BEDP ENVIRONMENT DESIGN GUIDE

TIMBER USE IN RESIDENTIAL CONSTRUCTION AND DEMOLITION

Fabiano Ximenes, Misheck Kapambwe and Rodney Keenan

Summary of

Actions Towards Sustainable Outcomes

Environmental Issues/Principal Impacts

- Buildings carry a significant greenhouse footprint. The footprint is expressed primarily by emissions associated with building operational energy and emissions due to the production of building materials.
- If commercial forests are managed sustainably, the proportion of the carbon in the harvested trees that is emitted as carbon dioxide as a result of burning or natural decay of residues is absorbed by other growing trees, making the process effectively greenhouse-neutral.
- A significant proportion of the carbon leaves the forest and is stored in wood products, extending the greenhouse gas mitigation benefits provided by forests.
- The average wood products usage per unit of floor area has decreased almost five-fold while the average useful area of dwellings over the same period has increased more than three-fold in just over sixty years.
- As the life-cycle greenhouse impact of forest products is typically significantly lower than that of competing, non-renewable products, a better understanding of the way timber is used and retained in the built environment is important.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:

- Consider all aspects of a product's life-cycle in the selection of materials, in addition to operational energy considerations, and promote the use of sustainably obtained materials.
- Emissions trading is likely to have a positive impact on the competitiveness on timber over materials whose manufacture is highly energy-intensive.
- Promote reuse of demolished timber as a first choice.

Synergies and References

- The *Australia's State of the Forests Report 2008*, published by the Bureau of Rural Sciences (http://www.daff.gov.au/forestry/national/australias-forests/stateoftheforests), is the most recent source of detailed information on Australia's forests and forest products. For a collection of papers on the LCA of wood products please see the special edition of the *Wood and Fibre Science*, Volume 37, December 2005.
- The Federal Government's Department of Climate Change (www.climatechange.gov.au) has many reports on many aspects of greenhouse science, including the latest figures on greenhouse emissions for the main industry sectors in Australia.

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Residential construction accounts for about 70 per cent of the total volume of sawn timber consumed in Australia, with the majority of the wood used for framing applications. Wood products have typically a lower greenhouse footprint than alternative products. A national survey of building professionals in Australia was conducted by The University of Melbourne and the NSW Department of Primary Industries which looked at trends of timber use in the residential sector, the longevity of this use, and disposal or reuse at end of life.

The research found that on average wood products usage per unit of floor area has decreased almost five-fold between 1945 and 2008 while the average useful area of dwellings over the same period has increased more than three-fold. The vast majority of demolished buildings are demolished for reasons other than failure of the structural systems, with builders, demolishers and timber recyclers reporting significant recycling levels of waste wood.

Keywords
houses, longevity, recycling, residential, timber, timber usage, waste

1.0 INTRODUCTION

This paper is based on a national survey of building professionals in Australia conducted by The University of Melbourne and the NSW Department of Primary Industries which looked at housing longevity, patterns of change in the quantity of wood used in housing over time, and the fate of wood following demolition or renovation. This knowledge is essential to better inform the development of policy for greenhouse gas abatement strategies in the built environment.

The research project was jointly funded by the federal Department of Climate Change (while still the former Australian Greenhouse Office), and Forest and Wood Products Australia (FWPA). The former in order to refine their understanding of carbon stocks within Australian housing for the National Carbon Accounting System, and the latter to promote the carbon storage properties of timber. It will also complement life cycle assessment projects funded by the FWPA.

The main aim of the project survey was to improve estimates of carbon stocks in housing in Australia, and the aim of this paper is to outline some of the key results of the survey. The survey results will be used to refine estimates of carbon storage in wood products in the National Greenhouse Gas Inventory. At the time of going to press the analysis of the data were still ongoing and the results of this research will be published in 2009 (refer to the Forest and Wood Products Australia website in 2009).

