95% for aluminium but only 20% for glass. Some reprocessing may use more energy, particularly if long transport distances are involved.

Construction materials can never be considered 'sustainable' when they are developed using energy obtained from a linear and carbon based energy system.

[5] http://www.cmit.csiro.au/brochures/tech/embodied/

3. Material progress

So what can be done to move us towards this materials utopia?

Considering the problems which have been discussed, what are the practical steps that can be taken from a political approach that may be able to assist with the transition to a sustainable system of material flow?

If Australia can be one of the leaders in developing a cyclic system of materials flow, it is undoubtable that we will be able to leverage this with our strong base of natural resources to create a strong economic advantage.

With the Governments lead, it will be important for the broader Australian construction and development industry to also take on the challenge. Obviously this will include raw material processors through to "waste management" operators.

3.1 Challenge one: cyclical material flows need to be achieved

It is essential that much is done to move towards a cyclical system of material flow. Currently, best practice involves "recycling". Unfortunately recycling of materials is low. The materials that are recycled are often actually "downcycled" i.e. they are turned into a product with a lower value than the original product. This can be seen when a plastic bottled is turned into a shopping bag, which is then turned into a speed hump, and finally ends up in landfill.

Our system of material flow needs to become more intelligent and either become a continuous loop or allow for materials to be returned safely back to the earth as a biodegradable component.

Design for deconstruction instead of demolition – cradle to cradle instead of cradle to grave

There is a requirement for a perception change in the way buildings and other infrastructure is viewed, and this needs to occur at the concept stage of infrastructure design. Currently designers will occasionally look beyond the construction phase of a buildings lifecycle, rarely looking at the occupancy phase, and almost never looking beyond the building's initial lifespan to a time when the building is no longer needed, and only the materials (the skin and bones) remain.

Currently, most design occurs for construction and demolition. One lifecycle is considered for the building and its component materials. This however, will change and recently the UK research body, CIRIA, has developed guidance to assist building designers look at designing for 'deconstruction' as opposed to demolition. This involves a culture shift as much as it involves a change in materials selection and design techniques.

In order to adequately develop a system of cradle-to-cradle material flows, it is essential that attention be paid to each step of the ***take-make-waste*** process in order to ensure that the system is not corrupted and flawed by materials that can't be utilised at the end of a products lifecycle.

Removing the monstrous hybrids

If infrastructure can be designed that requires deconstruction rather than demolition, there still needs to be consideration of what happens to the deconstructed materials.

One problem that is currently occurring with waste management involves the sorting of construction and demolition waste so that it may be recycled. This is complicated and rendered uneconomical when materials are developed that are hybrids; a combination of various types of metal, wood and polymers.

To ensure materials can readily be reused or recycled, it is vital that they are developed with their 'end of life' in mind.

Lessons from elsewhere

In Europe, various initiatives have emerged that attempt to encourage 'cradle to cradle' material flows. Of particular note has been the introduction of the End of Life Materials Directive (ELV). Effectively, this legislates that the automobile industry makes considerable attempts to ensure that automobiles are designed in a way that maximises opportunities for new cars to be developed from the materials recovered from the old car stock. This both conserves natural resources and minimises the amount of waste that is produced at the end of a vehicles useful life.

One of the industry responses to this directive has been the development of the International Materials Data System (IMDS). This is database onto which automobile manufacturers record the chemical composition of every component that is included into their products. This information is then available at the end of the vehicles life and maximises the opportunities for the materials to be managed and recycled.

This concept is now also being applied to electronic equipment in response to the EU Directive on Waste Electrical and Electronic Equipment, which will come into effect in August 2005 for electronics manufacturers. The companies involved will aim to streamline the take-back and recycling process and minimise costs through the economies of scale gained from mutual cooperation, and by finalising agreements with existing take-back and recycling companies.

Is this something that the Australian construction industry needs to begin to look towards? Can the Australian Government drive a world leading initiative like this?

New materials and research and development

New materials research and development is an essential element in regards to improving sustainability. Moving away from toxic and non-recyclable materials and towards materials that can either be returned to the earth as compost of endlessly recycled for our children and our children's children and even further. The technology is available today but we must make a change in the culture and systems that are used to drive the Australian construction industry.

