3.0 CONTENTS

3.1. Introduction

As discussed in Section 2, timber has many innate attractions.

Timber is an easy to manufacture product. In its most complex form it remains a relatively non-capital intensive process, while in its simplest forms, only an axe and human energy is required.

3.2. Timber in production and relative effects

Timber is one product amongst many designers can choose from. Many of these are promoted as environmentally viable options, but few have production processes as simple and low impact as most solid timber products.

Manufacturing processes generally utilise all of a log to produce a range of products with different values. However, all logs are not the same. As the product of a natural growth cycle, native forest logs come in all shapes and sizes. Plantation logs have a more controlled, uniform growth, but are generally smaller and the wood has different properties to non-plantation timber.

Solid wood products such as appearance grade veneer or sawn timber are higher value products than reconstituted wood products such as particle board, fibreboard or paper. However, milling solid wood products, such as flooring and furniture, requires straight logs with few defects such as rot or knot. In contrast, the manufacture of reconstituted wood products reduces logs of any shape or portion to woodchips or flakes before further processing back into products such as particle board, fibreboard or paper.

Unfortunately, more of the wood in a tree is generally suitable for processing into reconstituted products than for making solid wood products. This is especially true for native Australian hardwoods. Softwood logs from plantations are usually grown for desirable features such as straightness and minimal branches, improving the efficiency of sawmilling and in the future plantation eucalypt logs with these characteristic may be also increasingly available.

Transport

In some cases, the transport of raw and processed materials consumes a significant amount of energy.

Logs are harvested in the forest and weigh about 1 tonne/m^3. A large part of this is water which is removed later in the production process. Logs are transported from the forest in trucks on roads usually built for the purpose. As most sawmills are position near their log supply, transport distances from the forest to the mill are usually not long. If extended distances are involved, logs are usually loaded onto trains or, if being exported, ships.

Processed timber is also transported. Processed timber is a relatively light material, and generally weighs between 400 to 800 kg/m^3. This is much lighter than the approximate 2,500 kg/m^3 weight of concrete.

As timber is produced regionally, there is an economic incentive to sell locally as it reduces transport costs. This, combined with its light weight, has consequent environmental benefits as they tend to restrict transport impacts. Further transport to wholesalers, retailers and construction sites must also be considered.

3.2.1. Manufacturing sawn timber

Sawing the timber

Once the logs arrive at the mill or plant gate, the manufacturing stage begins. The conversion of raw resources into a usable product typically uses the most energy and creates the most pollution in the life cycle of a building product. However, compared to other products such as metals or plastics, timber requires only minor processing.

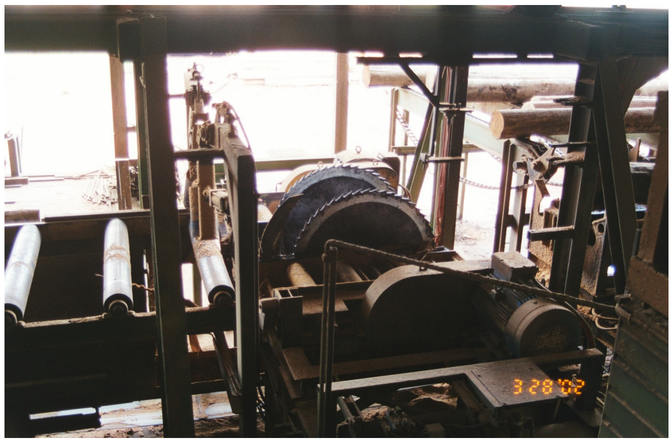

Figure 3.1: Inside a hardwood sawmill

Logs delivered to site are stored and then sawn. Because of the character of logs, only about 35% of hardwood and 45% of softwood logs is converted to timber. Hardwood logs have more irregularities such as hollow cores than softwood logs. They often need to be cut in a particular manner so that the timber can be properly seasoned. Higher yielding sawmilling and drying techniques are being developed to improve the proportion of high value product recovery.

The material that does not end up in a sawn board is a by-product such as woodchips or sawdust. As is discussed below, neither is wasted and an economic use is found for almost all the log entering the yard.

Timber drying (or seasoning)

After being cut, the timber is either dried in the open air or kiln-dried, as this provides a stable product for use in a range of building uses (Figure 3.2). This process is also known as seasoning. Air drying is a long but low energy process whereas kiln-drying process requires a high energy input. Air dried material can be finally dried in a kiln.

Except for maintaining the equipment and treatment of some material with biodegradable preservatives such as pyrethrums, generally no chemicals are used in sawing or drying process.

Figure 3.2: Timber in racks for drying

Many kilns in Australia are powered by boilers that burn shavings and dust generated by the sawing and milling processes. Others use fossil fuels, such as oil or natural gas, while some are solar powered and look very similar to large greenhouses.

Dry milling and sale

Dry timber can be dressed, moulded or be sold rough sawn to other processors. The process of planing the wood surface to a smooth finish is known as dressing. Moulding is simply the shaping of timber into forms other than rectangular.

Dressing and moulding are relatively simple industrial processes. Shaving and sawdust are often retained and either used in the boiler, sold as garden mulch, or as a filler or raw material in other industrial uses. In isolated cases, it is disposed in landfill.

Often, no other processes are necessary before it can be used.

Veneer manufacture

Veneer is a thin slice of wood cut from a log. It can be peeled from logs or sliced from flitches into sheets or leaves at a pre-determined thickness and grain orientation. Once sliced or peeled, the veneer is dried in a dryer, before being graded (Figure 3.3). After grading, the veneer is trimmed and can be laid up into sheets. To maximise recovery and return, the remains of flitches are often sold to furniture makers.