2.0 TIMBER IN CONSTRUCTION

Emissions from Building Materials

Figure 1 outlines the relative contribution of a range of building materials to Australia's building sector's Greenhouse Gas emission (GHG) footprint. Emissions that come from material inputs of the built environment represent 6.7 million tonnes of carbon dioxide-equivalents, or 1.2 per cent of Australia's

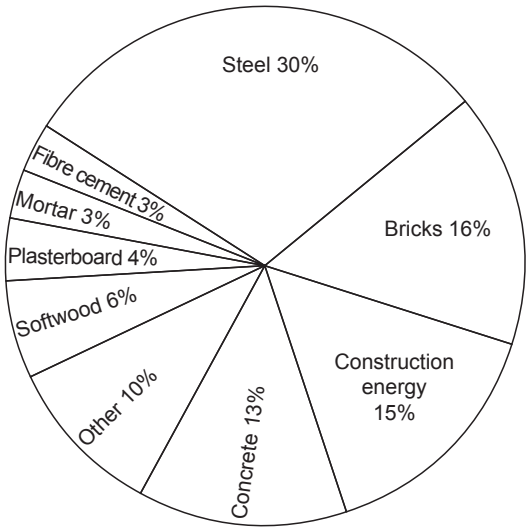

Figure 1. Contribution of building materials to the building sector's greenhouse footprint in Australia

(Source: AGO, 2006)

GHG emissions. The figures represent the emissions associated with the production of each of the major construction materials and also due to building construction, however figures on the rate of emission per unit of material are not available. GHG emissions associated with the use of steel represent nearly 30 per cent of the total, followed by bricks and concrete also with significant contributions (AGO, 2006).

According to the Australian Greenhouse Office (2006), a combination of management options, incorporating existing or currently forecast technology, has the potential to reduce greenhouse impacts from materials use in Australia by 45 per cent by the year 2055 from the base case: i.e. to hold emissions at 2005 levels in 2055. The analysis excludes efficiencies achieved through optimisation at design and construction stages.

Robust knowledge about the impact of the embodied energy in materials on the greenhouse footprint of

buildings is lacking in Australia. Although it is widely accepted that operational energy is a major component in the total energy budget of a house, the energy embodied in house construction can potentially represent up to 50 per cent of the total when periodic maintenance and refurbishment are considered (Treloar and Fay 1996).

Timber in Residential Construction

Residential construction accounts for about 70 per cent of the total volume of sawn timber consumed in Australia, with the majority of the wood used for framing applications (BIS Shrapnel 2008). Wood products have typically a lower greenhouse footprint than alternative products (e.g. Mclennan Magasanik Associates 1991; Buchanan and Levine 1999; Ximenes 2006; Gustavsson et al 2006, Perez-Garcia et al 2006).

Benefits of Using Timber

Before describing the results of the survey it is informative to review briefly the current level of knowledge of some of the key parameters associated with the use of wood products in housing. Globally there are a variety of applications for the use of wood of which its use as a fuel (in heating and also cooking in the developing world), and as pulp (for paper production) make up the largest proportion. Each year building construction, renovation and operation (heating) account for 25 per cent of the global wood harvest (Forintek 1999). Wood products have some important environmental advantages over other building materials:

- wood is a renewable resource
- wood stores carbon
- comparatively small amounts of energy are required in the manufacture of most wood products
- residues generated during the manufacture and processing of wood products can be used in many ways, including replacing fossil fuels to generate energy.

When using wood products in residential construction, it is important to ensure that the timber used was harvested sustainably. While forestry practices in Australia are considered to be among the best in the world, it is often difficult to determine whether some imported timber (particularly from Southeast Asia) was harvested sustainably, unless it carries a reputable certification stamp.

Quantity of Sawn Timber Used for Building

According to the Australian Bureau of Agricultural and Resource Economics (ABARE) (2007), 1.2 million m³ of sawn hardwood and 4.04 million m³ of sawn softwood were consumed in Australia in 2006/07. The volume of sawn wood used in residential dwellings in Australia accounts for approximately 70 per cent of the total volume of sawn wood consumed in Australia (BIS-Shrapnel 2008). The volume of wood used in residential dwellings is projected to increase over time as shown in Table 1.

