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# Recycling and End-of-Life Disposal of Timber Products





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***Researchers:***

J. Taylor, R. Mann and M. Reilly

**Ensis**

Private Bag 10, Clayton South, Vic 3169

M. Warnken

**WarnkenISE**

PO Box 705, Glebe, NSW 2037

D Pincic

**CSIRO Manufacturing and Infrastructure Technology**

Private Bag 33, Clayton South, Vic 3169

D. Death

**CSIRO Minerals**

Private Mail Bag 5, Menai, NSW 2234

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**Forest and Wood Products Research and Development Corporation**

PO Box 69, World Trade Centre, Victoria 8005

Phone: 03 9614 7544 Fax: 03 9614 6822 Email: [info@fwprdc.org.au](mailto:info@fwprdc.org.au)

Web: [www.fwprdc.org.au](http://www.fwprdc.org.au)

# **Recycling and End-of-Life Disposal of Timber Products**

Prepared for the

**Forest & Wood Products  
Research & Development Corporation**

by

**J. Taylor, R. Mann, M. Reilly, M. Warnken, D. Pincic  
and D. Death**

## Executive Summary

At the start of 2005, the Forest and Wood Products Research and Development Corporation (FWPRDC) commissioned Ensis to write a document reviewing issues surrounding the recycling and end-of-life disposal of timber products in Australia. There are various reasons why this literature review was commissioned. Within Australia, legislation is being developed to place more responsibility on producers (manufacturers) of timber-based products to ensure that they reduce waste to landfill. This follows on from legislation in various countries worldwide which provide incentives for recovery, reuse and minimisation of timber-based products and packaging. Most importantly, it reflects changing public attitudes and perceptions surrounding the sustainability of timber-based industries globally.

There are many different systems for classifying wood waste, such as differentiating between primary and secondary wood products and material type. The most important element of a classification system is the ability to differentiate between green wood, preservative-treated wood, untreated wood and composite wood waste.

The waste hierarchy suggests a preference for reducing the amount of wastes generated, reusing what cannot be reduced, recycling what cannot be reused and disposing of the remainder. The different methods of recycling wood wastes are:

- direct recycle, where timber products are recycled back into timber products,
- indirect recycle, where timber products are recycled into different product types, such as mulch, and
- energy recovery.

Wood waste is generally either diverted from landfill (either Construction and Demolition waste (C&D) or Commercial and Industrial waste (C&I)) or it is diverted from manufacturing industries (C&I waste). Available information on volumes of waste wood to landfill for Sydney and Melbourne estimate that approximately 446,000 and 623,000 tonnes (respectively) are disposed of annually. The Melbourne figure is enough timber waste to fill the Melbourne Cricket Ground 1.5 times.

Data on wood waste from other Australian states and territories are much less clear, as most of the figures are not differentiated from larger categories of waste, such as C&D waste. However, it is clear that huge volumes of waste wood are disposed of to landfill each year in all of the capital cities. Most of this waste wood is unsorted and may contain different timber species, preservative-treated timber and both solid and engineered wood products.

Wood wastes are independently regulated in each state and territory under the guidance of the federal government. Many states have initiated voluntary Extended Producer Responsibility (EPR) schemes, which places the responsibility to reduce and recycle (wood) wastes on manufacturers. All states and territories have both existing and proposed documentation which plans for future targets in reduction of specified waste to landfill. Within those strategies the reduction of timber wastes is often mentioned, particularly timber waste from the C&D and C&I waste streams.

Various public policies, such as the Renewable Energy Credits scheme, encourage the utilisation of waste wood for heat and energy production. Generation of heat using wood waste is via fairly straightforward combustion technologies such as grate-fired boilers, fluidised bed combustion and cement kilns. Energy production technologies have been developed which are able to utilise mixed biomass to create energy. Common technologies include steam turbines, gasification and pyrolysis.

There are numerous overseas examples on the regulation of wood waste. The European Union (EU) has passed several directives which directly influence wood waste disposal and recycling, including the *Directive on Packaging and Packaging Waste* which sets targets for up to 50-60% recovery of packaging waste and 25-45% recycling.

The UK has interpreted the EU Directive on *Packaging and Packaging Waste* into national law with two regulations; *Producer Responsibility Obligations (Packaging waste) Regulations 1997* and *Packaging (Essential Requirements) Regulations 1998*. They specify 50% recovery and recycling of packaging waste.

Germany has the most specific national legislation on the management of waste wood with the *Ordinance on the Management of Waste Wood* which was enacted in 2003. This ordinance classifies wood waste and identifies technologies for the utilisation of waste wood by either recycling or combustion. The ordinance also specifies maximum allowable levels of contaminants such as arsenic and copper. Germany also regulates packaging waste utilising a system established by private companies called the “Duales System Deutschland” (DSD). This system uses a ‘Green Dot’ symbol on recyclable containers to encourage consumers to dispose of the packaging into an established recycling system built specifically for the ‘Green Dot’ wastes.

In the United States of America (USA), the federal government is responsible for overriding environmental legislation and regulation. Each individual state, however, has independent authority over environmental protection laws. This means that regulation of (wood) wastes varies considerably across the states. For instance, more than 60% of the states regulate wood waste. Of those, about 20 states either ban or plan to ban wood waste from solid waste disposal facilities. Furthermore, it is legal under federal law to dispose of CCA-treated wood in a lined landfill, but landfill operators are not required to accept the material.

The waste timber resource includes unknown quantities of CCA-treated timber, which can cause issues when used for recycling and combustion. Although the Australian Pesticides and Veterinary Medicines Authority (APVMA) has moved to phase out CCA-treated timber used as decking and playground equipment, large quantities of CCA-treated timber will still be disposed of over the coming years. There has been some question as to whether it is safe to dispose of CCA-treated timber to landfill. Most studies have found that disposal of CCA-treated timber to lined landfills causes no risk to the environment. However, researchers have put some effort into developing technologies which can remove the copper, chromium and arsenic from treated timber. Most of these technologies are non-commercial and very expensive.

Engineered wood products also create issues in the utilisation of the waste wood resource, mainly because of the size of the wood available in the composite and the

presence of adhesives and coatings. However, several companies have successfully recycled wood composite panels into further panel products using a combination of technologies. Furthermore, the composite panel industry is a distinctively promising industry for utilising (solid) wood waste for new composite products.

Removal of chemical contaminants is difficult to do successfully as most technologies capable of scanning wood waste for contaminants are still in the developmental stages. Some of the more popular technologies which are being tested worldwide for separation of CCA-treated timber from the waste stream are Laser Induced Breakdown Spectroscopy (LIBS), X-Ray Fluorescence (XRF), Ion Mobility Spectroscopy (IMS), Electronic Nose (EN), Near Infrared (NIR) and Liquid Phase Biosensor. Each of these technologies has specific advantages and disadvantages. They also require considerable capital outlay to establish in-line scanning systems capable of sorting CCA contaminated wood at economic production speeds.

There are many opportunities throughout Australia for the utilisation of waste wood with relatively few regulatory hurdles to negotiate. The main issue preventing the utilisation of wood wastes is overcoming contamination, especially contamination by chemicals such as wood preservatives. However, technologies are being developed to overcome such issues, which may be viable for some of the larger industries wishing to use waste wood for manufacturing or energy production.

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# 1.0 Introduction to Wood Waste and Context of Recycling and End-of-Life Disposal

## 1.1 Classification Systems

Wood waste can mean many things to many people; a waste disposal problem for some and a resource recovery opportunity for others. There are several accepted standards for categorising waste wood worldwide. The most simple system of classification would differentiate between primary processing (pre-consumer) and secondary wood products. An example of this system of differentiation is presented in the table below:

**Table 1.1. Differentiation of Primary and Secondary Wood Products**

Primary Wood Products	Secondary Wood Products
Thinnings	Urban garden organics
Sawmill residues	Process by-products (ex. Furniture manufacture residues)
Harvesting residues	End-of-life residues (ex. pallets)

The most useful classification system from a recycling viewpoint is a breakdown of wood waste by material type. A working example of this breakdown is used in Germany where the *Ordinance on the Management of Waste Wood*<sup>1</sup> separates wood waste into four categories:

- A I untreated wood
- A II treated wood without halogenorganic compounds
- A III treated wood with halogenorganic compounds
- A IV wood contaminated with wood preservatives

Another common system of classifying waste wood according to material type was demonstrated by Warnken (2001). This system is commonly used in Europe and differentiates the wood by the type of wood product it was prior to becoming waste:

- A untreated solid wood materials
- B engineered panel products (particleboard, plywood, MDF)
- C preservative-treated timber

There is further scope to separate the waste wood stream in a different manner, utilising categories of wood use rather than material type. This system is commonly used in the UK and is presented in the table below:

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<sup>1</sup> [http://www.bmu.de/files/wastewood\\_background.pdf](http://www.bmu.de/files/wastewood_background.pdf)

**Table 1.2. Categories of waste and possible recovery options (Taken from <http://www.dti.gov.uk/sustainability/downloads/wood.pdf>)**

<b>Category</b>	<b>Description</b>	<b>Recovery Options</b>
<b>Green Waste</b>	By-product of the management of trees, such as copse thinning and pruning	Decomposition <i>in situ</i> ; chipping for land spreading and mulch; energy recovery
<b>Untreated Wood</b>	Mostly packaging wood (such as pallets) that has not been treated	Reuse, recycling; energy recovery
<b>Structural Wood</b>	Wood used in construction, etc., including rail sleepers and telegraph poles as well and C&D waste. Treated with preservatives and other chemicals	Reuse (poles, etc.); limited recycling and energy recovery
<b>Process Waste</b>	Sawdust, chippings, shavings, off-cuts	Reuse; recycling; energy recovery
<b>Waste Manufactured Products</b>	Products entirely or partly made of wood, such as furniture	Reuse and refurbishment; recycling; energy recovery

Various derivations of the above systems exist, however, for the most part, qualities of a workable system for utilising wood waste must be capable of separating green wood, (preservative) treated wood, untreated wood, and composite wood waste.

## ***1.2 Recycling and Recovery Options***

The recycling and recovery of value from wood waste has developed into a commercially viable business internationally. Some of the larger wood waste recyclers worldwide advertise their products on the internet for a variety of uses, such as animal bedding and wood flour.

When considering options for minimising waste, the waste hierarchy of “reduce, reuse, recycle” is a common feature across jurisdictions in Australia. The hierarchy expresses a preference to achieve sustainable outcomes by reducing the amount of waste that is generated, reusing what cannot be reduced and recycling what cannot be reused, with disposal as the last option.

Three different types of recycling are also distinguishable:

- direct recycle, where timber products are recycled back into timber products,
- indirect recycle, where timber products are recycled into a different product type, for example, landscape mulch,
- energy recovery, where the calorific value (heat energy) of timber products is recovered.

Some further examples of the application of the waste hierarchy to timber products are presented below.

### 1.2.1 Reduce

Waste reduction is one important component in protecting the environment and natural resources. Many countries are now legislating reduction in waste by the creation of laws for minimising the use of resources, such as the European Union *Directive on Packaging and Packaging Waste* (EU 1994) which aims to reduce the volumes of packaging created as well as its re-use. The national and international acts and regulations pertaining to the reduction of waste are covered more completely in the body of this report under the relevant state and national headings.