This offers a fantastic opportunity to fuel innovation in materials, systems and practices. And it is well known that innovation is at the root of modern economic growth.

Many countries in the world such as Canada, UK and the USA have targeted research as the means of priming the pump to address sustainability, climate change action and other environmental concerns of urban development. In spite of much rhetoric, the reverse has been the case in Australia where research funding is generally driven by market forces.

In January 2002, four priority areas were identified for ARC funding: Complex / Intelligent Systems, Genome / Phenome Research, Nano- and Bio- materials and Photon Science and Technology. As of January 2004, the funding agencies have still not caught up with the importance of funding materials science as the key to the changes in our usage patterns required for sustainability.

Fundamental changes are necessary to achieve real sustainability and if these are to occur without economic disruption, as the materials we use control the sustainability of the systems we proliferate, the materials paradigm we live in will also have to change.

The main benefit as far as Australia is concerned will come from establishing market leadership and being in a position to offer associated technical and engineering services.

Eco-labelling

The concept of Eco-labelling is becoming better known as a greater emphasis is placed upon the need for more environmentally friendly products and services. Green energy, green tourism, green packaging and so on; the number of products offered as a sustainable alternative is ever-growing and there is considerable scope within the construction materials industry for this concept to develop.

Eco-labels attempt to provide an indicator of how well a product is environmentally adapted. Typically, eco-labels are derived from programs having government, industry and consumer representation. Eco-labelling attempts to encourage the manufacturing of products with a reduced impact on the environment and to address public concerns about raw material scarcity and the impact of pollutants on the air and water. Eco-labelling rewards environmental leadership.

Eco-labelling represents another combined measure of sustainability. Eco-labels were initially used to endorse products, but this has evolved into methods for assessing entire buildings, such as the Green Building Council of Australia's Green Star building rating scheme. The promotion and development of innovative sustainable materials and the labelling of these materials against a credible rating system will benefit the built environment and influence the decision to build more sustainably. "Building materials can and should be individually rated"[6]

The relevance of eco-labelling is that it is a method that can encourage consumer demand for cradle-to-cradle materials without having to resort to regulation.

Producer responsibility

Producer responsibility is a concept that is being explored across many industries as a way to promote product foresight by manufacturers. This is a policy instrument which is going to play an increasing role across the globe in achieving waste reduction. It essentially implies that when a company produces a product they become responsible for the product at the end of its lifecycle. This particularly makes sense when one considers the detailed knowledge manufacturers have of their product's materials composition and combination. This scenario comes to the forefront, when manufacturers design products within a cradle-to-cradle framework so as materials retains value at the end of the product's initial lifecycle.

It is difficult to see how producer responsibility requirements can be cost effectively met without a detailed understanding of the material flows involved, in terms of the quantities of the different materials, and their location at the time when producers become responsible for them. Mass-balance studies detailing the flow of resources through the relevant economic sectors, and showing their geographic distribution, would seem to be an essential knowledge base for enabling producers to discharge their producer responsibilities at minimum net cost, and perhaps even with a net economic gain for some materials, as markets develop for the recovered resources, for re-use in the same or different sectors.

Service economy

In order to reduce the tendency for companies to design for a 'cradle to grave' lifecycle, there is growing advocacy for the further development of a service economy. In such an economy, consumers do not pay for products, but for the services that products provide. For the construction industry, this represents tenancy of a building as opposed to ownership. The difference with the current tenancy structure is that in a true service economy the product is returned to the manufacturer at the end of the building's useful life. Imagine the impact, if construction companies knew they were to be lumbered with unused buildings at the end of their useful life; this would significantly change construction practices.

To encourage recycling and remanufacturing the concept of service should be encouraged. For example if heating and lighting were supplied instead of electricity, utilities would make sure the most efficient systems available were installed. Consider the ubiquitous washing machine. Really what we buy one for is to wash clothes. If the deposit return concept above were taken further then what the washing machine company would sell would be washing machine hours of service. It would become the manufacturer's problem to make sure the machine worked and continued to work. Returning the responsibility for products including their disposal or reuse back to

[6] Rosemary Cousin, Director, Integra Planning Pty Ltd, Postgraduate Research Melbourne University

manufacturers has merit in that recycling is encouraged and quality assured. Technical recycling is kept within the technosphere and biological recycling less likely to be tainted.