2.1 Patterns of Wood Usage and Wastage in Residential Construction

The majority of wood used in houses in Australia is used for framing applications (nearly 52 per cent, according to estimates of wood usage from BIS-Shrapnel (BIS-Shrapnel, 2008)). According to BIS-Shrapnel, the dominant wall frame system in Australia is brick veneer with timber frame (61 per cent). The only states with significantly different dominant wall frame systems are Western Australia (double-brick) and South Australia (65 per cent brick veneer, steel frame) as shown in Table 2 below.

Suspended floors were dominant until approximately the 1970's, when there was a sharp increase in the use of concrete slabs, which are now the flooring system used in over 80 per cent of new dwellings (Dept. Housing

	2007		2018-22	
Construction activity	Softwoods ('000 m³)	Hardwoods ('000 m³)	Softwoods ('000 m³)	Hardwoods ('000 m³)
Detached Houses	1619	211	2330	287
Other dwellings	142	37	1999	41
Alterations and additions	1111	481	1499	460
Total	2872	730	4029	788

Table 1. Volume of wood used in residential dwellings in Australia in 2007
Source: BIS-Shrapnel, 2008.

Wall frame system	Australia (%)	NSW (%)	VIC (%)	QLD (%)	SA (%)	WA (%)
Double brick	22	1	4	3	0	100
Brick veneer with steel frame	5	5	0	0	65	0
Brick veneer with timber frame	61	81	86	78	16	0
Timber cladding with timber frame	4	5	5	6	0	0
Fibre cement with timber frame	5	6	3	8	12	0
Other	2	1	2	4	6	0
Total	100	100	100	100	100	100

Table 2. Type of external wall frame used in the construction of detached houses, by state, 2007
Source: BIS-Shrapnel report, 2008.

and Works, 2000; Kapambwe et al.,in press; CRC for Greenhouse Accounting, 2001).

Service Life

Annually about 2.3 per cent of the dwelling stock in Australia is lost to demolition and obsolescence, and replacement of demolished buildings accounts for 40 per cent of the building activity in Australia (AGO 2006). There is very little information on the service life of buildings in Australia. Estimates range from 44 years (CRC for Greenhouse Accounting, 2001) to about 90 years (Jaakko Poyry Consulting, 1999). Service life is an important parameter for greenhouse accounting, as it determines the longevity of the carbon stored in wood products in service.

Demolition

Construction, renovation and demolition of buildings are responsible for approximately 40 per cent of waste deposited in landfills in Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2003). Significant volumes of waste are generated as a result of construction and demolition activities in Australia. The Department of Environment and Heritage (DEH) estimated that of the 14 million tonnes of construction and demolition waste produced in 2002-03, 8 million tonnes were recycled and 6 million tonnes were disposed of in landfills (Department of Environment and Heritage, 2006). It is not known what quantity of this is timber as data is limited to a few states, though it has been estimated that approximately 800,000 tonnes of wood waste from construction and demolition projects were disposed of in 1996/97 in landfills in New South Wales, Victoria and South Australia. (Reddrop et al., 1997).

3.0 NATIONAL SURVEY

The survey which is the subject of this paper, was coordinated by Melbourne University and sent to truss and frame manufacturers, builders, architects, demolition companies and timber recyclers. It included questions on the volumes and application of timber used, service life of different house types and on the generation and fate of wood waste. The survey did not include the ACT and Northern Territory due to the small size of the former, and the low proportion of timber use in the latter.

The total combined response rate was 24 per cent as shown in Table 3 following. The answers given by respondents provide insights to a number of variables, including the number and size of completed dwellings, the amount of wood products used per unit of floor area, the longevity of dwellings and the amount and fate of construction and demolition wood waste.