### 1.2.2 Reuse

The reuse of materials is the preferred option in minimising waste, as the material is usually reused in its original form and little cost is incurred in re-forming or creating new products out of the waste material. Examples include pallets, furniture and solid wood flooring.

A survey conducted by the National Wood Pallet and Container Association in 1997 found that pallets are reused on average 9 times by users in the United States (Zimms and Barnett 2004). This demonstrates the ability to reuse specific commercial products, such as pallets, numerous times before they reach the end of their useful life.

It is this type of reuse that is the backbone of the business case for pool pallet companies, such as CHEP, who rely upon the reuse of their pallets in order to run a profitable business. They have developed a worldwide logistics system to support the reuse of pallets (up to 265 million pallets a day) for many thousands of specific customer needs.<sup>2</sup>

Other examples of successful reuse of wood waste are demonstrated by the various waste networks which have sprung up on the internet over the past few years. There appear to be wood waste networks established in many Australian states, providing quick and easy access to market for waste products such as timber flooring, windows and doors.<sup>3,4,5</sup> These internet waste wood resources are also available worldwide, creating a virtual 'shopping mall' of wood products available for reuse.<sup>6,7</sup> Appendix A contains a list of recycling case studies from both Australia and overseas as examples of the wide variety of successful recycling projects worldwide.

### 1.2.3 Direct Recycle

Recycling of wood waste most often means changing the form of the wood waste, such as size reduction, in order to make another product out of it. Direct recycling is

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<sup>2</sup> [http://www.chep.com/chepapp/chep?command=fwd&to=choosechep/who\\_is\\_che.jsp&lcd=en](http://www.chep.com/chepapp/chep?command=fwd&to=choosechep/who_is_che.jsp&lcd=en)

<sup>3</sup> <http://www.ecorecycle.vic.gov.au/www/default.asp?casid=3503>

<sup>4</sup> <http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-53LUW4?open>

<sup>5</sup> <http://www.wbdg.org/tools/cwm.php>

<sup>6</sup> <http://www.recycle-it.org/news/about.asp>

<sup>7</sup> <http://www.grn.com>

the manufacture of a new timber product, such as particleboard, from waste wood. Other examples include finger jointing and lamination, MDF and wood plastic composites.

**Finger Jointing and Lamination:** Manufacture involves joining the ends of two or more pieces of wood to produce a single length. This technique would be most suited to manufacturers who deal with large quantities of solid timber offcuts, all of which are relatively similar in width and depth. Lamination is simply the gluing and pressing of surfaces together to form a larger block or length of timber. Additional investments would be required in the purchasing of adhesive and staff training for operating new machinery.

**Medium Density Fibreboard (MDF):** MDF is a panel product used mainly in the manufacture of furniture. It can be laminated with a decorative finish or painted, as well as shaped or moulded to a specific design. MDF is manufactured by refining wood chips into fibres. Thinnings and harvesting residues are often used to manufacture MDF; Construction and Demolition and Commercial and Industrial waste has also been shown to be suitable in pilot scale studies. Rotating discs in the plant are used to tease the fibres apart and homogenise them. After drying, heat and pressure are used to bond the fibres together to form the sheet of MDF. Thermoset adhesives are typically added between the defiberising and drying stages.

**Particleboard (Chipboard):** Particleboard is also used for furniture manufacture (kitchen cupboards, desks, bookshelves and the like) and in the construction industry (flooring). It can be pre-machined or covered with a decorative finish. Particleboard is manufactured by adding a resin to wood flakes (typically softwood). The wood chip feedstock is cleaned, dried, and re-sized into flakes before being mixed with the resin. It is then formed into a flat mattress which is cured by heat and pressure. Particleboard is most often covered with paper laminates to improve its appearance.

The manufacture of particleboard using wood waste is common in Europe. However, in Australia the method is not widely used. Wood waste produced by the furniture manufacturing and construction industry is mostly particleboard, MDF and kiln-dried wood.

**Wood-Plastic Composite Materials:** Wood-plastic composites are made by combining wood fibre or flour with thermo-plastics and other additives. This material is then heated and formed into the required profile. There are some restrictions on the species of timber which can be used because of incompatibilities with the natural oils and resins in some species of timber and the production process.

#### **1.2.4 Indirect Recycle**

Indirect recycling of waste wood is the utilisation of waste wood by changing the form in order to make another (non-timber) product out of it. Some of the products which can be manufactured through the indirect recycling of waste wood include (Urban Harvest 2004):

**Animal Bedding:** A high value market for wood waste is animal bedding products. Animal owners are interested in materials with low levels of fine dust, due to concerns over potential respiratory problems for both animals and people. Furthermore, the benefits of using wood waste as bedding do not have to end after its first use. For example, used horse bedding is often used as a soil improver.

**Landscape Mulch:** Mulch is a layer of material placed on top of soil to aid weed control, protect plant roots from frost and reduce water loss. Solid wood off-cuts are required to produce mulches. The market for mulch is seasonal, however the simplicity of the process makes it a viable recycling option for untreated wood waste and “woody” garden organic material.

**Surfacing Products:** Wood chips are suitable for a number of surfaces, such as children’s playgrounds and equestrian arenas, because of the soft (cushioned) surface, good drainage and low maintenance.

**Composting:** Compost is manufactured when organic materials are microbially transformed in an aerobic condition and at an elevated temperature (in excess of 50°C for three days) in order to destroy animal and plant pathogens and weed seeds. Nutrient value and moisture are essential ingredients, so it is manufactured using sawdust or garden organics which have a high moisture and organic content. The market for compost includes potting mixes, soil improvement products and topsoil, and like mulch, is seasonable.

**Cement Board:** A 50/50 mixture of cement and wood or other lignocellulosic fibre. The material is unexpectedly lightweight, which makes it easy to nail and saw, as well as having good insulation properties. Cement board is resistant to moisture, rot, and insect and vermin attack (English 1994). Wood can also be used as the aggregate in cement to make lightweight building blocks.

### 1.2.5 Energy Recovery

Wood waste can be used as energy in a number of forms; as a prepared fuel product for domestic or commercial applications (either as a stand alone fuel or as a mixture of fuels – cofiring); for process heat, for heat to raise steam and drive electricity generators; for a combination of process heat and electricity – cogeneration; and for the production of a synthesis gas (syn-gas) that can be combusted directly in gas turbines for electricity generation. Ideally low value wood material should be used, that has energy recovery as its “best resource use” option and recycling is not possible (for more information see the Energy from Waste Sustainability Guide).

**Fuel Briquettes and Pellets:** Compressing sawdust and small wood chips into solids such as briquettes or pellets overcomes the difficulty of handling wood dust, and the compressed solids can be handled in the same way as solid off-cuts. However, dust derived from reconstituted panel products does not tend to bind together very well due to a lack of natural resins and low moisture content. The pellets have great potential for use as a domestic fuel. There is a market in Australia for wood pellets, used mainly for domestic heaters.

**Cofiring in Power Stations:** The majority of power stations in Australia are fired on coal. Some of these have developed the capacity to cofire wood waste (predominantly untreated timber). Growth in this area is being driven by the Mandatory Renewable Energy Target, which includes wood waste as an eligible fuel for the generation of Renewable Energy Certificates (RECs).

**Cofiring in Cement Kilns:** Cement kilns in Australia use either coal or natural gas as a fuel. Almost all kilns are being developed to use alternative fuels, and wood waste features as one such fuel. Because of the high temperature of the cement kiln, and the long residence time of burning, cement kilns are ideal combustion environments and are able to use untreated and engineered timber products as fuel.

**Cogeneration:** The use of wood as a fuel in cogeneration systems features in the sugar processing and paper production industries. For example, the Rocky Point Sugar Mill uses wood waste to augment bagasse (residues from harvesting sugar cane) as a fuel, and the Visy Pulp and Paper Mill in Tumut uses a combination of forestry residues and untreated urban wood waste to produce process heat and generate electricity.

**Stand Alone Biomass Power Stations:** Wood waste in the form of forestry residues, garden organics and untreated timber is used in biomass power stations such as the demonstration plant owned by Green Pacific Energy in Stapylton, South East Queensland. A variety of combustion technologies can be used, ranging from standard grate configurations, to fluidised bed combustion. Advanced technologies including gasification and pyrolysis can also be used. These manage combustion in an oxygen restricted or oxygen excluded environment, but are more capital intensive and operationally involved than their traditional counterparts.

### **1.3 Summary**

The term “wood waste” can be broadly defined as the solid waste wood pieces or particles resulting from the manufacture, use or disposal of wood products. In order to simplify the boundaries of what qualifies as waste wood, this report concentrates mainly on secondary wood product waste. This includes wood waste from manufacturing industry by-products (such as furniture manufacture) as well as end-of-life residues that arise within the urban environment.

When considering recycling, wood waste is further divided into the following general categories:

- A untreated solid wood materials
- B engineered panel products (particleboard, plywood, MDF)
- C preservative-treated timber

There are many options for the management of waste wood, including the initial reduction in the volume of wood waste produced. Once that waste is created, however, there are viable recovery options, including reuse (direct recycling), indirect recycling and energy recovery (see Table 1.3 below).

**Table 1.3. Recovery options for waste wood**

<b>Recovery Option</b>	<b>Examples</b>
Reuse	Pallets and furniture
Direct Recycle	Reconstituted wood materials such as finger-jointing and particleboard
Indirect Recycle	animal bedding, leisure surfaces, compost, mulch
Energy Recovery	Pellets, boiler fuel, process heat, electricity

However, not all of the above options are commercially viable for Australian conditions. Other issues to be considered include: reliable supply volumes and potential season variations, contamination minimisation (different timber species as well as preservative or other contamination), transport costs and legal obligation (regulations).

The following sections address several of these issues and presents an overview on the availability of waste wood resource in Australia, in addition to the current legislation and regulatory environment surrounding its recovery and beneficial use.



## 2.0 The Australian Waste Timber Resource

Most secondary wood waste (post-manufacture) in Australia is derived from either the Construction and Demolition (C&D) or the Commercial and Industrial (C&I) waste streams. It is difficult to find accurate data on the exact volumes of waste timber generated annually.<sup>8</sup> The Australian Waste Database (AWD), developed by the CRC for Waste Management & Pollution Control Ltd., identifies three sources of waste materials:<sup>9</sup>

- Municipal Waste
- Commercial and Industrial Waste (C&I)
- Building and Demolition Waste (B&D or C&D)

There is no further breakdown in the composition of these waste streams, or estimates on national volumes, making it difficult to determine national estimates. One author (Warnken 2004) estimated that there was approximately 1.8 million tonnes of wood waste generated annually in Australia and that in excess of 75% of the waste wood was disposed of to landfill. Apart from this, the most widely available information about wood waste is located in resources such as State EPA reports or waste authority studies. A state by state summary of available data is presented below, in addition to a national summary table.