Veneer is used as either a:

- **Decorative product**; or
- **Structural product**, usually assembled into an engineered wood product such as plywood or laminated veneer lumber (LVL).

Decorative veneering is highly dependant on selling into an appearance market, so sections of log containing undesirable parts are often sawn into timber sections.

Figure 3.3: Grading veneer

Engineered products

Plywood is a wood product assembled from veneers of timber glued together so that the grain of alternate layers is at right angles. Laminated veneer lumber (LVL) is a similar product but most of the layers are arranged so that the grain is parallel to the length of the board.

Both products use glues to bind the layers. While these glues have previously leaked formaldehyde after assembly, advances in glue chemistry mean that modern products have limited off-gassing.

Another group of engineered wood products involves the nailing of solid timber into trusses and beams. Nail plating of trusses is a highly effective technology that uses many short length of timber to assemble long length, structural reliable elements. A simple hydraulic press and a work space are required.

Glue lamination

Glue laminated timber, or glulam, is a material manufactured by gluing small pieces of timber, known as laminates, together to produce large sizes and long lengths. The individual laminates are usually finger jointed into continuous lengths and then assembled into the final piece (Figure 3.4). Glulam may be curved or straight and used for either structural or appearance application.

Glulam uses similar resins to plywood. Transport is the only effective limitation on the size of glulam members.

Figure 3.4: Prefabricating laminated beams

Reconstituted products

Logs that are unsuitable for other solid products and chips and waste from the sawing process are converted into the reconstituted wood panel products below or into paper and cardboard.

Wood panels are made from wood or wood fibres bound together with glue, or other binder. They include:

- Particleboard: a panel manufactured from lignocellulosic materials (usually wood) primarily in the form of particles, flakes or strands bonded together with synthetic resin, or another binder, under heat and pressure until cured.
- Medium Density Fibreboard (MDF): a wood-based panel manufactured from wood fibres bonded with synthetic resin or other binder under heat and pressure until cured. MDF is widely used as a substrate material due its smooth surface and edge-finishing qualities.
- Hardboard: produced by compressing wet individual wood fibres together. The fusion of natural lignins bonds the fibres together.
- Blockboard: usually made of strips of wood about 25 mm wide, glued together with the heartwood facing in alternate directions.

Board mills are generally equipment intensive facilities and use the most chemicals of any timber production process. However, they are still relatively benign facilities compared to other major production plants.

3.2.2 Recycling and disposal

The reusability of timber varies according to the particular species and how well the timber has been maintained. The feasibility of reuse also depends on the resources required for disassembly and remanufacturing.

In contrast to other major building materials such as glass, aluminium and steel, timber can often be reused without breakdown and complete remanufacture. Except for papers, timber products are rarely made of recycled material but salvaged (recovered) timber, furniture and joinery can often be recycled into a new building.

Intact timber elements can be used for other building applications. Common examples of reused timber products include: skirting boards, doors, window frames, architraves, floorboards, structural components from industrial buildings and weatherboards. Heavily worn timber elements can reappear as furniture, flooring, in landscaping or as fuel. Treated wood can be reused in a manner compatible with its original purpose, such as fence posts, retaining walls, landscaping, planter boxes and the like. Poles can often be reused in landscaping projects. Timber from warehouses, wharves and factories has been remilled and used in new domestic and commercial applications.

Apart from solid timber, products such as plywood, particleboard, fibreboard, glulam and LVL can all be recycled. The environmental properties of these different timber products vary, but in general all have very low embodied energy, little to no waste or hazardous by-products, low greenhouse gas emissions and they can be reused.

Timber production wastes can be (and usually are) recycled as particleboard, fibreboard, mulch or fuel for drying kilns.

When considering the issue of recycling timber, the following points should be taken into account:

- Research into the safe disposal of treated timber is currently in progress; and
- Such is the increasing demand for recycled hardwood in Australia that it is estimated that demand will outstrip supply in ten years.

The environmental impacts related to reusing timber are similar to those for using new timber. They may also include the environmental impact of removing paint, varnish or other finishes as well as the removal of old nails, screws etc.

When timber no longer has any use, it is either burnt as fuel, composted, or buried in landfall. For timber treated with preservatives, landfill is currently the only effective option.

3.2.3 The carbon cycle and timber production

Most energy used in the production of building materials is derived from fossil fuels, and embodied energy is a significant indicator of a material's impact on the carbon cycle. As timber and other forest products are largely made from atmospheric carbon, they do not have the same relationship between embodied energy and the carbon cycle as other major building materials.

This section will look at embodied energy and carbon cycle separately.

Carbon cycle and sequestration

As part of the process of photosynthesis, trees give off oxygen and absorb carbon dioxide from the air and *sequester* (store or fix) it in woody tissue (Figure 3.5). To produce 1 kg of wood, a tree takes in 1.47 kg of CO_2 and returns 1.07 kg of oxygen to the atmosphere. In effect, the tree acts as a storage sink for carbon. The tree also acts as net sinks for sulphur dioxide, nitrogen oxides and for particulate matter.

Figure 3.5: Forests store carbon dioxide

The capacity of a tree or forest to absorb carbon declines with age as growth slows and the decay of organic material increases, releasing CO_2. Carbon storage does continue in the ecosystem in, for example, leaf litter on the forest floor. This therefore implies that regrowth forests or plantations have a higher capacity to absorb carbon than mature forests as they are maintained in a perpetual state of net growth due to repeated harvesting. A plantation is likely to sequester between one and ten tonnes of carbon per hectare per year over a 30-year period (AGO 2001). Continually replacing felled trees in plantations of actively growing trees ensures that this absorption continues.

The clearing and burning of forests will release stored carbon back into the atmosphere in the form of $CO_2$and other greenhouse gases.