4.0 SURVEY RESULTS

4.1 Wood Products use in Residential House Construction

There has been an upward trend in the average size of dwellings (from about 78m² in 1945 to about 250m² in 2008). While the useful area of dwellings had a more than three-fold increase, the average wood products usage per unit of floor area has decreased from about 0.29m³/m² to about 0.06m³/m² over the same period, according to figures provided by builders of new dwellings across Australia. Thus the average amount of wood used per dwelling nationally has dropped from 24m³ in 1945 to 14m³ in 2008.

This reduced proportion could be due to a number of factors such as loss of sub-floor market (to concrete slabs), more open planning (less internal walls), less external timber cladding and more efficient timber use with smaller timber members. For example, up until the mid-1960's suspended floor systems (with bearers and joists) represented about 80 per cent of the market (and concrete slab about 15 per cent). Gradually that trend was reversed and by the beginning of the 1980's concrete slab accounted for 80 per cent of the market (CRC for Greenhouse Accounting, 2001), with no significant change since. Up until the 1950's timber accounted for about 50 per cent of the external cladding market. By the 1960's there was a sharp decline in timber use to constitute only 10 per cent of the market, with brick becoming the material of choice. Currently brick external cladding is used in over 90 per cent of detached houses constructed in Australia (BIS-Shrapnel, 2008).

4.2 Treated Timber in Structural Applications

Although the findings of this research were that demolition of timber constructed buildings was not due to structural failure, other industry sectors have highlighted the potential for timber decay in their marketing strategies. In response to this and to gain an understanding of the willingness of practitioners to use treated timber (treated to impart resistance to biological decay), the project looked at the proportion of practitioners who specified treated timber. Over 60 per cent of architects in the surveyed mainland states specified preservative treated timber for structural uses, and only 33 per cent in Tasmania. Builders and frame and truss manufacturers were asked if they used preservative-treated wood products in structural applications. Only a small proportion of builders in Tasmania reported usage of treated timber (only 18 per cent of the total respondents). The per centages

Surveys	Architects	Top 100 Builders	Builders – Additions	Other builders	Frame and truss	Demolishers	Recyclers
Sent	545	424	47	379	171	182	145
Replies	153	92	27	47	50	20	53
Response rate	28%	22%	36%	12%	29%	21%	37%

Table 3. National replies to the building industry survey

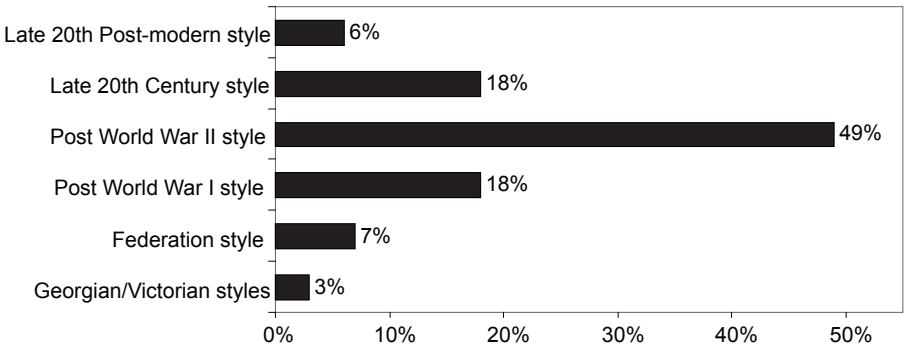

Figure 2. Construction type of houses demolished in Australia

of builders and truss and frame manufacturers that reported using preservative-treated timber products was highest in Western Australia (97 per cent), and lowest in South Australia (74 per cent).

4.3 Longevity of Dwellings and Patterns of Turnover

The average lifespan of dwellings (including detached/attached houses and flats/units) as estimated by architects was 61 years. This is higher than that suggested previously by the CRC for Greenhouse Accounting which says 44 years, and significantly lower than suggested by Jaakko Pöyry Consulting which says 90 years. The majority of demolished dwellings were built after World War II with 73 per cent in use for between less than 25 years and 58 years and were of Post-World War II, Late 20th century and Late 20th Post Modern styles (refer to Figure 2). The remainder of demolished homes were constructed pre-World War II.

