Environmentally Sustainable Building Materials - Selection

What is the Purpose of this Document?

This guide note reminds stakeholders in the building and construction industry, from design professionals and suppliers to contractors, about their ability to influence the selection of environmentally sustainable building materials and products. The Guide Note can be read in conjunction with Ecologically Sustainable Development (ESD) Guide Note 'Planning, Design and Delivery' of new and refurbished government building projects.

Building and construction industry practitioners are presented with significant environmental opportunities during their involvement with the life functions of a building. Substantial benefits are available, by careful selection of building materials, components and assemblies and the practices used to incorporate them into a built environment. These benefits range from conserving resources to reducing environmental impacts, improving environmental quality and accruing subsequent savings through improved productivity and waste reduction.

World's Ecological Footprint?

The world's ecological footprint is a measure of human demand on the Earth's ecosystems. It represents the amount of biologically productive land and sea area needed to sustain levels of resource consumption and waste discharge generated by the world's population. (Wackernagel & Rees)[1]

In the mid-1980s the earth reached the point where the rate at which its resources were being consumed, exceeded its carrying capacity. Australia requires on average, 7.7 global hectares per person to meet its current rate of consumption and this represents amongst the world's highest eco-footprints, substantially overshooting the world average of 1.8 global hectares per person. If the rest of the world consumed at Australia's rate the equivalent of over four planets would be needed to survive!

Green Building

"Green buildings incorporate design, construction and operational practices that significantly reduce or eliminate the negative impact of development on the environment and occupants."[2]

Green Building provides an integrated, holistic approach to addressing the environmental impact of buildings consistent with meeting triple bottom line principles. Many of the features are directly linked to resource reduction and selection of environmentally sensitive materials. Green Building addresses factors such as resource use (e.g. energy, water, materials), waste reduction including re-cycling, and efficiency in processing and construction, storm water re-use strategies, preservation of biodiversity and the natural environment. It includes consideration of social and cultural heritage issues, building-user amenity (e.g. indoor air quality, light, acoustics), and the conservation and selection of low energy, renewable, construction materials and processes.

[1] Our Ecological Footprint, Wackernagel and Rees, New Society Publications, 1996
[2] The Dollars and Sense of Green Buildings, 2008 Edition, Green Building Council of Australia

Government of South Australia
Department of Planning, Transport and Infrastructure

Material Resources

Materials are a finite resource. As the earth's population continues to increase, demand for a range of goods and services e.g. housing, places of work, health services, education, cars, refrigerators, and televisions will increase pressure on resources such as energy, water, steel, concrete, copper, aluminium, plastic and many other materials. (Meadows, Randers & Meadows, 2004)[3]

Resource Consumption – Building and Construction Industry

"The construction, renovation, maintenance and operation of buildings accounts for very large quantities of materials which are extracted from nature, processed, used and ultimately discarded."[4]

Building and construction activities worldwide consume an estimated 3 billion tons of raw materials each year. This represents a staggering 40 percent of total global use. (Roodman & Lenssen, 1995)[5]

Life Cycle Environmental Impacts

"The extraction, transformation, use and disposal of materials all have environmental costs, such as habitat destruction, resource depletion, energy use, air pollution, water pollution and solid waste problems."[6] The selection of green building materials, products, components and assemblies requires consideration of a range of environmental impacts during their various life cycle phases. Table 1 provides project teams with a reminder of the environmental opportunities available to those who add value during the process of resource extraction, transformation, use and disposal.

Green Building Material and Product Selection

Two Environmental Streams Categorising Green Building Materials

There are two main streams to consider when selecting green materials associated with the building and construction over a building's life cycle functions. Figure 1 broadly outlines the two streams and their component parts.

The first stream is preservation of the earth's finite resources through more efficient extraction, production and construction processes and by reducing waste. Using green building materials and products promotes conservation of dwindling non-renewable resources. "Integrating green building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling and disposal of these building industry source materials."[7]

The second stream of environmental considerations relates to the impact of the materials and their derivatives on building occupants because of their potential to adversely affect indoor air quality. Given that materials in their various guises are an integral part of the indoor environment where people spend something like 90% of their time, it follows that they can significantly affect indoor air quality and give rise to a range of risks from potentially harmful off-gassing, to increasing our exposure to fire where flammability and the release of toxic gases during fire can be a factor.