Sequestration in forests

There are many factors that affect the net balance of carbon storage through the process of harvesting mature forests and reforestation. The forests in the national estate grow and sequester carbon. During cutting and regeneration, a proportion of that growth is stored in products, a proportion return to the atmosphere through burning, and a proportion enters the soil. Converting cleared land to forests and plantations creates an extended sink that accumulates carbon dioxide, while land clearing reduces that sink.

In 2002 the National Greenhouse Inventory estimated that Australian forest growth locked up 21.8 million tonnes of CO_2 more than were released due to harvesting (AGO 2004). Forests were sequestering 50% as much CO_2 as passenger cars emitted in the same year (43.5Mt) (AGO 2004).

The Kyoto Protocol also recognises the importance of trees in storing CO_2 as they grow.

Sequestration in buildings and other forest products

Timber in buildings and wood in other products sequesters carbon from the atmosphere for at least as long as the building stands or the material is used and for much longer if the timber is not burnt.

With other wood products, timber buildings form a considerable carbon sink. Using saw logs for long-life products, such as buildings, or construction materials such as lumber, plywood, particleboard, and fibreboard, ensures that the CO_2 remains 'fixed' for long periods. Methods of determining the net effect of carbon storage as a result of different forestry practices are still being developed and refined.

Current greenhouse accounting method for forest products

The current greenhouse accounting method calculates decomposition of forest products over a product’s service life pools.

- Pool 1 - service life 3 years - paper products
- Pool 2 - service life 10 years - pallets, palings
- Pool 3 - service life 30 years - kitchen furniture
- Pool 4 - service life 50 years - poles, construction materials

At the end of service life in the pool, the carbon in the product is assumed to return to the atmosphere. While this model does take into account the varying initial service life of wood products, it does not allow for products to move from one pool to another, or to go into a state that effectively eliminates its return to the atmosphere. The consequence of this is that the amount of carbon in solid products quickly plateaus unless their use is continually increasing. The results of this method for Australia are shown in Figure 3.6

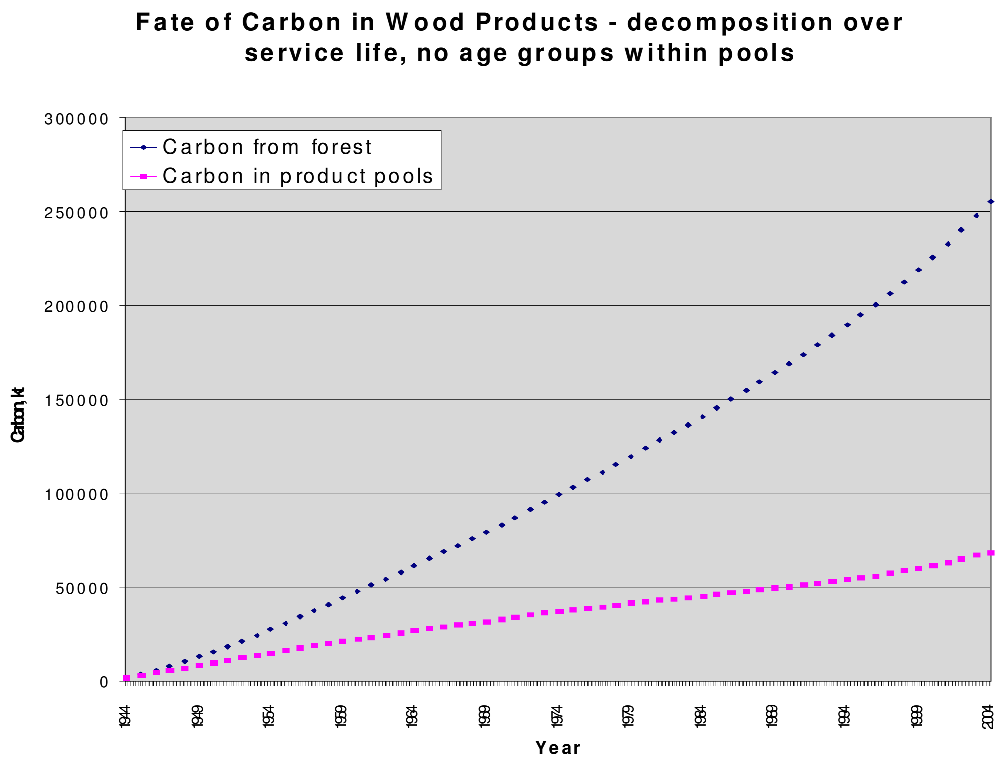

Figure 3.6: Source: Gardner *et al* undated

Alternative accounting method

An alternative method (Gardner *et al.* no date) focuses on a life-cycle approach to greenhouse accounting. In this model, wood products are allocated to different 'service life' classes and factors such as retention in landfill and recycling are considered. In other words, life-time storage of CO_2 is considered, not just the service life of a wood product. This better reflects research into measured retention of CO_2 in most stages of production, use and disposal.