We must also rethink the way in which materials move through our economy in terms of the infrastructure and support for recycling and waste management. We should remove all subsidies on waste management and tax the amount required to pay for the remediation of the environment due to landfill activities and resource extraction.

3.2 Challenge two: a sustainable energy system

While going beyond the scope of this document, it is important to recognise that materials and the cities they create can never be considered sustainable whilst they are reliant on a fundamentally flawed and unsustainable energy system. The sustainable cities of the future will need to ensure that they are not reliant on energy systems that cause a linear flow of molecules from one state to another as is currently the case with fossil fuels.

4. Moving to a built utopia – sustainable cities 2025

4.1 Cyclic material flows – a city that works like the Australian bush

If our current system of material flow is flawed, what changes are required to ensure that a sustainable system of material flow underpins the sustainable city of 2025?

The answer comes from looking at models that are already available to us for complicated systems of material flow that produce zero waste or pollution. That system can be seen in nature. The Australian bush is one such example; being a complicated system of molecular flows where there is no concept of waste and all molecules are continuously cycled in a system where every molecule is considered useful.

Eliminating the very idea of waste is something that doesn't come easily to the current design culture, which accepts waste as a natural part of material utilisation. But elimination of waste as a concept is precisely what is needed when trying to solve the problem of excessive resource extraction and pollution.

Any material that comes to the end of its useful life should be immediately considered a resource – not a waste. The question then is how we utilise this resource economically. The lack of an economic option at the end of a products useful life remains the bane of sustainability and has led to ongoing waste to landfill and incineration.

One of the key ways to make resource recovery an economic option is for materials to be easily reconstituted into their individual materials. If steel could easily be separated from concrete and timber could easily be separated from paint, it would be much easier to find uses for these materials at the end of their useful life as opposed to simply sending them to landfill.

One way of doing this is to see everything as belonging to a technical or biological system. Technical systems consist of polymers and metals that can be endlessly recycled back into their original forms.

Biological nutrients consist of organic material that can be safely biodegraded back into nature.

Michael Braungart and William McDonough, co-founders of US based environmental chemistry consultancy MBDC, have long espoused this dual system of material flows.

The key is ensuring they are separated so that technical nutrients such as metals are not sent back to contaminate nature in a form that can't be readily digested into nature's metabolism.

Once these materials can be recovered for reuse, the problem of excessive natural resource consumption begins to disappear as materials are already easily available from our technical system. Why would you excavate to extract bauxite that then requires processing and transporting, when a supply of aluminium is already available in an industrial area of Melbourne, through an effective recycling facility?

The concept of eco-efficiency also begins to become an irrelevant concept. If we are not causing increased resource depletion or increased levels of waste, then it suddenly becomes OK to use a bit more material for our constructions. The added artistic feature is no longer excessive use of materials; the extra degree of safety is no longer an excessive addition.

4.2 Beyond sustainability – the restorative city

One fundamental question that needs to be asked is "is sustainability enough?"

If we were able to achieve sustainability of greenhouse gas emissions today, we would still be in a situation where human induced climate change is inevitable. We would still have dangerously low levels of biodiversity.

Many parts of the earth are now in need of repair. Therefore, should we not be aiming for restorative cities as opposed to simply sustainable cities?

Imagine a building that created oxygen that sequestered carbon and nitrogen oxides, which increased biodiversity, a building that creates more energy than it uses. By changing our paradigm of what is possible and changing the way we use materials, such a building is possible.

Technologies now exist for eco-cement that absorbs carbon dioxide[7], photocatalytic paints that absorb nitrogen oxide[8], vegetated roofs that increase biodiversity and filter water[9] and solar window shades that produce energy[10].

Many examples exist of buildings that have achieved one or the other – it is possible with the technology we have today to create a building that not only doesn't harm the environment, but also actually restores it.