The primary reasons for demolition included site redevelopment (58 per cent), the building ceasing to suit owners' requirements (28 per cent), the dwelling becoming unserviceable (8 per cent), and for other reasons such as damage by fire, storms, etc (6 per cent). Few dwellings were demolished due to the failure or decay of wood products. Most buildings were demolished for reasons other than the state of the structural systems.

4.4 Generation and Fate of Wood Products Waste During Construction

On average, builders included an 8 per cent allowance for construction waste when they ordered wood products, to account for potential losses, breakage and theft during construction.

Of the waste generated during construction of detached houses, building practitioners estimated that approximately 45 per cent was utilised in some way either on the same site or offsite. According to builders, about 53 per cent of the remaining wood waste from construction sites was taken to waste transfer stations. Of the remainder, 19 per cent was reused as noggings, packers and blocks, 15 per cent was used to produce mulch whilst 13 per cent was used for heating (mostly firewood).

4.5 Generation and Fate of Wood Products Waste After Demolition

According to demolishers, approximately 56 per cent of demolished wood products were salvaged from detached houses, 26 per cent from attached dwellings and less than 18 per cent from flats/units. Types of wood products salvaged included roof beams, ceiling battens, sub-floor timbers and flooring, interior wall framing timbers (if not contaminated with asbestos fibres), windows and doors and their framing, and internal trims. Demolition contractors indicated that the majority of salvaged wood products from demolished dwellings were taken to salvage/recycling yards or waste transfer stations for further processing or sale to various end users. According to demolition contractors approximately 40 per cent of demolished timber is salvaged, with the remaining 60 per cent disposed of in landfills.

Timber recyclers sourced most of their wood products from residential demolition sites (46 per cent), commercial demolition (31 per cent), and 12 per cent each from dwelling construction and renovation sites. About 77 per cent of wood products that are reused, are used in new dwelling construction as flooring, internal wall and ceiling panelling, and external cladding. Other reuses included outdoor furniture and children's playground construction. About 18 per cent was used to produce mulch and animal bedding and about 5 per cent for heating (mostly as firewood).

Timber in Landfill

In the Intergovernmental Panel on Climate Change (IPCC) currently assumes in its Guidelines that 50 per cent of the total carbon in forest products is decayed in landfill (IPCC, 2006). However recent Australian research by one of the authors of this paper (Ximenes et al 2008) demonstrated that sawn forest products in landfill represent a net sink of carbon. At least 82 per cent of the carbon originally in the sawn wood was still present after up to 46 years of burial, regardless of the species (Ximenes et al 2008). The greenhouse impact of forest products in landfill will depend on how much carbon is released as methane, and also on whether any methane generated is simply released into the atmosphere, flared or utilised to generate electricity.

4.6 Carbon Storage in Timber

A number of construction techniques were suggested by building professionals in the survey that could potentially create new markets for wood products. Better awareness of the environmental properties (see section 2.0 under Benefits of Using Timber for further discussion) of wood products would greatly assist in this task, as pointed out by many of the professionals surveyed. Carbon accumulated in wood products in service increased by 1.6 per cent per year in the period from 2001 to 2005, with the bulk of it stored in "very long term" products (defined in the National Carbon Accounting System as 30-90 years (Richards et al 2006)) such as timber used for construction. In 2004, 97 million tonnes of carbon was stored in wood products in service, equivalent to 61 per cent of Australia's total annual emissions (Bureau of Rural Sciences 2008). The greenhouse benefits of a potential increased market share for wood products should be quantified. For example, a significant shift back from concrete slabs to timber flooring systems in the construction of new dwellings in Australia would potentially result in greenhouse savings of approximately 600,000 tonnes of CO_2-e/year. This estimate is based on a 60 per cent shift from concrete slab to timber bearers and joists (assuming 150,000 new dwellings/year), and using the relative greenhouse footprint of production of wood and concrete determined by the CRC for Greenhouse Accounting for a typical single-storey house in Sydney (InWood Magazine, 2004).