This method establishes five service life pools of 3, 10, 30, 50 and 90 years with three age groups within each pool – Young, Mid and Old

As shown in Figure 3.7 wood products then progress through each age group with one of five alternatives:

- Progress to next age pool
- Leave pool and enter landfill pool
- Leave pool and enter recycling pool
- Leave pool and their carbon is emitted to atmosphere
- Long-term storage beyond pool service life

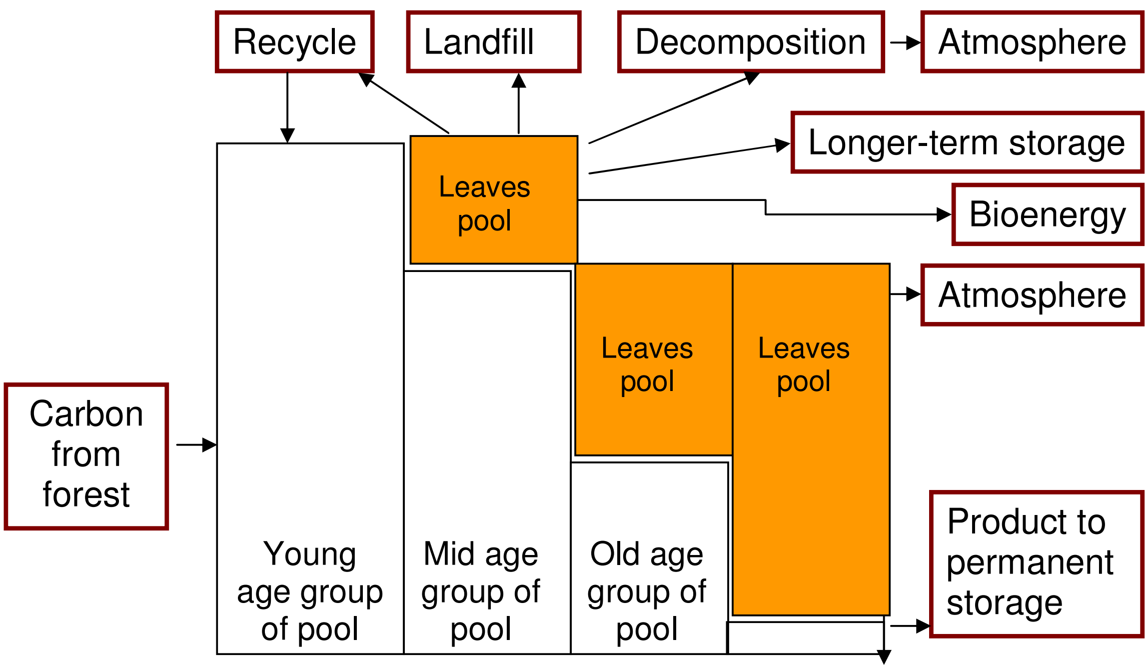

Figure 3.7: Alternative accounting model. Source: Gardner *et al* undated

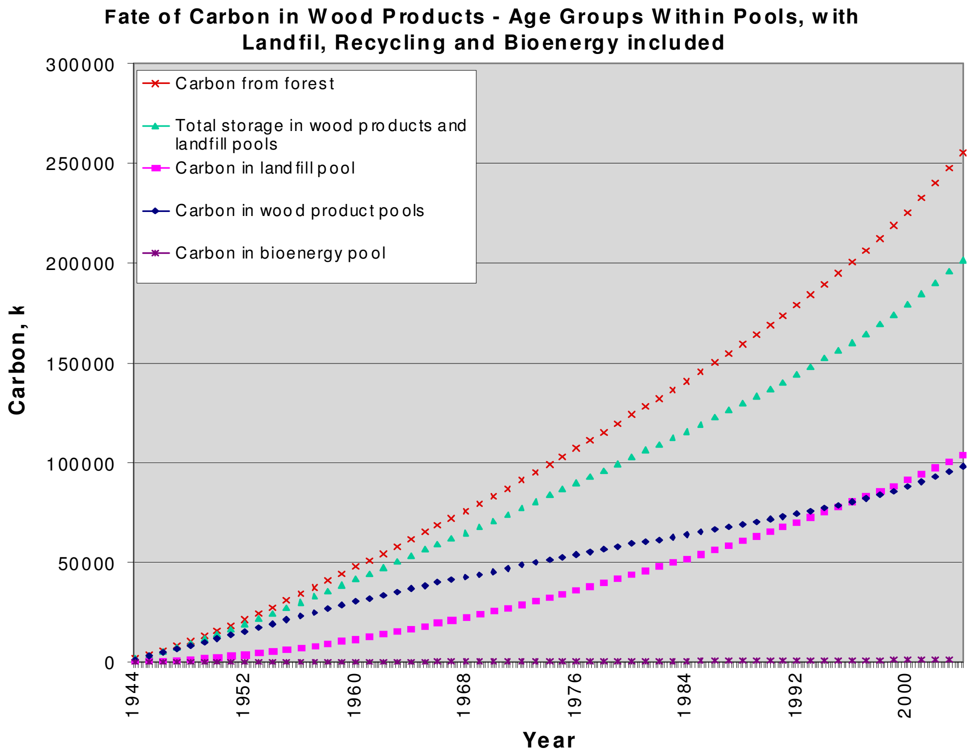

Figure 3.8: Effect of alternative accounting model. Source: Gardner *et al* undated

The effect on calculated emissions in this manner is shown in Figure 3.8. It shows that a life cycle approach, including consideration of the use of residues, storage in service, recycling and disposal to landfill has the potential to significantly decrease the contribution from wood products to Australia's estimates of greenhouse gas emissions.

Overall, while trees are continually replanted and the timber used in long-life applications (such as buildings), timber is much less of a contributor to the enhanced greenhouse effect than its substitutes in the construction industry. The amount of sequestration is limited mainly by the number of trees being grown and the availability of long-term applications for the timber products.

A particularly useful summary of work on embodied energy and carbon dioxide liberation in production of construction materials is provided in a report by Buchanan and Honey (1994). Included in the report are case studies involving analyses of alternative designs of structures ranging from single family homes to an industrial building and a large office structure.

3.2.4 Embodied energy and timber production

Embodied energy measures the total energy used to transform raw materials into ready to use building products. It is expressed in gigajoules per tonne (GJ/t) or megajoules per kilogram (MJ/kg)

The embodied energy of materials in buildings forms a significant component of the total life cycle energy consumption. Embodied energy includes:

- the energy required to obtain raw materials, process them and produce the building material;
- the energy used in transporting the material (at all stages); and
- the energy used in construction.