This does not aid our quest for sustainability of the building only benefits one generation but leaves a mountain of waste for future generations. We must begin with a re-evaluation of what we are trying to achieve when we construct our cities infrastructure – and we must ensure that both the make-up and flow of materials within our cities is considered.

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[7] http://www.tececo.com
[8] http://www.wme.com.au/categories/emissions/june2_04.php
[9] http://www.greenroofs.com/
[10] http://www.newscientist.com/news/news.jsp?id=ns99993380

5. Barriers to progress

There are some imbedded systems that make it difficult for a sustainable system of material flows and therefore a sustainable built environment.

5.1 Business is driven by economics

Businesses are inherently driven by our economic system, but this does have flaws. Our economic system places certain values on things in order to allocate scarce resources. This value is generated by the degree of utility the product will give a particular person. Unfortunately, the current economic system does not accurately reflect the value of many resources. For example, fresh water in a stream is often valued as free with the only economic cost coming if the water is pumped for use.

Currently only things with "utility" have a price. Pollution is either free or charges a nominal fee, as the earth does not charge a fee for the disutility of the natural environment, and this creates a significant imbalance.

Linear material flows are still economic

Currently our economic system works well in a linear fashion of ***take-make-waste***. In order to achieve sustainability, this linear system needs to be made cyclical. It needs to look something like ***take-make-make-make-make-make*** and on and on.

This is very difficult to achieve with construction materials, as many of the materials that are produced are not developed with any ***make*** stages beyond the first one in mind.

Waste is a feasible option

Currently, sending materials to waste is a feasible option and this perpetuates a linear system of material flows. Prices for waste disposal in Australia are still comparatively low and there is no further consequence for sending a material as waste apart from paying the initial disposal cost. For example, a builder looking to dispose of $12m^3$ of material would be looking at paying a mere $340. The material is probably not designed to be used again and so has no economic value, therefore the $340 is a feasible economic option and more waste is added to our landfills.

5.2 Level of construction industry sophistication

Many Australians aspire to own their own house. This is symptomatic of cultural norms and links to financial security. Unfortunately, this leads to a housing market that is full of uneducated purchasers. The clients of construction and infrastructure are often not aware of the impacts of the purchasing decisions they make. This has a particular effect on materials flow as cradle-to-cradle design is not requested from purchasers and so designers will not take the effort and time to ensure that this is a consideration in the end product.

6. The formation and role of AASMIC

6.1 Why another association?

AASMIC was formed by a concerned group of multi-disciplinary professionals in response to the challenge of creating a sustainable built environment. As has previously been discussed, one of the key issues when creating a sustainable built environment is attempting to swim against the tide of a system of material flows that is inherently unsustainable.

In 1999, construction activities contributed over 35% of total global CO2 emissions - more than any other industrial activity. Mitigating and reducing the impacts contributed by these activities is a significant challenge for urban planners, designers, architects and the construction industry, especially in the context of population and urban growth, and the associated requirement for houses, offices, shops, factories and roads.

6.2 Cross disciplinary and inclusive

Because the issue of material flow is so imbedded in across economic, social and environmental spheres, a key premise is to ensure that AASMIC is a cross disciplinary association with input from scientists, engineers, planners, builders, architects, economists and others.

It is also attempting to be an inclusive organisation playing the role of knowledge sharing, discussion, argument, consensus and vision building.

AASMIC is attempting to link in as much as possible with existing organisations and committees, again, in order to maximise the cross fertilisation of ideas and leveraging of other skills and networks.

6.3 Material leadership

AASMIC is looking to envisage a system of material flows that will free development and the construction industry from the burden of non-renewable, polluting and carbon intensive materials.

Through innovation in design, materials science, materials engineering, policy, regulation and industry culture, a change is possible to lead us from a current unsustainable pattern of natural resource consumption and wastage.

A cradle-to-cradle material flow is a viable and sustainable paradigm that should be recognised globally as we move through the 21st century.