### 2.1 New South Wales

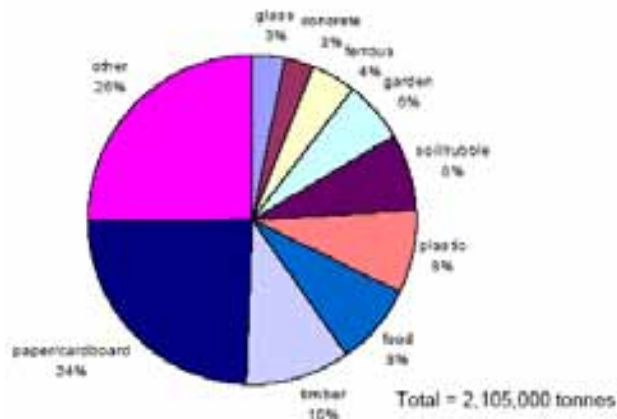
There have been numerous reports written since 2000 which give estimates of wood waste volumes to landfill in the greater Sydney region (Wright *et al.* 2000; Russell 2001; NSW Waste Boards 2000; Robson *et al.* 2002; NSW Waste Boards 2001). Most of the literature agrees that approximately 335,000 to 350,000 tonnes of wood waste is generated in the Sydney metropolitan region annually. To put the volume of waste wood into context, the total volume of waste generated in the Sydney metropolitan area is approximately 9 million tonnes, making wood approximately 4% of waste materials generated. This amount of wood waste is estimated to take up approximately 1.05 million cubic metres of landfill each year in the Sydney region.

Estimates of timber waste generated in the three main waste streams for the Sydney metropolitan area suggest waste wood volumes amount to 6% of total C&I waste generation annually. This accounts for approximately 174,000 tonnes annually (Department of Environment and Conservation NSW 2004). The other 161,000 tonnes of wood waste is found in the C&D stream, with only minimal volumes accounted for in the municipal waste stream. Of this C&I waste wood approximately 55% was particleboard, 15% was untreated timber, 15% was MDF, 10% treated timber and 5% plywood (Warnken 2001b).

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<sup>8</sup> (waste generated = recycling + disposal to landfill)

<sup>9</sup> <http://www.civeng.unsw.edu.au/awdb/awdb2.htm>

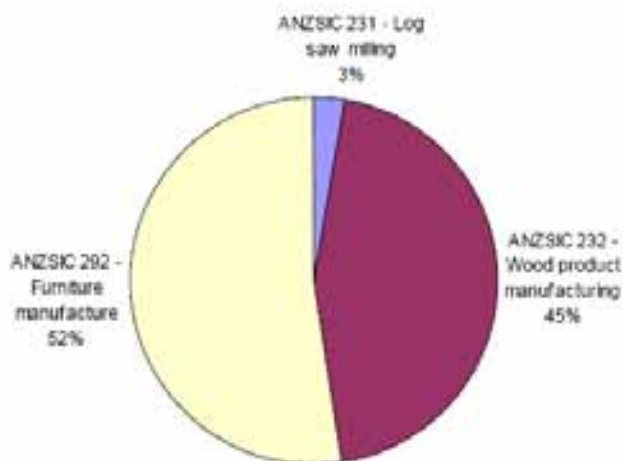


**Figure 2.1. Composition of the C&I waste stream in the Sydney Metropolitan area (Taken from Russell 2001)**

A study of waste wood generated in the C&I waste stream in Sydney indicates that most waste wood was generated in one of three Australian New Zealand Standard Industry Classifications (ANZSIC) categories:

1. ANZSIC 231 – Log saw milling
2. ANZSIC 232 – Wood product manufacturing (including kitchen joinery and cabinet makers)
3. ANZSIC 2921 and 2929 – Wooden furniture manufacturers

Russell (2001) determined that furniture manufacture contributed to the highest generated volume of waste wood, followed by wood product manufacturing and finally sawmilling.

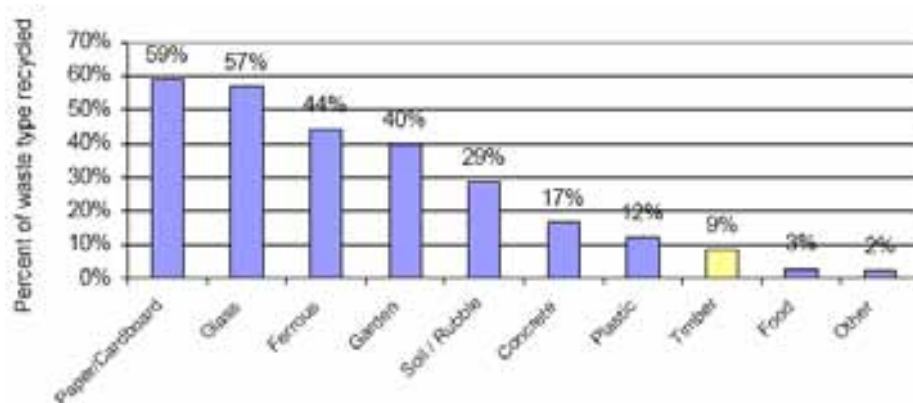


**Figure 2.2. Relative contribution of the different ANZSIC categories to the generation of waste wood in Sydney (Taken from Russell 2001)**

Waste timber is a substantial portion of waste to landfill in Sydney, when compared to other recyclable waste products such as glass and plastic. The volumes of waste timber which are recycled compare poorly to other recyclables as well, particularly paper.

**Table 2.1. Estimated volumes (tonnes/year) of waste disposed of and recycled in the Sydney metropolitan area (Taken from Department of Environment and Conservation NSW 2004)**

	Municipal		Commercial and Industrial		Construction and Demolition	
	Disposed	Recycled	Disposed	Recycled	Disposed	Recycled
Paper/Cardboard	138,000	225,500	318,000	274,000	3,500	Nil
Plastic	59,500	17,000	199,000	29,000	8,500	Nil
Glass	37,500	82,000	20,000	38,000	Nil	Nil
Ferrous	22,000	8,000	59,500	365,000	39,500	365,000
Garden	334,000	417,000	59,500	156,500	15,000	Nil
Food	367,500	Nil	79,500	31,500	Nil	Nil
Timber	Nil	Nil	139,500	34,500	83,000	78,000
Soil/Rubble	Nil	Nil	Nil	Nil	370,000	890,000
Concrete	Nil	Nil	Nil	Nil	331,000	1,296,000
Other	234,000	2,500	1,115,500	61,000	117,000	304,000
<b>Total</b>	<b>1,192,500</b>	<b>752,000</b>	<b>1,991,000</b>	<b>989,500</b>	<b>967,500</b>	<b>2,933,000</b>



**Figure 2.3. Percentage of waste material recycled in the C&I waste stream (Taken from Russell 2001)**

On a state wide basis it has been estimated that 315,000 tonnes of wood is disposed of to landfill and 131,000 tonnes of wood is recycled, meaning that some 446,000 of wood waste is generated annually (Department of Environment and Conservation NSW 2004). The NSW total estimate on annual waste generation is approximately 12 million tonnes, with wood making up approximately 4% of this total.

## 2.2 Victoria

Raw data on volumes of waste to landfill are collected by EcoRecycle Victoria. The raw data are available by interpretation of the Victorian Landfill Levy, which was introduced by the *Environmental Protection Act in 1992*.<sup>10</sup> These data are currently broken down into general waste categories (municipal, B&D, and C&I) with no further discrimination into subcategories (such as bricks, timber and concrete).

<sup>10</sup> <http://www.ecorecycle.vic.gov.au/aboutus/statistics.asp>

In 2003, EcoRecycle Victoria released a report *Towards Zero Waste - Supporting Analysis to the Strategy & Plan*, as part of the development of its waste strategy (EcoRecycle Victoria 2003). The report stated that for the 2000/2001 period, 623,000 tonnes of waste wood were generated in Victoria, comprising 470,000 tonnes disposed of to landfill and 153,000 tonnes recycled. That accounts for approximately 7% of total waste to landfill in Victoria by weight, and is enough timber to fill the Melbourne Cricket Ground 1.5 times.<sup>11</sup>

The most significant generation of waste wood is from the C&I waste stream, which produces approximately 325,000 tonnes of waste wood annually (EcoRecycle Victoria 2002). This is followed by the C&D waste stream (195,000 tonnes) and the municipal waste stream (103,000 tonnes). Of the C&D waste sent to landfill in metropolitan Melbourne, approximately 39% is sourced from residential demolition, 33% from commercial demolition, 15% from residential and commercial construction and the balance from roads and civil construction and demolition.

The volumes of wood waste recycled each year in Victoria have slowly increased, assisted by initiatives such as the Wood Waste Network, supported by EcoRecycle Victoria, and established in 1998.

## **2.3 Queensland**

Wood waste data are limited for Queensland; however, a 2002 state-wide survey of waste management found that a total of 3,866,300 tonnes of waste were disposed of to landfill in 2001-2002 (Queensland EPA 1999). Of this total, C&D waste accounted for 645,000 tonnes and C&I 577,400 tonnes.

Interpretation of recycling data indicates that 20,700 tonnes of C& I waste and 330,000 tonnes of C&D waste were intercepted for recycling, in addition to a further 642,100 tonnes of other recycling (including garden organics). Thus for Queensland the total annual waste generation is 4,859,100 tonnes. Applying the average rate of wood waste generation of NSW and Victoria to this total (5.5%), there is an estimated 267,000 tonnes of wood waste generated annually in Queensland.

## **2.4 South Australia**

A total of 1,006,000 tonnes of waste were sent to landfill in South Australia during 2003 (Zero Waste South Australia 2004). Data from an audit of 6 landfill sites conducted in 1998 revealed that 53% of land filled waste was generated by the construction and demolition waste stream (South Australia EPA 2000).

Recycling in the Adelaide area is predominantly conducted by four major recyclers who process approximately 700,000 tonnes of mainly construction and demolition waste (Nolan-ITU Pty. Ltd. 2001). Most of the material they recycle, therefore, tends

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<sup>11</sup> <http://203.147.170.129/www/default.asp?casid=3278>

to be concrete and asphalt. When other recycling activities (including garden organics) is added, South Australia recycles some 2,147,000 tonnes of materials.

The total annual waste generation for South Australia is estimated as 3,153,000 (Zero Waste South Australia 2004). Applying the average wood composition rate of 5.5% results in a wood waste generation estimate of 173,000 tonnes per annum.

## **2.5 Tasmania**

Data for Tasmania-wide wood waste does not exist. The Southern Waste Strategy Authority (SWSA) has released information on volumes of waste to landfill in Southern Tasmania which was extrapolated from Victorian recycling statistics.<sup>12</sup> The SWSA estimates that approximately 165,000 tonnes of waste were sent to landfill during the survey period. Of that waste, approximately 47% was from the C&I waste stream and 5% from B&D.

Recent communications cite approximately 360,000 tonnes of waste disposed of to landfill Tasmania-wide with no data on recycling (Cretney 2005). Applying the average wood composition rate of 5.5% gives at least 20,000 estimated tonnes of wood waste generated annually.

## **2.6 Western Australia**

The Western Australia Department of Environment and Waste Management Board has correlated landfill data for the Perth area in recent years (Western Australia Department of Environment and Waste Management Board 2003). In 2002, estimated total waste to landfill was 2,541,165 tonnes (Government of Western Australia 2003). The construction and demolition waste stream contributed to over 50% of waste to landfill (by volume).