[3] A synopsis Limits to Growth – The 30 year Update, D Meadows, J Randers & D Meadows 2004
[4] An Architect's Guide for Sustainable Design of Office Buildings, Public Works & Government Services, Canada
[5] California Integrated Waste Management Board, Sustainable (Green) Buildings, 1995, 2009
[6] An Architect's Guide for Sustainable Design of Office Buildings, Public Works & Government Services, Canada
[7] California Integrated Waste Management Board, Sustainable (Green) Buildings, 1995, 2009

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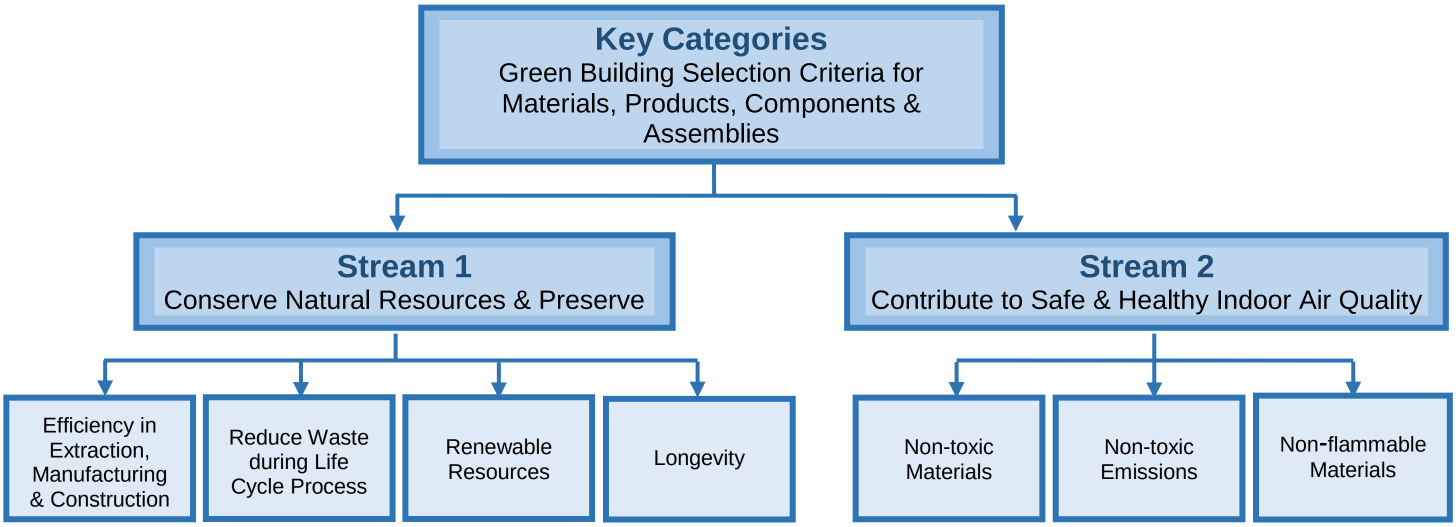
Key Categories



Selection Criteria:

Green Building Materials, Products, Components and Assemblies

As outlined above, there are two main streams to consider when selecting green materials, products, components and assemblies associated with the building and construction industry over the life cycle process.

The following expands upon these categories and helps define the credentials of green environmental selection criteria:

Environmental Criteria Stream 1 – Conserve Natural Resources and Preserve Biodiversity

Resources must be used more efficiently and effectively during the building life cycle process by using less per capita, being more efficient in their deployment and reducing the amount of waste generated. When selecting materials and products being incorporated in the building process, design teams should also consider the potential environmental impacts generated during resource extraction, manufacture and operation relating to the building process where toxic waste, by-products and emissions can occur.

The following criteria should be considered when selecting materials, products, components and assemblies:

Efficiency in Extraction, Manufacturing and Construction

Materials and their associated products derived from efficient design, manufacturing and construction processes provide significant opportunity to conserve material inputs including embodied energy[8] and water and reduce waste as a result of recycling, using re-usable, reprocessed or salvaged inputs.

Efficient building design can significantly reduce the use of resources and extend the useful life of a building. For example, space planning that optimises configurations and floor plates can extend the useful life by virtue of increasing a building's flexibility and adaptability. Similarly the use of disassembly or de-constructible building techniques can provide future flexibility and options to meet changing business functions or respond to a change of use. Locally sourced materials, products, components and assemblies reduce the environmental impact that would otherwise be incurred from transport, i.e. the attendant energy and associated resource inputs.

[8] See Table 2 Materials: Embodied Energy Content

Waste Reduction

Waste reduction presents significant opportunity to conserve finite resources through a nationally recognised waste management hierarchy which lists practices from most desirable to least desirable, i.e. avoidance, reduction, reuse, recycling and recovery.