The consumption of energy during each of the above stages can have similar environmental impacts to the consumption of energy in the operation of the building.

Wood production in the forests requires little energy (only ~1% of the energy content of wood). Manufacturing of wood-based semi-finished and finished products also requires little energy; in almost all cases much less than the energy content of the wood employed for product manufacture. The manufacture of wooden houses and furniture uses less energy than what can be provided by burning residues occurring during processing or by utilising the energy contained in the wooden product itself at the end of the life cycle.

3.3 Timber impacts compared to other materials

Timber is only one of a range of materials available for construction. All materials have an impact and it is possible to compare their use in manufacture and use with LCA techniques.

3.3.1 Impacts of the manufacture of different building materials

Timber uses less fossil fuel to manufacture

The manufacture of rough sawn timber uses vastly less fossil fuel energy per unit volume than does that of steel, concrete or aluminium. Table 3.1 shows that the fossil fuel energy required to manufacture rough sawn timber is 1.5 MJ/kg while the manufacture of aluminium requires 435 MJ/kg of fossil fuel energy. In many of its forms, timber requires much lower production energy than most comparable materials. The results are graphically presented in Figure 3.9.

Material	Fossil fuel energy (MJ/kg)	Fossil fuel energy (MJ/m^3)
Rough sawn timber	1.5	750
Steel	35	266000
Concrete	2	4800
Aluminium	435	1100000

Table 3.1: Fossil fuel required to produce four common building materials. Source: Ferguson *et al* 1996

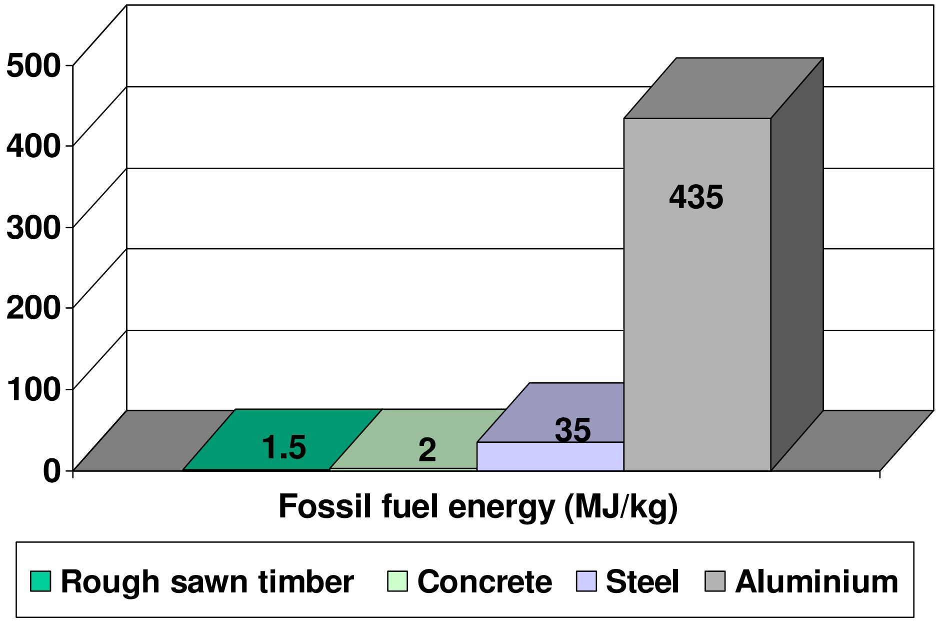

Figure 3.9: Fossil fuel energy used in the manufacture of building materials. Adapted from Ferguson *et al* 1996

In Australia, the majority of our energy comes from burning coal to generate electricity. Less coal, therefore producing less CO_2, is burnt by manufacturing a given amount of timber compared with similar quantities of steel, aluminium, concrete or plastic.

Timber stores up to 15 times the amount of CO_2 released during its manufacture, whereas steel and aluminium store negligible amounts.

The CO_2 released and stored by various building materials during their construction are summarised in Table 3.2.

Material	Carbon released (kg/t)	Carbon released (kg/m^3)	Carbon stored (kg/m^3)
Rough sawn timber	30	15	250
Steel	700	5320	0
Concrete	50	120	0
Aluminium	8700	22000	0

Table 3.2: CO_2 release and storage of four major building materials. Source: Ferguson *et al* 1996

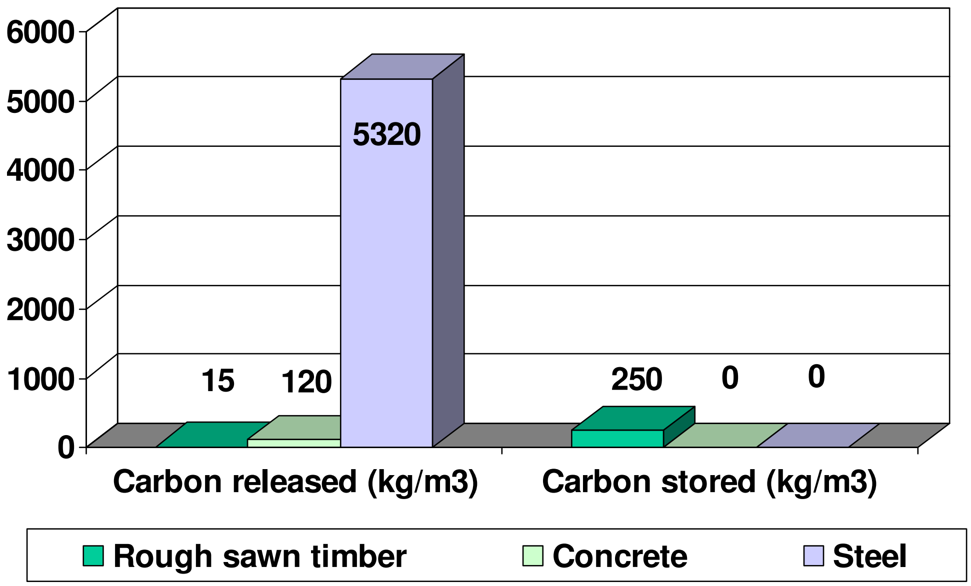

Figure 3.10: Carbon released and stored in the manufacture of building materials. Source: Ferguson *et al* 1996.