Recycling data have been distributed within the *Construction and Demolition Waste: Sector Actions* document.<sup>13</sup> This document estimates that about \$10 million worth of materials are salvaged from construction and demolition sites around Perth annually. Other estimates put this amount of recycling as 134,250 tonnes.

The total waste generation for Western Australia is estimated as 2,675,055 (Government of Western Australia 2003). Applying the average wood composition rate of 5.5% results in a wood waste generation estimate of 147,000 tonnes per annum.

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<sup>12</sup> <http://www.southernwaste.com.au/WasteComposition.pdf>

<sup>13</sup> [http://www.environ.wa.gov.au/downloads/1040\\_W20200301.pdf](http://www.environ.wa.gov.au/downloads/1040_W20200301.pdf)

## 2.7 Australian Capital Territory

The total annual waste generation for Australian Capital Territory is estimated as 708,669.<sup>14,15</sup> Applying the average wood composition rate of 5.5% results in a wood waste generation estimate of 39,000 tonnes per annum.

## 2.8 Northern Territory

No data are available for Northern Territory waste generation. Using a population based comparison of two thirds (198,000 NT and 301,000 ACT), gives a wood waste generation estimate of 26,000 tonnes per annum.

## 2.9 National Summary

There are large volumes of waste wood sent to landfill in Australia each year. Most recent estimates suggest Melbourne and Sydney generate over 500,000 tonnes of waste wood collectively each year. Most of the waste wood is disposed of to landfills which are located at or near the major cities. The waste wood is usually unsorted and may comprise various species of timber, solid timber and engineered wood products, and preservative-treated timber as well as lead-based paints and metal contaminants (nails).

Using a combined average of wood waste generation from NSW and Victoria, the following table summarises the total waste generation estimates across Australia.

**Table 2.2. Total Wood Waste Estimates Across Australia**

State/Territory	Total Waste Generated (tonnes/annum)	Wood Waste Generated (tonnes/annum)
New South Wales	12,169,500	446,000
Victoria	8,470,000	623,000
Queensland	4,858,771	267,000*
Western Australia (Perth)	2,675,055	147,000*
South Australia	3,153,000	173,000*
Tasmania	360,000	20,000*
Australian Capital Territory	708,669	39,000*
Northern Territory	-	26,000*
Total	32,394,995	1,741,000

\*estimated on the basis of 5.5% of total waste generated (recycled + landfilled)

<sup>14</sup> <http://www.nowaste.act.gov.au/styles/actresourcerecovery.pdf>

<sup>15</sup> <http://www.nowaste.act.gov.au/styles/landfillgraphpdf.pdf>

The total estimate for Australia is likely to be an underestimate as Western Australia data are based on Perth only, and not the whole state, no additional allowance for timber products included as garden organic materials has been made and data used are in the order of 2-3 years old. Care must also be taken when using this estimate as only NSW and Victoria have provided wood only data. Nevertheless, the estimate agrees well with the previous national estimate of 1.8 million tonnes.

NSW and Victoria data put the recycling rate at somewhere between 30% and 25% respectively. Applying the lower amount at a national level would suggest that some 435,000 tonnes of wood waste is recycled and some 1,306,000 tonnes of wood waste is disposed of to landfill on an annual basis.

Although volumes of waste wood are high, the resource is highly variable in composition as well as volume. Waste studies in the Sydney region demonstrate that wood waste from particular industries (wood product manufacture and the furniture industry) makes up a substantial portion of wood waste in the Sydney region. Given that those industries tend to cluster in the more industrial areas of the region, it is likely that potential industries hoping for reliable wood waste resource could establish a direct relationship with those industries and by-pass the landfill altogether.

## **3.0 Australian Waste Wood Legislation**

Regulation of wood wastes is independently legislated in each state by an environmental protection authority or equivalent. National guidance on waste related issues is provided by the Australian Government Department of the Environment and Heritage, in addition to working groups that sit under the auspices of the Environmental Protection and Heritage Council (EPHC). Each state is responsible for developing environmental policy and implementing further regulations which legislate the reduction of waste and environmental harm caused by those wastes (Appendix A). As a result, some states have started to investigate extended producer responsibility schemes which places the burden of action on manufacturers for the end-of-life management of their products. This could mean that timber related manufacturers would need to reduce and recycle wood waste in the general waste streams. The sections below present an overview of waste related legislation across Australia and its potential implications for wood waste recycling and disposal.

### **3.1 New South Wales**

In 2003, The *NSW Waste Avoidance and Resource Recovery Strategy* was released (Resource NSW 2003). This strategy incorporates broad targets to reduce waste generation, increase recovery of waste, reduce toxic substances and reduce litter and illegal dumping. The strategy includes specific targets for increasing recovery rates in each of the main waste streams (municipal, C&D and C&I).

One of the most significant elements of the New South Wales waste management policy is the introduction of Extended Producer Responsibility (EPR), of which treated timber is one of the 16 wastes of concern (Department of Environment and Conservation New South Wales 2004). The NSW DEC has established an Expert Reference Group (ERG), comprised of representatives from the NSW DEC, a local government authority, recycling industry, environmental group and consumer organisation. The ERG holds regular meetings with timber industry representatives whose task is to evaluate the EPR or product stewardship schemes. The implication is that further legislation will require the industries producing those wastes to act to reduce the amount of waste and/or the impact of their products on the waste stream.

EPR schemes have been implemented across Europe, United Kingdom, United States, Canada, Taiwan and Japan. The focus in each case has been on developing sustainable systems to eliminate or minimise a products environmental impact over its life cycle.

The introduction of the EPR will realise various benefits across all the sectors. Within the community it will reduce the amount of hazardous material released into the environment as well as reducing litter. Recyclers will notice an increase in demand for recycling operations, and it will encourage the development of new technologies. Hence, local governments should be relieved of the burden of managing inappropriate waste, while producers will create a greener image and assist in products becoming internationally compliant (refer section 4.1.6 EU Directive on Packaging and



Packaging Waste). Industry may benefit in a number of ways, such as: reduced cost of pollution control measures, better product design and energy and resource savings.

With the implementation of the EPR, the producers are more able to take the necessary actions to avoid waste. It is recognised however, that the costs incurred by the producers through delivering the EPR will more than likely be passed onto the users of the products.

Some benefits of a properly designed and implemented EPR scheme would include:

- Resource recovery encouragement
- Efficient and competitive manufacturing
- Reduction in landfill and waste treatment facilities and their environmental impacts
- Efficient use of natural resources and materials
- Possible elimination of potentially hazardous components
- Encouragement of closed material loops

Bringing the states together would be highly beneficial for the EPR scheme, to enable their thoughts and ideas on a number of issues to be pooled. Key issues include: the prevention of further contamination of recyclable wood; development of appropriate technology to identify CCA-treated timber at waste collection centres; guidelines for composting of waste timber treated with CCA; and, alternative products for applications such as playground equipment.

Other key acts and policies influencing wood waste management in New South Wales are listed in Appendix B.

### **3.2 Victoria**

Waste management in Victoria is dominated by policies established by both the EPA and EcoRecycle Victoria. In Victoria, product stewardship is embedded in the *Environment Protection Act 1970* and the *Towards Zero Waste* draft strategy, which sets out priority products for this approach.<sup>16</sup>

The aim is to improve the efficiency of raw material use, increase resource recovery rates, extend product life and manage toxic wastes.

Legislation subordinate to the *Environment Protection Act 1970* can take three forms:

1. State Environmental Protection Policies (SEPP's)
2. Waste Management Policies (WMP's)
3. Regulations

Legislation which influences waste wood management in Victoria is listed in Appendix B.

Further strategies for waste recovery and avoidance for CCA-treated wood in particular are not expected to come into effect until 2009/10. Victoria currently has no

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<sup>16</sup> <http://www.ecorecycle.vic.gov.au/www/default.asp?casid=2564>

direct legislation which regulates the use of waste wood. The limitations on the use of waste wood are brought about indirectly through state policies. All state policies regarding waste are enacted under the primary legislation of the *Environmental Protection Act 1970*. Subordinate legislation on waste includes State Environmental Protection Policies, Waste Management Policies and State Regulations. Industry standards associated with relevant manufacturing industries provide further guidelines on the utilisation of waste wood.

### **3.3 South Australia**

*South Australia's Environment Protection Act 1993* and *State Environment Protection Policy* established waste facilities and waste levies. However, it falls short providing incentives for waste minimisation. Further regulation of wood waste can be found in the acts and policies listed in Appendix B.

### **3.4 Queensland**

The *Environmental Protection Act 1994* establishes a general duty to reduce environmental impact and the requirement for waste management plans. The *Waste Management Strategy for Queensland 1996* was created as a framework for managing various waste streams. The *Environment Protection (Waste Management) Regulation 2000* further elucidated illegal activities under the *Environmental Protection Act* and incorporates various acts and regulations into the one document. This document is further supported by the *Environment Protection (Waste Management) Policy 2000* which defines acceptable waste management.

### **3.5 Tasmania**

The *Environmental Management and Pollution Control Act 1994* is the cornerstone act in preventing pollution and environmental harm. The *Solid Waste Management Policy* and the *Hazardous Waste Management Policy 1994* set out the recovery of building materials and product recovery by establishing salvage authority. Tasmania is also working on a draft EPR strategy set out in the document *Towards a Tasmanian Waste Management Strategy*.

### **3.6 Western Australia**

The regulatory authority for waste management in Western Australia is set out in the *Environmental Protection Act 1986*. The *Environmental Protection Regulations 1987* followed the *Environmental Protection Act* but more recent regulations such as *The Environmental Protection (Controlled Waste) Regulations 2004* (relate to the transport of waste) and the *Environmental Protection (Landfill Levy) Act 1998* (established the levy on disposal of waste to landfill) have recently added more strength to the regulation of waste management.

Discussion papers have recently been released on suggested EPR schemes, however, no formal scheme is currently in place.

### **3.7 Summary**

New South Wales and Victoria appear to have the most developed EPR schemes relating to wood wastes. Both states are proactive in convening working group meetings on a regular basis in order to encourage industry to take responsibility for making changes rather than waiting for those changes to be legislated.

Appendix B contains a comprehensive list of the relevant acts, policies and regulations on waste management and environmental protection relating to waste wood disposal and recycling for each of the states and territories.

Legislation of waste wood reuse and disposal in Australia is relatively immature when compared to regulations on the international scale. The next section explores international regulations pertaining to waste wood disposal and reuse and provides an interesting comparison of the state of regulation in Australia compared to the rest of the developed world.

## 4.0 Legislation Affecting Wood Waste Overseas

### 4.1 European Legislation

Most legislation affecting waste in Europe is derived at least partially as a result of Directives laid down by the European Union (EU). EU waste related legislation is created on three different platforms (Wasteline 2004):

- **horizontal legislation**, contains general definitions and principles of waste and establishes the overall framework for the management of waste
- **legislation on treatment options**, sets technical and operational standards for waste facilities
- **legislation of specific waste streams**, sets targets and other requirements for material specific components of the waste stream.