As waste management initiatives progress up the hierarchy, consideration needs to extend beyond recycling to the more challenging, higher yielding end of the hierarchy i.e., reuse, reduce and avoid.

- ### Avoidance

  Cleary, elimination of waste from life cycle processes by demand management techniques and supply chain efficiencies is the most effective solution to conserving resources and reducing waste. Innovative design during the resource extraction, production, planning and construction processes can substantially avoid resource consumption and the generation of waste.

- ### Reduction

  Waste reduction promotes addressing the resource conservation objective during design, manufacturing and construction processes.

- ### Reuse, salvaged or recyclable

  Easily dismantled or recovered materials, components and assemblies can be reused or salvaged at the end of their useful life or for purposes of renewal or replacement. Not only does this reduce waste that would otherwise go to landfill, but saves embodied energy and water and other resource inputs. Designing to facilitate easy recovery, disassembly and de-constructability of materials, products, components and assemblies can therefore contribute significantly.

  Recyclable materials, components and assemblies particularly post-consumer recycled content plays a significant role in conserving limited resources and in diverting waste from landfill. Extended producer responsibility or closed-loop recycling and ‘take back’ programs are gaining acceptance particularly in the supply of carpet as a legitimate way of reducing waste, conserving resources and managing life costs.

Renewable Resources

Materials from natural, renewable sources such as plantation forests (preferably with independent certification) and those made from agricultural waste products such as straw have sound green credentials because they are not depleting finite resources.

Material, Product Component and Assembly Longevity

Selection of durable materials can reduce the replacement cycle and hence conserve the rate of resource consumption. Durable materials also contribute to reduced building operating costs including environmental impacts associated with maintenance and cleaning. Durability is also contingent upon design, construction detailing and assembly of materials and components that together, reduce exposure to weather and other external impacts.

Environmental Criteria Stream 2 – Indoor Air Quality

Most people spend about 90% of their time indoors. Materials, products, components and assemblies can significantly affect the indoor air quality and give rise to a range of risks from potentially harmful off-gassing to increasing our exposure to fire where flammability and the release of toxic gases during fire can be a factor.

Careful selection of materials, products, components and assemblies can therefore have a considerable impact on the wellbeing of building occupants. The following criteria relating to indoor environmental quality should be considered when selecting materials, products, components and assemblies:

Material Toxicity

Some materials, products, components and assemblies discharge carcinogens and other deleterious substances, such as toxicants and irritants, which can be ingested by people. Careful consideration of environmental risks is essential and the choice of low or non-toxic materials and their associated products should be maintained.

Hazardous materials such as asbestos, lead-based products, mercury and polychlorinated bi-phenyls contained in fluorescent luminaires, brominated fire retardants, pesticides (organochlorines), polyvinyl chloride (PVC) can be ingested through the air we breathe and through the skin. Certain paints, solvents and chemical cleaning products fall into this category.

Toxic Emissions

Material selection can be problematic where off-gassing of toxic emissions occurs. Off-gassing from Volatile Organic Compounds (VOCs) should be avoided. For example, off-gassing binding agents such as urea formaldehyde resin may have been used in the production of Medium Density Fibre board. Safe work practices must be implemented where potential toxic emissions from adhesives are employed.

Substances that deplete the ozone layer such as hydro fluorocarbons (HFCs) and greenhouse gases, e.g. carbon dioxide and methane, may also be used or emitted as a result of activities associated within the built environment.

Flammable Materials

Some materials and products such as paints, solvents and adhesives can be flammable. Indeed some materials can release toxic gasses and smoke during fires and consideration of these factors needs to be given when selecting materials.

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Summary

In summary, the environmental objectives pursued by building professionals when selecting materials, products, components and assemblies during the building and construction process can be summarised as follows:

- reduce impact on natural environment and biodiversity;
- reduce use of finite resources in accordance with achieving a sustainable eco-footprint;
- resources must be used more effectively and efficiently in material, product, component and assembly production and during construction i.e., improve output per unit input;
- reduce energy and water inputs to reduce embodied energy and water;
- reduce waste generated during the material life cycle flows;
- select durable, long lasting materials;
- select materials and components with low maintenance and cleaning requirements;
- use efficient, flexible space configuration;
- where available opt for local materials and product to reduce transport energy impacts;
- promote renewable, reusable, recycled and recyclable material content; and
- select materials, products components and assemblies that enhance human health and contribute to a healthy indoor air quality e.g. low VOC emissions, toxicity and flammability in the event of fire.