The manufacture of timber products is also associated with lower emissions of carbon monoxide, sulphur dioxide, volatile organic compounds and hydrocarbons than the manufacture of steel or concrete. This is discussed below.

The high energy requirements for steel and aluminium manufacturing account for a large portion of the carbon dioxide emission difference (Tables 3.1 and 3.2).

3.3.2 Impacts of different construction types

In the on site construction stage, individual products, components and sub-assemblies come together to make an entire building. This process includes on site construction of the structural elements, transportation of the material from local plants or suppliers, the energy required and other environmental effects during construction. The major impacts of this stage are caused by the energy used for transportation and construction equipment and the solid waste generated during construction.

Timber performs favourably in terms of energy use and ease of construction in comparison to other major building products.

Because timber building products are generally light and easy to handle with high strength to weight ratios, they generally require less energy to transport and position than heavier materials like concrete. Studies by the Forest and Wood Products Research and Development Corporation (2003) found that brick cladding for houses uses significantly more on site energy than wood cladding (See Table 3.3).

Element	Description	MJ/m^3
Floors (including flooring, framing, reinforcement, DPC, membranes etc)	Timber suspended sub-floor structure	740
	Timber suspended, brick sub-floor wall	1050
	Concrete slab on-ground	1235
Walls (including as appropriate framing, internal lining, insulation)	Weatherboard, timber frame	410
	Brick veneer, timber frame	1060
	Double brick	1975
Windows (including at least 3mm glass)	Timber frame	880
	Aluminium frame	1595
Roofs (including plasterboard, ceiling, R2.5 insulation, gutters, eaves	Concrete tile, timber frame	755
	Concrete fame, steel frame	870
	Metal cladding, timber frame	1080
	Clay tile, timber frame	1465

Table 3.3: Energy requirements of different building materials. Source: Forest and Wood Products Research and Development Corporation 2003

Embodied Energy of Materials

The results of an analysis by the National Timber Council (2001) show:

- The embodied energy of a lightweight timber dwelling is the lower than its alternatives.
- Minimum total life-cycle energy consumption and greenhouse gas emissions are achieved when dwellings have well insulated walls and ceilings.
- The total life-cycle energy and greenhouse gas emission is lowest for a lightweight timber construction compared with more massive construction (especially if this construction is not fully insulated).
- When benefits and costs of various housing solutions are considered lightweight timber construction generally rates as the best performer.

Timber has lower embodied energy in construction

The construction stage includes on site construction of the structural elements as well as transportation of the material from local plants or suppliers. The major impacts of this stage are caused by the energy used for transportation and construction equipment and the solid waste generated during construction. The energy use for wood and steel framing systems on the construction site are virtually the same.

Steel framing generally generates less waste on the job site than wood framing. Steel framing is usually pre-cut and any on site cut-offs can be recycled, reducing the amount of solid waste. The quantity of solid waste from wood framing depends greatly on the construction system used and builder's attention to material use. Changing economics are reducing construction waste from wood frame construction and redirecting it to other uses rather than landfill.

Table 3.4 presents data for the construction and operation of houses built with different materials. It shows estimates of energy embodied in the walls of a house of standard size in terms of the initial energy required for the construction, and the total energy after allowing for subsequent maintenance over a 40 year life. The final energy use for wood and steel framing systems on the construction site is the same. As in the manufacturing stage, there is low embodied energy use associated with high timber use.

Type of Construction	Energy per unit area of assembly (MJ/m^2)	Energy used to complete construction (MJ)	Energy used in maintenance over 40 years (MJ)
Timber frame, timber clad, painted	188	31020	24750
Timber frame, brick veneer, unpainted	561	92565	0
Double brick, unpainted	860	141900	0
Autoclaved Aerated Concrete, painted	464	76560	24750
Steel frame, fibre cement clad, painted	460	75900	24750

Table 3.4: Energy embodied in the construction and maintenance of buildings with different wall materials. Source: Lawson *et al* 1996. Note: Data presented are taken from one study only and should be taken only as indicators of the relativity between materials.

While the amount of embodied energy in a building obviously varies with its design and location, the following can be drawn from the above Table and other sources:

- a steel beam requires more than 10 times the production energy of the equivalent timber beam;
- brick cladding for houses uses significantly more energy than wood cladding;
- aluminium window frames use over 50 times the energy equivalent wooden frames;

- on a weight-for-weight basis, the manufacture of sawn timber involves approximately 10-30% of the energy needed to manufacture steel and less than 6% of the energy needed to manufacture aluminium; and
- much of the energy used for drying kilns is waste material from the harvesting process. In comparison, most of the energy used in the extraction and processing of substitute materials is non-renewable fossil fuels.

3.3.3 Pollution impacts of different materials

The manufacture of raw materials into building products produces waste in the form of by-products. This section compares the by-products produced through the conversion of different raw materials into building products. Waste products are generally considered as 'externalities' to the production process, although in some areas, this is beginning to change. An externality is a cost that is not directly borne by the producer or the consumer of a good, but rather, by a third party. Pollution is one of the classic externalities first considered by economists.