**Table 4.1. European Union waste legislation affecting wood waste**

Directive	Publication Year	Directive Number
<b>Horizontal</b>		
Directive on Waste (Waste Framework Directive)	1975	75/442/EEC
Directive on Hazardous Waste	1991	91/689/EEC
<b>Treatment</b>		
Directive on Integrated Pollution Prevention and Control	1996	96/61/EC
Directive on the Landfill of Waste	1999	1999/31/EC
Directive on the Incineration of Waste	2000	2000/76/EC
<b>Waste Stream</b>		
Directive on Packaging and Packaging Waste	1994	94/62/EC

#### 4.1.1 The Directive on Waste

*The Directive on Waste* sets out definitions and creates a framework by which waste management can be implemented by the EU. One of the main goals of the document is to create a uniform approach by EU member states regarding waste management. Certain requirements are laid out by the directive including (Wasteline 2004; EU 1975):

- the recovery of waste and use of recovered materials
- the prevention of environmental harm during recovery and disposal of waste
- the prohibition of uncontrolled and unregistered dumping
- an integrated waste disposal network
- provision of waste management plans
- allocation of the polluter-pays principle for treatment of waste.

The general purpose of the Waste Directive, as with most EU directives, is that each individual member country should implement the framework established within the directive in a manner appropriate for their individual country by an agreed-upon date. In other words, the EU waste directives should eventually be transposed into law by each individual member nation.

#### **4.1.2 The Directive on Hazardous Waste**

*The Directive on Hazardous Waste* establishes a list of properties which defines hazardous waste. It also establishes requirements in addition to those required for the *Directive on Waste* regarding mixing of hazardous waste, keeping of records and international movement of hazardous waste (Wasteline 2004; EU 1991). Waste CCA-treated timber was established as a hazardous waste by this directive as a result of *Commission Decision 2000/532/EC on 3 May 2000* (EU 2003).

#### **4.1.3 Directive on Integrated Pollution Prevention and Control**

*The Directive on Integrated Pollution Prevention and Control* was established to define the basic requirements by which major industrial waste sites are regulated. The purpose was to prevent discharges into water, air and soil as well as preventing waste, energy and water wastage and environmental accidents (Wasteline 2004; EU 1996). The directive regulates the metal production and processing industry, energy, minerals, chemical production and waste management industries and provides a basis for applying licenses and permits for the industrial installation.

#### **4.1.4 Directive on the Landfill of Waste**

*The Directive on the Landfill of Waste* provides stringent operational guidelines and technical requirements on waste to landfill in order to prevent negative effects on the environment (EU 1999). This directive contains some of the most over-arching legislation pertaining to waste management in the EU by setting strict goals for reduction of waste to landfill and highlighting issues (and bans) with specific waste streams (such as used tyres) (Wasteline 2004). Specific strategies for waste reduction include:

- within 5 years reduce biodegradable municipal waste (BMW) to 75% (by weight) of that produced in 1995
- within 8 years reduce biodegradable municipal waste (BMW) to 50% (by weight) of that produced in 1995
- within 15 years reduce biodegradable municipal waste (BMW) to 35% (by weight) of that produced in 1995

The directive also classifies landfill as hazardous waste, non-hazardous waste or inert waste and bans the disposal of hazardous and non-hazardous waste together after July 2004. It also requires the quantity and hazardous nature of landfill be reduced prior to disposal by pre-treatment and that any by-products (landfill gas) be utilised to produce energy or flared (Wasteline 2004).

#### **4.1.5 Directive on the Incineration of Waste**

*The Directive on the Incineration of Waste* was created to regulate emissions of harmful substances from incineration (EU 2000). The directive sets emission standards as well as operational conditions. For example, it requires all plants to keep the incineration or co-incineration gases at a temperature of at least 850°C for at least two seconds. The directive is a requirement for both new and old waste incineration plants from 28 December 2005. It covers all waste incineration and co-incineration plants which process more than 50 tonnes of waste per year and, therefore, does not include plants treating only wood waste below that volume.

#### **4.1.6 Directive on Packaging and Packaging Waste**

*The Directive on Packaging and Packaging Waste* was created to set targets for recovery and recycling of packaging waste (EU 1994). These include:

- 50-60% recovery of packaging waste
- 25-45% recycling, with a minimum 15% by weight for each packaging material.

This directive sets the groundwork for Extended Producer Responsibility of packaging and packaging wastes in Europe. Furthermore, the directive encourages minimisation of packaging (volume and weight) as well as the use of the recycled packaging materials for the production of other packaging or products.

### **4.2 UK Specific Legislation**

Each individual member EU country is responsible for creating policies and legislation which enact the EU Directives in a manner suitable for the individual country. There are, therefore, numerous other policies and interpretations of EU directives relevant for each member country.

#### **4.2.1 Directive on Waste**

The *EU Directive on Waste* has resulted in the creation of several acts in the UK in order to implement the EU Directive in UK law. The following legislation was created as a result of the original *EU Directive on Waste (75/442/EEC)* (Wasteline 2004).

- *The Environmental Protection Act 1990.*
- *The Control of Pollution (Amendment) Act 1989*
- *The Waste Management Licensing Regulations 1994*
- *The Controlled Waste (Registration of Carriers and Seizures of Vehicles) Regulations 1991.*

The UK legislation enables the Environment Agency to act as a licensing authority (Wasteline 2004). It also allows the Environment Agency to police compliance with the legislation and operating conditions on waste management sites. The

*Environmental Protection Act* also introduces the concept of “Duty of Care” with regard to importation, production, carrying, storing, treating and disposing of waste. This requires the authorised person to take “all reasonable measures” to prevent illegal activities in managing the disposal of waste only by authorised persons with a written description of the waste.

#### **4.2.2 Landfill Regulations**

The UK has implemented the *EU Directive on the Landfill of Waste (1999/31/EC)* through the introduction of the *Landfill (England and Wales) Regulations 2002* (Statutory Instrument 2002 No. 1559). This regulation sets operational guidelines for landfills and also sets deadlines for compliance (July 2009) (Department for Environment, Food and Rural Affairs 2004).

The UK is required (by the *EU Landfill Directive*) to reduce municipal biodegradable waste to landfill to 35% of the 1995 levels by 2020.<sup>17</sup> SITA UK estimates the current amount of waste sent for disposal to landfill is at 80% of 1995 levels.<sup>18</sup>

Consultation on the landfill regulations is ongoing and it is expected that further regulations will come into force in 2005 which will redefine the Waste Acceptance Criteria (WAC) parameters on limit values for landfills as well as set the date for bans on land filling non-hazardous waste and the pre-treatment of non-hazardous waste (DEFRA 2004).

#### **4.2.3 The Landfill Tax**

In the UK, one of the main drivers in reducing the amount of waste disposed of to landfill is the UK landfill tax, introduced in October 1996 (Statutory Instrument 1996 No. 1527). This tax is on a sliding scale dependent on the weight of the waste as well as whether it is biodegradable or inert (Magin 2001). The tax is currently charged at two rates:

- £2 per tonne for inert waste
- £15 per tonne for active waste

The landfill tax for active waste will increase by £3/tonne from 2005-2006. The landfill tax is paid in addition to the cost of disposal (landfill fees) and generates approximately 500 to 600 million pounds of revenue per year. Some of the income generated from the landfill tax (about 6.8%) is invested in environmental projects which are applied for through the Landfill Tax Credits Scheme. However, this scheme will be discontinued and the Waste Resources Action Programme (WRAP), a unit of the Department for the Environment, Food and Rural Affairs (DEFRA), will in future be responsible for spending the generated tax on public awareness campaigns, local projects and demonstration waste networks.

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<sup>17</sup> <http://www.sita.co.uk/our-environment/legislation>

<sup>18</sup> <http://www.sita.co.uk/what-we-do/landfill/landfill-tax>

The cost of landfill in the UK is generally about £20-30 per tonne (AUD \$50-75), including the tipping fee and the Landfill tax.

#### **4.2.4 The Packaging Waste Regulations**

The UK has taken the *EU Packaging and Packaging Waste Directive* and converted it into national law by the development of the following legislation (Wasteline 2004):

- *Producer Responsibility Obligations (Packaging Waste) Regulations 1997*
- *Packaging (Essential Requirements) Regulations 1998*

The regulations require 50% of packaging waste be recovered or recycled. Wood packaging was added as a material-specific packaging material in 2000, and has a 21% recovery target by 2008, compared with paper for example, which has a recovery target of 70% by 2008.

The *Producer Responsibility Regulations* require businesses with an annual turnover of more than £2 million or who handle more than 50 tonnes of packaging annually to comply with the Packaging Waste regulations. This includes registering with the Environment Agency, meeting recovery targets, certifying they meet recovery targets, and informing the public of their recovery and recycling activities. Further requirements of *The Packaging (Essential Requirements) Regulations* include minimisation of packaging volume and weight, re-design of packaging to maximise recovery and limits on heavy metals in packaging.

#### **4.2.5 Other Legislation**

There are various other regulations and legislation effecting the recycling and land filling of wood waste in the UK. International treaties, such as the Kyoto protocol, may influence landfilling of wood waste because of its contribution to methane emissions as it decomposes and, under the international commitment to reduce greenhouse gasses, regulations on allowable methane released from landfill may either reduce the allowable waste wood landfilled or require capture of the methane and its use for energy production.

The increasing pressure to conform to sustainable development initiatives may also influence the types of timber-based products used in building construction and the recycling and reuse of those products at the end-of-lifecycle (Department of the Environment, Transport and Regions 2000).

### **4.3 Germany Specific Legislation**

The overriding waste management legislation in Germany is “Kreislaufwirtschafts – und Abfallgesetz” (*Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal*) from 7 October 1996 (Merl 2001). This law was enacted in accordance with EU waste management legislation. The law defines “waste”, provides for producer responsibility of waste and creates



obligations which enforce a closed substance cycle.<sup>19</sup> The German Government has issued a further 7 statutory ordinances and one guideline which set limits for classification of landfill waste which fall under the waste law.

### 4.3.1 Ordinance on Management of Waste Wood

The “Altholz-Verordnung” (*Ordinance on the Management of Waste Wood*) was enacted on 1 March 2003.<sup>20</sup> The ordinance classifies wood waste as residual wood from industrial processes and wood products which have become waste. It identifies the current technologies for the remanufacture of wood waste into useable products, such as production of timber composite products and as a fuel source. It then states the requirements for recycling and energy recovery from waste wood, allowing the waste holder free choice as to which recovery route to take. It breaks wood waste into four categories (Merl 2001).

- A I - untreated wood
- A II – treated wood without halogenorganic compounds
- A III – treated wood with halogenorganic compounds
- A IV – wood contaminated with wood preservatives

The ordinance further describes particular contaminants and their maximum allowable limits:

**Table 4.2. Maximum allowable quantities of contaminants allowed by the German Waste Wood Ordinance**

Contaminant	Limit (mg/kg)	Contaminant	Limit (mg/kg)
Arsenic (As)	2	Lead (Pb)	30
Cadmium (Cd)	2	Mercury (Hg)	0.4
Chromium (Cr)	30	Fluorine (F)	100
Copper (Cu)	20	Chlorine (Cl)	600
PCP	3	Creosote	5

Further regulation of the individual wood waste categories is described by more specific acts and ordinances:

<sup>19</sup> <http://www.un.org/esa/earthsummit/gmny-cp.htm>

<sup>20</sup> [http://www.bmu.de/files/wastewood\\_background.pdf](http://www.bmu.de/files/wastewood_background.pdf)

**Table 4.3. Specific acts and ordinances regulating wood waste in Germany**

<b>Recycling Path</b>	<b>Governance</b>
Energy recovery	Federal Emission Control Act
PCB disposal	PCB/PCT Waste Ordinance
Manufacture of active carbon/industrial charcoal	Federal Emission Control Act and Seventeenth Ordinance on the Implementation of the Federal Emission Control Act
Production of synthetic gas	Federal Emission Control Act and Seventeenth Ordinance on the Implementation of the Federal Emission Control Act
Derived timber products	Annex IV, Article 6, Ordinance on the Management of Waste Wood

The *German Ordinance on the Management of Waste Wood* is the first of its kind in any EU member state and, as such, stands as a pilot ordinance for specific material regulation.