7. Conclusion and Recommendations

7.1 Conclusion

> *"The next 50 years could see a fourfold increase in the size of the global economy and significant reductions in poverty but only if governments act now to avert a growing risk of severe damage to the environment and profound social unrest. Without better policies and institutions, social and environmental strains may derail development progress, leading to higher poverty levels and a decline in the quality of life for everybody."*
> **World Bank Report: World Development Report 2003: Sustainable Development in a Dynamic World**

Chapter three of this document identified three issues of key influence to sustainable material flow and therefore sustainable cities. There were:

- Key issue one: materials are the link between the earths 'biosphere' and the human created 'technosphere'
- Key issue two: Construction materials; the building blocks of the sustainable city 2025
- Key issue three: take-make-waste, materials and embodied energy

Chapter four identified the two main challenges as being:

- Challenge one: cyclical material flows need to be achieved
- Challenge two: a sustainable energy system

The built environment is our footprint on earth, a major proportion of the technosphere and our lasting legacy on the planet. It is responsible for the dominant proportion of all materials flows.

To achieve sustainability in construction materials requires

- A closed loop flow of technical materials that are used to build and maintain our technosphere.
- A managed flow of biological materials that can be harvested for use in the technosphere and then returned safely to the biosphere as food for ecosystems
- Both material flow systems powered by a sustainable supply of energy

7.2 Recommendations for Government

There are several mechanisms available to the Commonwealth Government to bring about change, particularly in the built environment where ecologically sustainable patterns of settlement are required.

Acknowledgement

The first thing that must be done is to acknowledge that the system of material flow and energy on which our entire society is based is fundamentally flawed. We are literally hoping that we can go on working against the laws of thermodynamics, expecting that matter will be created or destroyed to suit society's short term needs and the current economic system.

By carefully selecting appropriate materials to construct the built environment, it is possible to reduce emissions and even provide net sequestration, reduce the ***take*** from the environment and improve the effective life of built resources. It is also possible to reduce ***waste***, as correctly selected materials can be recycled for use in the same or other useful applications.

> *"Every generation has its taboo, and ours is this: that the resource upon which our lives have been built is running out. We don't talk about it because we cannot imagine it. This is a civilisation in denial."*
> **George Monbiot, The Guardian, 2003**

Leadership and encouragement of cradle-to-cradle loops

Once there is acknowledgement that we are running on a flawed system, it is essential that government take a leadership role in changing the current paradigm of material flow.

The change proposed is not minor. It is no less than the instigation of a second industrial revolution. And such a change must be treated with the respect that a task of such magnitude deserves.

The management of such a change requires carefully crafted policies and practices to ensure that gradual and consistent change is instigated that will begin to align Australian industry practices with the physical reality of the materials flow that our society is based on. This is an opportunity for Australia to take the lead on an issue that will increasingly need to be tackled across the globe.

Negligence can be defined as knowing we are doing something wrong but continuing to do it. Insanity is sometimes defined as doing the same thing over and over but expecting a different result. If we acknowledge the reality of our material flow situation but do not take leadership on the issue to instigate change, we are being both negligent and insane.

The decisions we make beginning today will shape the destiny of tomorrow's Australia. Future generations will look back and either praise us as visionary leaders or curse us as negligent and insane.

One of the first ways governments can demonstrate leadership is through beginning to instigate the principles of cradle-to-cradle design within its own procurement practices.

Data collection

One of the great statistical triumphs of the twentieth century was the development of the national accounts. In retrospect it is hard to imagine how policy and decision-makers even approached their tasks of economic management when they had no sound statistical basis to describe that which was to be managed. Of course, the national accounts do not guarantee good economic management. But they make it more likely; and they also provide clues about problems when things go wrong, and give some basis for actions that are intended to put them right.

The national accounts describe the flows of money through a national economy. What they do not reveal is that, associated with the great majority of such flows, and all money flows related to the flow of goods and services, there is a flow of materials. The sizes of these flows are fundamental to an understanding of the resource requirements of the economy, and therefore to understanding the possible impacts of resource depletion on economic security. The size and nature of the resource flows are also a fundamental determinant of the impacts of resource use on the natural environment. Both these aspects of resource flows are fundamental to whether the economy, and society as a whole, is developing sustainably.