Green Rating Tools

In addition to the availability of guidelines and reference texts about the selection of environmentally suitable building materials incorporated in the built environment, a number of rating tools are already available to complement them and assist project teams practicing in the building and construction industry.

Building Rating Tools

The two most commonly accepted tools in the commercial / public building sector are the Green Building Council's Green Star suite of design tools and the National Australian Built Environment Rating System (NABERS) for the performance of existing buildings. The Green Star tools provide recognition for environmentally sustainable material selection and assembly techniques and their associated relationship with indoor air quality.

Similarly the NABERS suite of tools managed by the NSW Office of Environment and Heritage, recognise materials and products chosen for their ability to minimise impacts on indoor air quality.

Materials and Product Rating Tools

Ecospecifier is a commercial tool that evolved from an initiative of the RMIT University's Centre for Design in Melbourne. It provides an on-line life cycle analytical approach to the selection of a wide range of environmentally preferable products and materials and exceeds 5,000 listings.

Contact

For more information contact:

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Attachments

Table 1 - Resource to Materials, Products, Components & Assemblies - Life Cycle Flows and Life Cycle Environmental Impacts

Table 2 - Materials: Embodied Energy Content

References

- Our ecological footprint, Wackernagel and Rees, New Society Publications, 1996
- The Dollars and Sense of Green Buildings, 2008 Edition Green Building Council of Australia
- A synopsis Limits to Growth – The 30 year Update, D Meadows, J Randers & D Meadows 2004
- Environmental Assessment and Specification of Green Building Materials, Lynn M. Froeschle, The Construction Specifier, October 1999
- An Architect's Guide for Sustainable Design of Office Buildings, Public Works & Government Services, Canada
- California Integrated Waste Management Board, Sustainable (Green) Buildings, 1995, 2009
- Canadian Architect, Magazine - Toronto, Canada 'Measures of Sustainability' http://www.canadianarchitect.com/asf/perspectives_sustainibility
- Zero Waste SA – http://www.zerowaste.sa.gov.au/about-us/waste-management-hierarchy

TABLE 1 - Resource to Materials, Products, Components & Assemblies: Life Cycle Flows and Life Cycle Environmental Impacts

Resource Extraction

- Consumption of finite resources
- Energy & water inputs
- Impact on Natural Environment & Biodiversity (externality) air, water, soil, greenhouse emissions, habitat destruction
- Human health / workers
- Waste

Transformation of resources during Industry, Agriculture and Building & Construction Processes

- Energy & water inputs
- Impact on Natural Environment & Biodiversity (externality) air, water, soil, greenhouse emissions, habitat destruction
- Resource inputs
- Human health / workers / IAQ
- Waste

Use / operation

- Energy & water usage / consumption
- Resource inputs eg, materials, products, components & assemblies
- Impact on Natural Environment & Biodiversity (externality) air, water, soil, greenhouse emissions, habitat destruction
- Human health / workers / IAQ occupants
- Waste

Disposal

- Impact on Natural Environment & Biodiversity (externality) air, water, soil, greenhouse emissions, habitat destruction
- Human health / workers
- Waste

Table 2 – Materials: Embodied Energy Content[9]

	Embodied Energy[10]	
Material	**MJ/kg**	**MJ/m3**
Aggregate	0.10	150
Straw bale	0.24	31
Soil - cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30Mpa)	1.30	3180
Concrete pre-cast	2.00	2780
Timber	2.50	1380
Brick	2.50	5170
Cellulose insulation	3.30	112
Gypsum wallboard	6.10	5890
Particle Board	8.00	4400
Aluminium (recycled)	8.10	21870
Steel (recycled)	8.90	37210
Shingles (asphalt)	9.00	4930
Plywood	10.40	5720
Mineral wool insulation	14.60	139
Glass	15.90	37550
Fibreglass insulation	30.30	970
Steel	32.00	251200
Zinc	51.00	371280
Brass	62.00	519560
PVC	70.00	93620
Copper	70.60	631164
Paint	93.30	117500
Linoleum	116.00	150930
Polystyrene insulation	117.00	3770
Carpet (synthetic)	148.00	84900
Aluminium	227.00	515700

There are two forms of embodied energy in buildings:

- Initial embodied energy
- Recurring embodied energy.

Initial Embodied Energy in buildings represents the non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site and construction.

Recurring embodied energy is buildings represents the non-renewable energy consumed to maintain, repair, restore, refurbish, or replace materials, components or systems during the life of the building.

[9] Source: Canadian Architect, Magazine - Toronto, Canada 'Measures of Sustainability'
[10] Embodied energy values based on several international sources – local values may vary.