### **4.3.2 Industry Packaging Waste Reduction**

In 1989 the German government proposed a law which gave producers extended liability for their product packaging. The proposal required producers to take back all transport and sales packaging. As a result, in 1990, about 600 companies joined together and formed the “Duales System Deutschland” (DSD) (EPA Germany). The “dual” collection system operates by distributing a yellow packaging waste bin to all German households (excepting Munich). Householders dispose of consumer packaging which carries the ‘Green Dot’ symbol in this container. A ‘Green Dot’ signifies that the company is a part of the DSD system and pays a levy to finance the collection and recycling of their package.

The waste management companies which collect the ‘Green Dot’ waste are responsible for the recycling of the packaging waste. Because there are not enough recycling facilities in Germany to handle the volumes of packaging waste collected by the DSD system, much of the packaging waste is exported to other countries, such as China, Pakistan and Indonesia, which have the capacity to recycle the large volumes of waste. In the first few years of the DSD program, some of the companies overseas which accepted the packaging waste were not legitimate and the waste was found to be landfilled rather than recycled. However, the DSD system now has a strict system in place to ensure exported waste is recycled by legitimate businesses and is not illegally dumped.

The DSD program also has strict recycling targets which must be met by the members of the system.<sup>21</sup> The targets have been set by material specification, such as board, paper, plastics, aluminium, tinplate and composites. The targets have been relaxed in recent years because of a lack of recycling capacity and resultant stockpiles of materials waiting to be recycled. Another major issue is that recycling technologies

<sup>21</sup> [http://www.informinc.org/xsum\\_greendot.php](http://www.informinc.org/xsum_greendot.php)

for some of the collected materials do not even exist. Those materials are also being stockpiled.

#### **4.4 Wood Waste Legislation in the United States of America**

The federal government is responsible for environmental legislation in the United States and together with the EPA, the environmental regulatory body, creates national minimum standards to be respected by all states. The states however, retain substantial independent authority to issue environmental protection laws applicable to their citizens and residents and are free to enact stricter environmental regulations. States are responsible for issuing permits, monitoring and enforcement related to waste management. The following national legislation aims to reduce waste and pollution:

- *Solid Waste Disposal Act*
- *The Resource Recovery Act*
- *Pollution Prevention Act*
- *Resource Conservation and Recovery Act*
- *Clean Air Act*
- *Clean Water Act*

The Environmental Protection Agency (EPA) has been authorized to monitor solid waste generated in the United States since the passage of the *Solid Waste Disposal Act of 1965*. The primary statute governing solid waste in the USA is the *Resource Conservation and Recovery Act (RCRA)*. The regulations developed provide a framework for the management of wastes that may cause an unacceptable risk to the environment and human health when mismanaged.

*RCRA* defines a subset of solid wastes as hazardous wastes. It also provides specific rigorous requirements for managing hazardous wastes and it is the generator's responsibility to determine whether its solid waste is hazardous (Townsend *et al.*). The US EPA has published several documents that provide an overview of the requirements of *RCRA* (US EPA 2000).

Solid Waste Management is governed by *Subtitle D of RCRA*. This primarily affects state and regional solid waste management authorities, and includes requirements for comprehensive solid waste planning as well as encouragement for recycling and recovery.<sup>22</sup> There seems to be, however, an increased likelihood that *RCRA* will be altered to address the environmental impacts of industrial solid waste. *RCRA* also addresses the "cradle to grave" requirements for hazardous waste from the point of generation to disposal, as well as containing less restrictive requirements for non-hazardous solid waste.

The *Land Disposal Program Flexibility Act of 1996* amends certain sections of the *Solid Waste Disposal Act*. In particular, this Act makes adjustments relative to land disposal restriction (LDR) provisions, and to ground water monitoring at solid waste

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<sup>22</sup> <http://www.chemalliance.org/Handbook/background/back-rcra.asp>

landfill units. The legislation also includes various technical corrections to the *Solid Waste Disposal Act*.<sup>23</sup>

The *Federal Hazardous and Solid Waste Amendments* are the 1984 amendments to the *RCRA* that required the phasing out of land disposal of hazardous waste. Some of the other mandates of this strict law include enforcement authority for EPA and more stringent hazardous waste management standards.

The *Pollution Prevention Act (PPA)* recognised that pollution should be prevented or reduced at the source wherever feasible; pollution that cannot be prevented should be recycled in an environmentally sound manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally sound manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.<sup>24</sup>

Additional federal regulations include *RCRA*, which classifies wood waste as a non-hazardous solid waste; the *Clean Air Act*, which regulates wood waste combustion; and the *National Energy Policy Act*, which provides incentives for manufacturers to use wood as a bio-fuel.<sup>25</sup>

Although the *1990 Clean Air Act* is a federal law covering the entire country, the states do much of the work to carry out the Act. A state air pollution agency holds a hearing on a permit application by a power or chemical plant or fines a company for violating air pollution limits. Under the Act, EPA sets limits on how much of a pollutant can be in the air anywhere in the United States. However, the law allows individual states to have stronger pollution controls, but states aren't allowed to have weaker pollution controls than those set for the country.

#### **4.4.1 National Programs**

To divert wood from landfills, respond to the needs of wood products users, and help ensure an abundant fibre supply, the America Forest & Paper Association (AF&PA) developed the National Wood Recycling Directory in cooperation with the USDA Forest Service.

This directory contains a nationwide listing of over 700 wood waste centres which produce new products from recovered wood. Products created include landscaping materials, pallets, plywood, hog fuel, engineered wood, particleboard, furniture, absorbents, flooring, and paper.

The intention of the directory was to help individuals, groups, communities, builders, re-modellers, and demolition contractors identify receiving sites for recovered wood. This helps to avoid costly landfill fees and better use existing resources.

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<sup>23</sup> <http://www.eh.doe.gov/oepa/laws/ldpfa.html>

<sup>24</sup> <http://www.eh.doe.gov/oepa/laws/ppa.html>

<sup>25</sup> [http://www.wasteage.com/mag/waste\\_wood\\_waste\\_processors/](http://www.wasteage.com/mag/waste_wood_waste_processors/)

The American Forest & Paper Association organised the Wood Recovery Alliance in 1999 to improve the recovery of used and scrap wood. The Alliance advocates for appropriate policy and regulatory positions, addresses quality issues, and shares data and research information. The Alliance is represented by a group of over two dozen businesses, government agencies, and organisations committed to the recovery of used and scrap wood.

While federal location and design requirements have been circulated for municipal solid waste (MSW) landfills, industrial waste and construction and demolition (C&D) debris disposal are regulated at the state level, the regulatory requirements vary dramatically among states.

#### 4.4.2 State Legislation

In the US, states have the option to develop more stringent regulations than that required under federal rules. Californian rules related to hazardous waste characterisation are an example of how treated wood products can be characterised as a hazardous waste. In addition to using the toxicity characteristic leaching procedure (US EPA 1996) to determine hazardous waste status, California employs a method known as the Waste Extraction Test.

These approaches in California resulted primarily as a result of the *1989 Californian Integrated Waste Management Act*, which established mandated goals for solid waste diversion from waste disposal; 50 per cent diversion to be achieved by 2000 and subsequent years thereafter. The state commitment to this target and the possibility of severe penalties including fines of up to \$10,000 per day have motivated industry to strive to comply.<sup>26</sup>

The *Integrated Waste Management Act* also established the Californian Integrated Waste Management Board (CIWMB), an organisation mandated to develop and implement numerous strategic programmes related to waste and to offer advice on the development of waste related legislation.

For instance, model legislation has just been introduced in California to ban the production and use of the three heavy-duty wood preservatives, chromated copper arsenate (CCA), pentachlorophenol (penta), and creosote. This requires the disposal of wood waste in accordance with the regulations adopted by the Department of Toxic Substances Control governing universal waste.<sup>27</sup>

However, CIWMB has indicated that it would like to “move away from mandates and penalties towards viable markets that stand on their own” and is looking to “embrace European models of product stewardship” and work with manufacturers towards more environmentally preferable products.

California landfill tipping fees average about US\$30 per tonne. Such relatively low disposal costs act as a disincentive to reuse and recycle wood because it is cheaper to

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<sup>26</sup> [http://www.green-alliance.org.uk/ CPPWCalifornia\\_pdf\\_media\\_public.aspx](http://www.green-alliance.org.uk/ CPPWCalifornia_pdf_media_public.aspx)

<sup>27</sup> [http://www.beyondpesticides.org/wood/resources/SB202.Romero\\_CA.pdf](http://www.beyondpesticides.org/wood/resources/SB202.Romero_CA.pdf)

transport wood waste to a landfill than to separate, process, and transport it to markets.<sup>28</sup>

California is not the only state looking into wood waste issues. More than 60 percent of the states regulate wood waste, according to a Solid Waste Association of North America project, funded by the Department of Energy's National Renewable Energy Laboratory. State governments are developing incentives that may fuel waste-to-energy (WTE) growth. In 1998, five states enacted legislation requiring that some percentage of energy sold within the states be generated from renewable energy sources, such as WTE.

Twenty states in the USA ban wood waste at solid waste disposal facilities, or plan to do so in the immediate future. An additional five states allow their counties and municipalities to ban wood waste disposal. Also, some states include wood waste materials in their mandated recycling goals.<sup>29</sup> (For further state recycling laws, see Appendix C).

For example, Massachusetts is considering a landfill ban on wood, separating it from the waste stream for recycling. With landfill capacity decreasing, such a ban may be necessary. The Environmental Resource Return Corporation (ERRCO) views this regulation as a business opportunity even though tipping fees would increase substantially.

It is also important to note that while it is legal under federal solid waste rules to dispose of treated wood in a lined landfill, landfill operators are not required to accept the material. Many states, including Florida, Texas and California, do not require liners for C&D debris landfills. The legality of treated wood disposal in unlined C&D debris landfills depends on the state. Certain states forbid the disposal of treated wood products in C&D debris landfills, while others allow it.

## **4.5 Summary**

The international regulations pertaining to environmental protection and waste management suggest the regulation of waste, and waste wood, will increase in future. Although federal governments have overriding jurisdiction over such legislation, individual states or countries have the ability to enact much stricter regulations. Many, such as Germany, have chosen to exercise that power and regulate individual waste streams, such as waste wood.

It is likely that Australia will follow suit with stricter regulation of waste in the future, applying practices established in Europe, the UK and the USA. How the tightening of waste regulations may influence waste wood is yet to be seen, but the discussion in the previous section suggests that waste wood is a waste stream of concern and will likely have stricter regulations applied in respect of both recycling and disposal targets.