Evidence from numerous environmental assessments suggests that Australia, along with other countries and the world generally, is not on a path of sustainable development. The Australian Government, along with many others, has proclaimed its determination to remedy that situation. Achieving this will require a management of materials and resources that is informed by knowledge and understanding of resource flows that is as detailed and comprehensive as that deriving from the national accounts in respect of money flows. Making development more sustainable requires sustainable materials management. This in turn requires much improved information about resource flows.

Currently there is only poor data available on the origin, flow and waste of the huge volumes of construction materials that move throughout Australia's economy. There are only a handful of countries across the world that actively works to understand eco-efficiency and eco-effectiveness of their raw materials and construction resources.

The UK has recently used funding from their landfill taxation system to instigate a detailed study of material flows across their economy. Further information on this study can be found at http://www.massbalance.org/

Detailed information on resource flows is essential in order to achieve an increase in material efficiency and effectiveness. It is recommended that Australia undertake a mass balance of the Australian construction industry in order to understand the level of material flow and the level of efficiency with which this material flow is driving economic productivity.

Technology

Ongoing development of improved technology that is designed with socially, economically and environmentally positive properties is essential. It is vitally important that products begin to be designed for incorporation into a closed loop system of material flows. This needs to be the new paradigm for all new material developments.

The Federal Government has a role to play in prioritising research and development funding to include the funding of new materials technologies that embrace this paradigm. The main change required is to bring national priorities of research up to date with the urgent requirements of climate action, cradle-to-cradle materials flow, general materials science, sustainable energy reform and other important sustainable technologies.

Education and Culture

An emphasis needs to be given to the education across all disciplines as to the importance of sustainability. A wide range of professionals including investors, developers, local governments, construction clients, accountants influence the sustainability of the built environment. An understanding of sustainability needs to be fostered from a young age in everyone. The education of professionals into the consequences of materials flow and the benefits of using sustainable materials is a high priority and could be linked to higher education funding.

Economics and Taxation

The economic system also needs to be acknowledged as flawed in so far as it encourages sustainable development. One way the economic system can be levered to encourage more sustainable use of materials and resources is through intervention by taxation.

Taxes and rebates are a powerful tool in the hands of governments to direct expenditure in perceived desirable directions. It is important to move away from taxing "goods" and "services" and to begin taxing "bads" and "disservices".

Taxation on carbon emissions, landfill, incineration, water extraction and other such environmentally damaging practices could be used to offset taxes on employment, health care, education and positive investment practices.

The proliferation of various state run systems of carbon taxes such as in Queensland and NSW should be superseded as soon as possible by a worthwhile national carbon trading legislation. Joining Kyoto would be one means to internationalise and legitimise carbon trading

Regulation and building codes

Regulation is another way of forcing change and bending the economic system. Leading sustainability designer and thinker, Bill McDonough, states, "Regulation is a signal of design failure". Regulation needs to be imposed when there is a failure to design with the environmental, social or economic reality in mind.

Building codes are one form of regulation used in the construction industry in Australia. Building codes can be used to raise minimum standards across the industry. However, if too specific, building regulations can hamper innovation. Current formula or product-based standards should be required to follow the modern trend of performance based specifications giving new materials the ability to gain a footing within the industry by achieving the specified performance criteria.

Regulation to ensure environmental declaration of environmental performance of construction materials may be required in order to speed the availability of information required for the industry to initiate change. Eventually, manufacturers should be forced to explain any deviation from design for closed loop material flows.

7.3 Final words

If both Australian Federal and State Governments committed to building social, environmental and economic sustainability into every element of governance, we could be an example to the rest of the world. We must get our energy systems right and we must get our material flows right.

> *"Dire predictions, apocalyptic talk and doom-and-gloom scenarios are not enough to inspire people to change either their politics or their day-to-day behaviour. But neither can we afford to downplay the problems we face nor think that sustainable development will happen of its own accord. At the dawn of this new century, we must make a choice. We have the human and material resources needed to achieve sustainable development, not as an abstract concept but as a concrete reality."*
> **Kofi Annan, Ghanaian diplomat, seventh secretary-general of the United Nations, 2001 Nobel Peace Prize.**

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