The greenhouse savings associated with the use of wood products vary according to the product used, as composite products (e.g. particleboard and MDF) typically require more energy in their manufacture. A recent project conducted by CSIRO (due to be released in 2009) has developed extensive life cycle information (planting, management, harvest and processing) for the main commercial forests and forest products in Australia. This information will form a strong basis for full life cycle analysis involving forest products in Australia.

5.0 DISCUSSION

5.1 Actions to Increase Residential Timber Usage

Given sawn timber's carbon storage ability, and to otherwise see how to promote greater timber use, the study looked at how use of timber products might be increased. This study provides the most current snapshot of the patterns of usage of wood products in residential dwellings in Australia. The declining volume of wood products usage per square metre of dwelling construction indicates an opportunity for promotion of wood products for a variety of applications.

Building practitioners were asked for their opinion on actions that could be taken to increase wood products usage in residential dwelling construction. Many useful comments were submitted by architects, builders and frame and truss manufacturers. The comments could be sub-divided into three main categories: education/marketing, environmental issues and construction techniques/ performance. A representative subset of quotes from various practitioners is included in the appendix at the end of this paper to demonstrate the range of ideas presented.

5.2 Increased Timber Supply

Forest Supply

A potential increase in the demand for wood products would place extra pressure on forest resources. This extra demand may be met in the short to medium-term by the significant volume of additional plantation pine that is expected to be ready to harvest in the next decade or so. The availability of softwood saw logs in Australia is expected to increase steadily over the next 15 years, as a result of the increased planting programs of the 1970s and early 1980s (BIS Shrapnel, 2008). It could also be met by converting some of the recent expansion of the hardwood plantation 'estate' (now about 800,0000 ha, Bureau of Rural Sciences 2008), that has been established largely for pulpwood production, to solid wood production. There is currently a high demand for pulp, and pulp plantations typically cost less to maintain, and provide quicker financial returns due to the shorter 'rotations' or harvest cycles (potentially resulting in a 10-20 year as opposed to a 35 year rotation).

Other Issues

The service life of houses is an important parameter for projections of demand for new housing as well as for estimates of longevity of carbon stored in wood products in service. The 90 years figure suggested by Jaakko Pöyry Consulting is too high according to architects responses to the survey and also according to a previous survey of demolished buildings in NSW (CRC for Greenhouse Accounting unpublished report). Turnover of buildings is typically influenced by factors other than their structural soundness, and include subdivision of land, area redevelopment, lack of maintenance, new fashion and others.

Information about the current usage of preservative-treated wood products is important for carbon accounting purposes, as the chemical treatment increases the longevity of the wood product.

Estimates of wastage associated with building construction are difficult to obtain. According to the building professionals surveyed, the current waste generation and disposal levels are lower than previously thought. This is likely to have been driven by the need to cut costs (construction materials as well as disposal fees) and by improved construction techniques.

6.0 CONCLUSION

There are no significant incentives for the building industry to collect timber for reuse as recycled timber or use as a fuel, thus landfill is the end point for the majority of timber. A fuller understanding of life-cycle assessment is required to provide data on the best end of life use of timber.

Robust knowledge about the impact of the embodied energy in materials on the greenhouse footprint of

buildings is lacking in Australia. However further analysis is planned to estimate the carbon storage implications and opportunities associated with the use of wood products in residential construction in Australia by the project team, which will be released in 2009.

As noted earlier, although construction materials form a lesser quantity of emissions when compared to emissions associated with the operation of buildings, those involved in the selection, construction and disposal of building materials can make a real contribution to reducing greenhouse emissions associated with the built environment, by selecting materials of low-greenhouse intensity, by requesting good design strategies and by incorporating energy-saving measures in the buildings.