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<sup>28</sup> <http://www.ciwmb.ca.gov/Markets/StatusRpts/WoodWste.htm>

<sup>29</sup> [http://www.wasteage.com/mag/waste\\_wood\\_waste\\_processors/](http://www.wasteage.com/mag/waste_wood_waste_processors/)

## 5.0 Contamination Control and Sorting Technologies

Contamination control and sorting is an important process in the utilisation of waste wood. Sorting enables the removal of “gross contamination” which can interrupt the recycling process as well as enabling some sort of risk management in the utilisation of waste wood for industries dependent on quality parameters (such as the potential for creating pollution from burning contaminated waste wood for energy).

Various technology options exist for facilitating the utilisation of contaminated waste wood. This contamination can stem from many sources, but is most easily broken down into two broad categories, solid contaminants (soil, metals) and chemical contaminants (preservatives). The table below lists a few examples of contaminants which fit each of the categories.

**Table 5.1. Solid Contaminants and Chemical Contaminants of Waste Wood**

<b>Solid Contaminants</b>	<b>Chemical Contaminants</b>
Soil	Preservatives
Plastics	Lead
Metals	Waxes
Glass	Oils
Paper	

One option which enables wood waste diverted from landfill (such as C&D wood waste) to be utilised, is to separate the contaminated wood waste from the “clean” waste. The following section discusses the issues and technologies behind separation of contaminants from waste wood.

### 5.1 Contaminants

The primary contaminants of waste wood are similar to those in many manufacturing industries, namely unwanted solids. These contaminants may be either mixed with or imbedded in the wood (eg metal nails). They include, but are not limited to:

- Soil
- Stones
- Metals
- Plastics
- Glass
- Paper
- Rubber
- Tyres

There are also many chemicals which are considered contaminants, including the following (Asari *et al.* 2004):

- Copper chrome arsenic (CCA)
- Creosote (polycyclic aromatic hydrocarbons)
- Chlorophenols

- Polychlorinated dinenzo-*p*-dioxins
- Dibenzofurans
- Organochlorine insecticides (drin and chlordane compounds)
- Lead
- Boron

Other contaminants of concern, particularly to the panel industry and energy production are (Baker 1991):

- Phenol formaldehyde resin
- Urea formaldehyde resin
- Linseed oil
- Alum
- Sulfuric acid
- Wax
- Dyes
- Inks
- Heavy Metals
- Extenders
- Adhesives
- Plastic overlays
- Other resins
- Pigments (including components of lead, titanium, zinc, iron and cadmium)
- Urethanes
- Oils
- Inorganic materials
- Clay fillers

The source of heavy metal contamination, in particular, is varied and can include the following:

**Table 5.2. Potential sources of heavy metal contamination in wood waste (taken from Irle *et al.* 2004)**

<b>Copper</b>	<b>Lead</b>	<b>Chromium</b>	<b>Cadmium</b>
electrical wire	paint	stainless steel	ceramics
brass fittings	old water pipes	audio tapes	batteries
coins	ceramic ware	health supplements	metal coatings
plumbing	coloured newsprint	electronics	pigments (plastics)
kitchen ware	battery casings	circuit boards	cigarette smoke
garden products	lead acid batteries	leather goods	fertilizers
treated timber		chromium plating	vulcanized tyres
		paints	

Some of the contaminants are recognised by the *Industry Standard WPIF/UKFPA/1-2000* and maximum allowable quantities have been declared for manufacture of particleboard.



**Table 5.3. Maximum allowable quantities of contaminants allowable in particleboard (Industry standard WPIF/UKFPA/1-2000)**

<b>Contaminant</b>	<b>Limit (mg/kg)</b>	<b>Contaminant</b>	<b>Limit (mg/kg)</b>
Arsenic	25	Lead (pb)	90
Cadmium (Cd)	50	Mercury (Hg)	25
Chromium (Cr)	25	Fluorine (F)	100
Copper (Cu)	40	Chlorine (Cl)	1000
PCP	5	Creosote	0.5

The presence of contaminants can render an entire batch of timber being unsuitable for recycling. Therefore, industries use specific methods and equipment to remove both solid and chemical contaminants.

## **5.2 Removal of Solid Contaminant Materials**

There are a variety of approaches for the removal of contaminant materials such as metal, glass and plastic, ranging from manual sorting to automatic separation through screening and sifting (Warnken 2001).

### **5.2.1 Gross Contamination Removal**

Within loads of wood waste there can be a range of other waste materials that could disrupt the size reduction process or contaminate the end product from either an aesthetic or chemical perspective. For example, sheet glass, metal support beams, large pieces of polystyrene, plastic shrink wrap and bricks.

For these ‘gross contaminants’ separation options include mechanical assisted sorting (excavator with grab), hand sorting on hard stand after unloading and hand sorting off conveyor belts in sorting cabins (usually after a rough grinding to, say, a minus 300 mm product). These methods, though labour intensive and costly, can usually be justified by recovery of higher value reusable timbers.

### **5.2.2 Metal Contamination Removal**

Metal contamination contributes to excessive wear on size reduction machinery (hammer mills, tub grinders and shredders). Large metal pieces, like railway ties, have the potential to damage components and cause excessive down-time. Ferrous metals are removed with electromagnetic separation, while non-ferrous metals are removed using eddy current separation.

Electromagnets can take the form of an overhead belt magnet or a magnetised drum in the out-feed of a wood waste grinder. However, if the magnet is too strong it will pull out wood pieces with fastenings still attached. A two staged magnetic separation process can be used to overcome this, with a primary magnet to remove large pieces of tramp iron after primary size reduction, and a more powerful secondary magnet to remove smaller pieces of metal after subsequent processing.

Eddy current separation operates with powerful magnets spun at revolutions greater than 3000 rpm to produce an “eddy current”. The eddy current reacts with non-ferrous metals, creating a repelling force on the non-ferrous metal. Some grades of stainless steel can also be separated with this technology.

### **5.2.3 Plastic and Paper Contamination Removal**

Wind sifting is used to remove lighter contaminants such as paper and plastic. These materials may not upset the performance of the recycled wood product, for example plastic in landscape mulch, but can greatly impact the physical appearance of the product.

During wind sifting a steady pressure of air lifts the lightweight materials away from the wood chips, leaving the heavier wood particles behind.

### **5.2.4 “Hard Core” Contamination Removal**

Hard core materials refer to items such as bricks, concrete, masonry, dirt, ceramics and glass. They are inert, but have the potential to disrupt wood waste processing and can cause down stream problems, especially where recovered wood is used to manufacture particleboard or is used as a fuel.

A variety of screening configurations are used to remove these materials, including fractionators, disk screens, vibrating screens and trommels. These machines rely on the hard core contaminants being less than 5 mm in size, and so are usually employed at the end of a processing line.

Other options for removal prior to processing, or immediately after an initial size reduction, include water baths and ballistic separation. Water baths rely on wood floating, leaving denser materials on the bottom of the bath. They can be water intensive and increase the moisture content of the recovered wood, which may not suit some end uses. Ballistic separation also relies on material density differentiation and must be finely tuned to ensure that high volumes of wood are not also removed.

## ***5.3 Removal of Chemically Contaminated Wood Waste by Wood Waste Scanning and Sorting***

Currently there are no quick and easy methods to identify the presence of chemically preserved timbers in recycled waste wood. Visual sorting poses numerous challenges including variable accuracy due to dirty or weathered wood, and operator training. In addition, there are a number of occupational health and safety issues associated with manual sorting techniques. The use of chemical indicators, such as chrome azurol, can be time intensive and ultimately relies on operator skill and training. Thus the development of automatic on-line sorting technologies to distinguish treated and untreated timber is becoming a high priority.

Irle *et al.* (2004) conducted a very comprehensive study of contamination levels in recycled timber for WRAP in the UK. They consistently found that contamination levels decreased as wood particle size increased. This indicates that there is potential to increase the success of an in-line scanning system for contaminants by scanning larger pieces of timber, rather than woodchips.

Irle *et al.* (2004) also found that the distribution of contaminants was irregular with a very high co-efficient of variation. This could possibly be due to the distribution pattern of contaminants in waste wood. As an example, perhaps just one piece out of every hundred pieces of waste wood is contaminated with CCA. A randomised testing technique may or may not happen to pick that one piece of timber during the test process. If that piece of timber is found, then the levels of CCA would be quite high for that sample when compared to the levels in the other (non CCA-treated) waste timber. This can result in irregular distribution of contaminants and high co-efficient of variations.

These workers also found that, because of the irregular distribution of contaminants, and because of the strict levels of allowable contamination (Industry Standard WPIF/UKFPA/1-2000), other sources of contamination, such as a small piece of copper wire, also resulted in high contamination levels with resulting high co-efficient of variations. This confirms the importance of high quality pre-screening of waste wood using conventional screening methods to remove other potential sources of contamination such as metals.

Several techniques to identify chemical contamination and improve the separation of treated and untreated wood have been investigated. Their potential to be developed into commercially available products is reviewed.

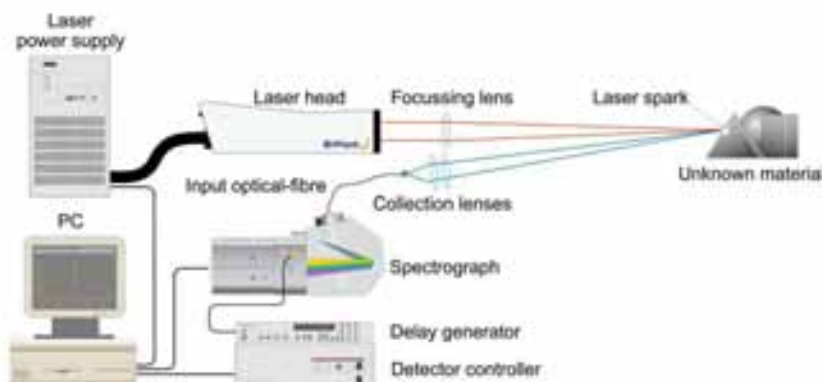
### **5.3.1 Laser Induced Breakdown Spectroscopy (LIBS)**

Laser-induced breakdown spectroscopy (LIBS), as the name implies, uses a laser to ablate and ionise the elemental components of a target sample into a plasma or laser spark. The plasma generated by the laser emits light in the form of discrete spectral lines. Each element has a set of unique spectral lines and the appearance of a line in a LIBS spectrum indicates the presence of the element in the target sample. The intensity of the spectral line depends, among other things, on the quantity of the element present. LIBS is, therefore, a method for the simultaneous multi-elemental analysis of solids, liquids and gases, and is capable of identifying a wide range of elemental constituents.

The LIBS technique has been broadly applied to the on-line analysis of ore in the mineral industry, to measure the composition of molten iron and steel and for the detection of CCA preserved timber in waste woods (Rochester 2004, Uhl *et al.* 2001).

A LIBS system is generally made up of a pulsed laser, light collection and transfer optics, a method for spectral discrimination (spectrograph), timing electronics and a detector, see Figure 5.1. An important aspect of any LIBS measurement is the timing of the measurement. The detector is usually time gated so that the measurement of the

light emitted by the plasma can be delayed until some time after the laser pulse and the initial bright flash of the plasma has occurred (typically about a microsecond).