Pollutant	Cost ($/kg)	Wood wall (4)	Steel wall (4)
Electricity		1.46	4.67
CO_2	0.15	47.00	145.65
SO_2	1.80	0.66	6.65
NO_X	4.47	4.52	7.04
Particulates	2.62	0.49	1.55
Effluents	0.05	0.61	24.80
Total		54.74	190.57

Table 3.5: Environmental externality costs. Source: Lawson, 1996

Table 3.5 shows that the estimated environmental cost incurred in the production of a timber wall comparable to a steel wall is less than 30% of the environmental cost of the steel wall.

Air pollution

The manufacture of timber products is associated with lower emissions of CO_2, CO, SO_2 and volatile organic compounds than the manufacture of steel (Figure 3). Consider the following:

- Forests act as net sinks for SO_2, NO_2 and particulate matter.
- The manufacture of iron and steel results in emissions of CO, SO_2, and NO_2 (totalling 40 kg/t of steel) to the atmosphere.
- Fully fluorinated compounds (FFCs) are a by-product of aluminium smelting. These are much more powerful greenhouse gases then CO_2 because of their extremely long lives.
- The manufacture of cement can involve the emission of up to 240g of sulphur dioxide and of up to 6kg of nitrogen oxides per tonne of cement.

Solid Waste Generation

- Large quantities of solid waste are created during manufacture of iron and steel. Smaller quantities of hazardous waste are also produced and may be disposed of in landfill.
- In Australia over 15 million tonnes of caustic mud and red sand are generated each year as by-products of aluminium production. Over 200 million tonnes are presently stockpiled.
- The quantity of solid waste from wood framing depends greatly on the construction system used and the builder's attention to material use.
- Timber residues can be (and usually are) recycled as, for example, particleboard, fibreboard, mulch or fuel for drying kilns.
- Steel framing is usually pre-cut and any on site cut-offs can be recycled, reducing the amount of solid waste

Water Pollution

- About 150,000 litres of contaminated water (containing hydrocarbons and other organic compounds, sulphides, phenolics, ammonia, metals, cyanide, oil and grease) are produced for each tonne of steel produced.
- Water consumption and liquid effluents are a significant aspect of concrete production and usage. Each cubic metre of concrete generates between 1500 and 3000 litres of alkaline effluents.
- Steel manufacturing has a greater impact on the quality of the waste water.
- The manufacture of iron and steel results in the release of heavy metals and oils to water.

(Australian Timber Design 1998)

3.4 Treatment and allied products

Timber preservation and treatment

In some circumstances timber will require treatment with preservatives to reduce the risk of degradation from weather, insects and fungus. The decision whether or not to use preservative treated wood will be at least partly based on:

- Presence of a hazard
- The degree of structural reliability required
- The desired or expected service life of the structure
- The natural durability of the structure
- The type or design of the building or component
- The presence of sapwood

Preservatives may be applied to green or seasoned timber. All preservatives have the potential to be hazardous to human health and the environment. Other surface coatings may be used for decoration, and to ease maintenance. Some of the more common treatments include:

- Boron salts – protection against insect borers, generally only suitable for weather protected timber.
- Light organic solvents – generally fungicides, these may also act as insecticides and wax and resin additives can help protect against water damage.
- Creosote – because creosote bleeding has been minimised, creosote timber can now be used in a wide range of applications.
- Copper Chrome Arsenic – most commonly used preservative in Australia, this helps protect against insect attack and marine conditions. Products using CCA include structural timber, and landscaping products.

Chemicals used for the protection of timber are rigorously controlled by government environment legislation and Australian Standards (AS 1604 - 2000).

Any of these preservative treatments can also produce externalities in the form of pollution.

Glues and binders

Solid timber is a natural product and does not off-gas toxic chemicals.

However, the glues used to reassemble small dimension timber into products such as glulam and LVL, the binders in many particle and fibreboards, and the varnishes and coatings used to finish the timber can all off-gas. The extent of the off-gassings varies considerably with types and quality of the products and finishes.

The adhesives currently used by the Australian plywood industry are phenol formaldehyde, melamine urea formaldehyde and urea formaldehyde base.

MDF, or medium density fibre board, is a widely used product made of wood fibres usually bound together with a urea formaldehyde.

In the past 15 years, emissions levels from this product have significantly decreased. Emissions also decrease as the product ages. Presig *et al.* (2001) recommend a limit of 1 m^2 of MDF for each 1 m^3 room volume.

3.5 Principles of ESD timber material selection.

There are two fundamental differences between the raw materials for timber and other major building materials.

- Timber is can be regrown and renewed in a relatively short time, generally about 25-80 years. The raw material for bricks, concrete and steel can only be replaced over geological time (Figure 3.11).
- Timber character varies with a number of variables including age, environmental factors, management regime and current design preferences for hardwoods. The properties of minerals in the ground do not significantly change over 'human' time scales. Our forestry decisions

today anticipate a certain position in the future. Wood character is very important to an architect's use of timber.

Figure 3.11: Forest mosaic; reserve areas between plantations

Sustainable design, as far as it relates to materials, is often connected to the material's ability to perform a task suitably in the surfaces, structure or envelope of a building over time. For timber products, the ability to do this is being affected by moves to sustainable forestry and the decreasing availability of large slowly grown timber. These changes will affect timber size, density and hardness, strength and durability, colour and grain, and feature.

As part of a move towards a sustainable industry, increasing consideration will need to be given to the environmental impacts of using different materials as these impacts become more apparent through constant updating of LCA analyses. Design professionals will need to look for new design options and a broader range of assembled sections in order to foster the production and specification of timber from sustainable sources.

They will also need to ensure that they are developing efficient and economic uses for all the material that can be usefully employed, not just what looks immediately the 'best'.