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BIOGRAPHY

Fabiano Ximenes works for the Science and Research Division – New South Wales Department of Primary Industries, PO Box 100, Beecroft, NSW 2119

E fabianox@sf.nsw.gov.au

T 02 9872 0143

Misheck Kapambwe works for the Faculty of Land and Food Resources at the University of Melbourne.

Rodney Keenan works for the Faculty of Land and Food Resources at the University of Melbourne.

APPENDIX – COMMENTS FROM SURVEY

Education/Marketing

A significant proportion of the comments received from the survey of building professionals highlighted the need for better education of building professionals and the general public regarding the benefits of using timber. The need for better marketing of existing products and construction systems was also mentioned. Below are a selection of comments gathered from the survey responses, which capture some of the salient points:

Architects

Victoria

"Promote structural advantages and time saving opportunities when using wood products in flats and units."

"Education of builders, engineers regarding sustainable timbers, Forest Stewardship Certification important."

"Increase marketing of LVL and other engineered timber products to architects, engineers, builders."

Western Australia

"Advertising comparisons with cavity brick construction in terms of climate benefits."

"WA market needs huge public education that timber is okay in detached houses despite the termite:s and that it is a cheaper construction technique."

"Product manuals [need to focus] on how to achieve required fire rating limits in attached dwellings."

Tasmania

"Better education of the public/consumers about carbon storing benefits of using timber to create more user demand."

"Greater publicity of successful timber projects in mainstream media."

New South Wales

"Education of the client is the more important goal, but we need to be able to say that timber versus other materials is cost neutral."

Frame and Truss Manufacturers

Victoria

"More marketing for timber clad houses, not brick dwelling."

New South Wales

"What we need is a nationalised advertising/education program where our industry can actually agree on the benefits of using timber, the grading of timber, product identification i.e. grading, treatment levels etc. at present it is disjointed, confusing and plays into the hands of competing products."

Environmental Issues

The main environmental issues mentioned by building professionals related to timber certification, sustainability, use of illegally sourced products and the carbon storage and greenhouse credentials of wood products.

Architects

Victoria

"Information regarding source of timbers and information regarding carbon sink values."

"Promotion of energy efficient frame performance and lower embodied energy in manufacture."

"Investment in growing attractive Class 1 timber locally – like Meranti and Jarrah so that the concept of using timber like these does not make us feel guilty as specifiers."

South Australia

"Promote environmental benefits of timber framing/cladding compared to brick/brick veneer e.g. carbon storage and less energy usage (embodied)."

Construction Techniques / Performance Techniques / Performance

Comments received supported the adoption of innovative techniques for greater incorporation of wood products in buildings as well as opportunities for greater uptake in existing construction systems in different States.

Architects

Victoria

"Promotion of reverse brick veneer with timber cladding/weatherboards."

"Overcome the prejudice of timber cladding so brick is not obligatory."

"Use of timber cladding between party walls in attached dwellings."

"Promotion of membrane roofing supported on plywood and timber beams as an alternative to flat roofing in flats and units."

South Australia

"Further development for engineered timber products, long span members, and more use in external applications."

"Introduction of tested timber construction systems to conform with noise/fire separation requirements in flats and multi-units."

Builders

Western Australia

"Currently double-brick could utilise timber framing, as [it was] in the past – [this would result in a]100 per cent increase in timber usage."

Frame and Truss Manufacturer

Victoria

"Ensure party walls are designed using timber as the primary material in attached dwellings, flats and units - not concrete or steel solutions."

"95 per cent is steel studs at present in high rise partitions. We supply many jobs in finger-jointed non-structural product that competes very well on price and application. The challenge is to have it [timber framing] designed more often."

"Government community housing could increase timber use in housing dramatically almost immediately."

Queensland

"Better documentation of span tables, better party wall detail, more consistent design methods in attached dwellings."

(Source: selected quotations taken from the author's research)