Material Selection

- **Use timber in construction where it is appropriate and fit for purpose.**

  This implies that the designer uses timber with some skill and understanding of the properties of the material.

- **Ideally, use certified local timber or recycled timber if it is available and fit for purpose**

  Local certified material has been available since mid 2004, and its supply should increase over time. Recycled timber is available from an increasing range of suppliers.

- **Use certified imported or local timber that is fit for purpose.**

Plantation pine is available for most structural applications. It is not desirable for appearance and wear applications due to its softness and the presence of knots. Native hardwoods are preferable for appearance and wear applications and are suitable for high strength structural application. Use high durability and slow growing material with care in high value applications.

- **Develop relationships with local producers and seek to understand the supply and characteristics of local species.**

This can open opportunities to recover and use material that may otherwise not be used to its full potential.

- **Avoid imported tropical rainforest species unless it is certified or comes from an independently verified and sponsored source.**

The Greenpeace sponsored 'ecotimber' from Melanesian community ecoforestry is an example of this.

Specification Guide

- **Do not specify large sawn sizes if assembled sections are available.**

Mature logs have historically provided a wide range of sizes. Because smaller regrowth and plantation logs yield a greater proportion of smaller material, the availability of large section material will decrease. To make larger sections, timber is laminated with nail plate connectors or glue. Reassembled sections and engineered products (such as LVL) will become more common.

- **Do not specify high appearance grades as a default.**

The level of feature in timber is a function of the character of the tree. The infatuation with 'clear' and 'select' material must be broken down. This requires acceptance of minor features that may satisfy grade but not dominant market perception (Figure 3.12). Products such as crown cut veneer and high feature timber will have to be accepted.

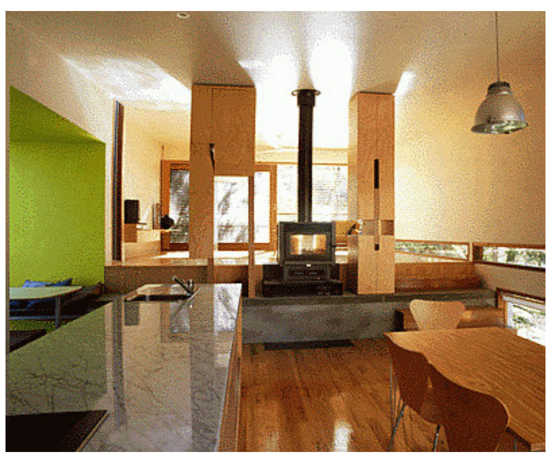

Figure 3.12: High feature flooring

- **Be careful with expectations of colour.**

Extractives and other chemicals in the wood that provide colour in the timber (Bootle 1983) build up over time. In general, the colour of regrowth and plantation timber is lighter than mature wood and also less consistent. This will be most noticeable with richly coloured timber. Perceptions of the colour of different species will have to change, or the material sorted into acceptable bands of colour. However, sorting may create groups that will not be used for their full potential value.

- **Select the species for hard wearing applications carefully.**

The density and hardness of regrowth (Waugh and Rozsa, 1991) and plantation timber is either lower, or more variable, than mature timber of the same species. Species traditionally favoured for high wear applications due to their hardness may not longer be suitable if they are from young regrowth or plantations (Figure 3.13).

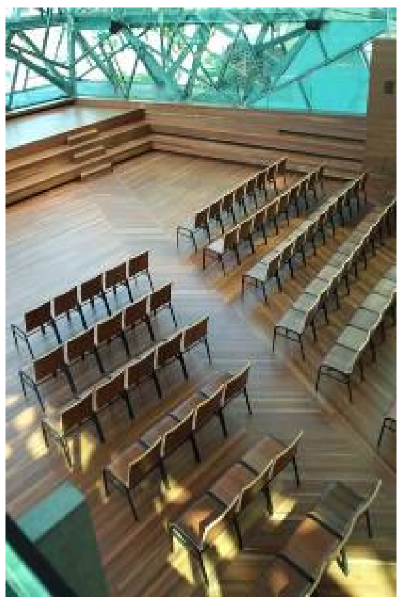

Figure 3.13: Theatre floor and seating

- **Detail timber in external applications well and finish carefully. Use durable species or treat selectively.**

Hardwood's durability is coincident with extractives formed in the heartwood (Bootle 1983). As the level of extractives appear to be lower in regrowth and plantation material than timber from a more mature resource, traditional understandings of the durability of particular species will be found wanting. In part this will be offset by an increased ability to treat some hardwoods but it will inevitably demand that architects improve their detailing and arrangement of untreated timber used externally (Figure 3.14). Sustainability is not served by letting good timber rot due to bad detailing.

Figure 3.14: Well detailed timber bush house

Additional Resources

Australian Timber Design, 1998, Pollution Concerns, January 1998

Australian Greenhouse Office and the Murray-Darling Basin Commission 2001, *The Contribution of Mid to Low Rainfall Forestry and Agroforestry to Greenhouse and Natural Resource Management Outcomes: Overview and Analysis of Opportunities*' Australian Greenhouse Office, Canberra

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Ferguson, I., La Fontaine, B., Vinden, P., Bren, L., Hateley, R. and Hermesec, B. 1996, *Environmental Properties of Timber*, Research Paper commissioned by the FWPRDC.

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National Association of Forest Industries 1989, *Timber Datafile P4 – Timber – Design for Durability* Timber Manual, NAFI

Preisig, H., Dubach, W., Kasser, U. and Viriden, K, 2001, *Ecological Construction Practice* Werd Verlag Winterthur, 180p

Todd, J.J. and Higham, R.K. 1996, *Life-Cycle Assessment for Forestry and Wood Products* Research Paper commissioned by the FWPRDC and the Tasmanian Forest Research Council Inc.