**Figure 5.1. Schematic diagram for LIBS equipment (After Rochester 2004)**

Field trials of a LIBS system for identification of CCA treated timber at a construction and demolition waste recycling facility in Sarasota County Florida USA (Solo-Gabriele *et al.* 2001, Moskal & Hahn 2002) demonstrated successful discrimination between CCA treated and untreated timbers in an industrial setting. Moskal & Hahn (2002) reported accuracies of between 92 & 100% for the LIBS based analysis of the timber samples. Factors including the age or weathering of the samples, the presence of rot and the wetness of the samples diminished the accuracy of discrimination. Their LIBS system used a Nd:YAG laser with an output pulse energy of 200mJ per pulse and a pulse repetition rate of 2 pulses per second. The measurements also demonstrated the ability of LIBS to identify and discriminate wood coatings such as paints and stains.

Uhl *et al.* (2001) tested a LIBS system manufactured by LLA Instruments GmbH specifically for application to the wood processing industry. The study reported measurements of a range of metal species including copper, chrome, arsenic, tin, lead, mercury and boron. The article includes a table detailing element specific detection limits in wood for these metals at the ppm level (Uhl *et al.* 2001). The laser system used was a flashlamp pumped Nd:YAG laser with a pulse rate of 10 pulses per second. Better discrimination and detection limits were found for multiple laser shots i.e. signal averaging.

Flashlamp pumped Nd:YAG lasers are high pulse energy moderate average power devices capable of pulse rates up to a maximum of 30Hz. The rate at which a laser can be pulsed will ultimately determine the speed at which individual target samples can be discriminated and sorted. New generation Nd:YAG lasers are available which have lower peak pulse energy available at a much higher pulse rate. These diode pumped all solid-state devices potentially enable the sorting of a variety of materials directly on-line at moderate to high tonnage throughput rates.

Advantages of LIBS include:

- Simple and rapid analysis
- Little or no sample preparation is necessary
- Simultaneous multi-elemental analysis

- Versatile sampling of solids, gases or liquids
- Small sample sizes of material (~0.1µg to 1 mg) and practically non-destructive.
- Ability to detect Copper Chrome Arsenic (CCA)
- Allows analysis of ceramics and superconductors, materials which are hard and difficult to dissolve or digest.

Disadvantages of LIBS include:

- Detection limits aren't as good as established solution techniques
- Increased cost and system complexity
- Precision range between 5-10% that is dependant on the sample and properties of the laser
- Difficulty in obtaining suitable standards
- Some preservatives may cause problems with detection
- Calibration is required on a weekly basis
- OHS issue in regard to the high energy laser (damage to eyes)

### 5.3.2 X-Ray Fluorescence (XRF)

X-ray Fluorescence (XRF) is a nondestructive method for the elemental analysis of solids and liquids. The method exposes the sample to an intense x-ray beam, which is absorbed by the sample and then re-emitted at longer X-ray wavelengths as a result of the interaction. These fluorescence x-rays are characteristic of the elements inside the sample and can be analysed to determine which elements are present within the sample. X-ray analysis can be used to carry out both qualitative and quantitative analysis (Homan and Militz).

The elements commonly detected range from sodium to uranium, with lighter elements such as Boron and Fluorine not being reliably detected. XRF is a bulk analysis technique with the depth of sample analysed varying from less than 1 mm to 1 cm depending on the energy of the emitted x-ray and the sample composition.

The technique is well known and has a long track record of being used to detect preservatives. Hand-held devices have been used for the sorting of CCA-treated wood in America. These devices are also being used in sorting scrap metal and for the detection of lead in paint. The handheld equipment would cut down on detection time when compared with a conveyor system.

Advantages of XRF include:

- No sample preparation required
- Non-destructive analysis
- Analysis time between 30-120 seconds which is dependent upon sensitivity level
- Portable, as it is available as a handheld device
- Durable (equipment)
- Inexpensive

Disadvantages of XRF include:

- Small danger of radiation exposure
- Only detects elements with an atomic number higher than sodium
- Can confuse a combination of Magnesium and Iron with Chromium
- Radioactive source needs to be changed every 18-24 months

### 5.3.3 Ion Mobility Spectroscopy (IMS)

Ion Mobile Spectroscopy involves ionising a gas phase analyte using a small radioactive source. The ionized sample drifts through the cell under the influence of an electrostatic field. A shutter grid is biased electrically to either block the ions or allow them to pass through. This shutter grid is pulsed to periodically allow the ions into the drift region. There they begin to separate out based on their size and shape while flowing counter to a drift gas flow, which is introduced at the end of the drift tube (Junsun Instruments). The speed at which the ions drift is used to determine the chemical composition of the sample. The technique works best for polar or lightly polarisable molecules.

IMS has been previously used to identify organic preservatives in wood. The sampling technique involves heating a sample of wood to approximately 150°C and performing IMS on the released gas. The detection time for the test is relatively quick, with results being available within a minute. However, when IMS was tested for fast on-site assessment of contaminants in waste wood, it was found that about four minutes were needed to assess each sample (Schröder *et al.*).

For IMS to be used, it requires different wood types and preservatives to be programmed into the computer so that the preservatives can be recognised when present.

Advantages of IMS include:

- Detection level down to 0.001 mg/kg, can be very accurate
- Proven record in the identification of preservatives in wood
- Not effected by different wood types
- Portable, available as a handheld device
- No sample preparation required
- Quick analysis time
- Low operating costs

Disadvantages of IMS include:

- Extensive staff training required in order to interpret results
- Analysing results can be difficult
- Only detects organic compounds

### 5.3.4 Electronic Nose (EN)

The Electronic nose uses specially chosen ceramic sensors to detect substances. The wood sample has to be sealed in a vial to enable the sensor to “smell” the gaseous

vapours emitted from the wood sample (Rochester 2004). Hand-held versions of the EN are currently being developed.

Advantages of EN include:

- Recognises both organic and inorganic compounds
- Can detect more than one compound at a time

Disadvantages of EN include:

- Different wood types for different background smells which can confuse the EN
- Sample has to be cut and put in a vial for testing
- Slow analysis time

### **5.3.5 Near Infrared (NIR)**

Near Infrared (NIR) refers to the region of light immediately adjacent to the visible range, falling between 750 and 3000 nanometres. When the substance in question has been exposed to NIR, the bonds within the molecules become excited and the chemicals that are present can be determined.

NIR has been used to detect both organic and inorganic preservatives in wood. Interactions between inorganic salts of preservatives and the wood cell walls alters the signal that the matrix emits and therefore inorganic wood preservatives could be detected. There are portable NIR spectroscopy devices available, which are rapid and relatively low cost.

As well as analysing the chemical properties, the physical properties of the wood can be measured using NIR technology. The strength and stiffness of softwoods and hardwoods can be predicted from their NIR spectra as well as information on density and the orientation of the wood fibres (Kelley *et al.*).

Identification of contaminants in waste wood have been successfully done using NIR. However, results varied because of moisture differences in the wood and differences in surface texture (Feldhoff *et al.* 1998).

Advantages of NIR include:

- Little if any preparation time
- Rapid analysis & low cost
- Detects both organic and inorganic compounds
- Minimal training required
- Rugged equipment/no recalibration required
- Can perform quantitative and qualitative analysis

Disadvantages of NIR include:

- Possible issue with high moisture content
- The surface may need to be clean and smooth
- Sample may need to be pressed onto the equipment

### **5.3.6 Liquid Phase Biosensor**

Liquid Phase Biosensor uses bioluminescent bacteria to detect contaminants. The preservative must first be extracted from the wood, after which it is added to a kit containing the bioluminescent bacteria. The luminescence is measured using a luminometer. The more toxic the test compounds, the less the flow from the bioluminescent bacteria because the toxic compounds disrupt the metabolic activity of the bacteria.

Advantages of Liquid Phase Biosensor include:

- Can detect low levels of contaminant
- Analysis in short time period
- Luminometer is a hand-held device
- Low cost test kit

Disadvantages of Liquid Phase Biosensor include:

- The preservative must first be extracted from the wood sample for testing
- Cannot detect individual type of preservative, only relative toxicity

## **5.4 Summary**

There are numerous technology options available for utilising waste wood and diverting it from landfill. One of the main areas of technology advancement is in the sorting and scanning area, as is it internationally recognised that one of the overriding issues with using waste wood is the ability to remove contamination and guarantee quality of the wood waste material. Several technologies are presented which are able to scan wood waste for contaminants, such as CCA-treated timber. Most of these technologies are still in the development stage, particularly for use as an on-line detection unit on a conveyer belt or similar.

A major issue surrounding the use of these technologies as on-line systems is that they lose some reliability when required to work at production speeds. However, further investment in the technologies will see these barriers overcome.



## 6.0 Technologies for Heat and Energy Production from Waste Wood

### 6.1 Energy Recovery

As environmental and public pressure increases attention on the utilisation of finite resources for energy production, various renewable energy options become increasingly popular. One of those options is the utilisation of waste wood as a fuel source, either by itself or mixed with other fuel sources. There are also increasing numbers of public policies which encourage the use of waste materials for energy production, such as Renewable Energy Credits.

The recovery of energy from wood may take two separate paths; thermal recovery/heat production and energy production. Each of these uses distinctively different technologies and can operate on very different scales.

### 6.2 Heat – Thermal Recovery

Utilisation of wood for heat production is perhaps one of the first technological advances in the definitive history of mankind. Given that approximately 50% of timber grown worldwide is used for heating and cooking purposes (fuel wood), it is no surprise that the use of waste wood has been considered a viable option for heat production in modern society (Trossero). Production of heat with wood can take place on both the small scale, for individual domestic heaters, or on the larger scale, utilising wood chips or wood pellets for boilers. Wood waste is also increasingly being utilised as an alternative fuel source creating process heat for cement kilns (Warnken 2001; Foster and Collins 2004).

There are many small combustion heaters available in Australia and overseas which utilise wood and wood pellets. Most of the medium-scale boilers produce hot water which is then used as a heat source for heating houses and apartments.

More interesting on the industrial scale are the technologies available for utilising wood waste for heat and process heat. The **grate-fired boiler** is one of the more common systems. Wood is either manually or mechanically loaded into the boiler where the fuel is burned on top of a grate. There are various configurations of the grate-fired boiler available commercially.

**Fluidised bed combustion** is another common technology used for burning wood waste and is particularly useful in burning low-calorific fuels. Combustion takes place on a circulating medium (sand).

Utilisation of wood for **process heat** requires the fuel to be as dry as possible, making waste wood a particularly favoured resource. Cement kilns burn at extremely high temperatures for long periods of time which means there is very little ash produced.

The ash which does remain is incorporated as part of the clinker and remains bound up within the matrix of the cement.

One issue with using waste wood for heat and process heat production is contamination. Solids contamination (metals and grit) cause slagging which reduces the efficiency of burning as well as producing waste which usually has disposal issues. Excess chlorine in the burning process also reduces burning efficiency and can act as a contributor to the production of dioxins (other factors include management of the combustion process (time, temperature and turbulence) and control of air emissions as dioxins form within temperature ranges of 150°C to 450°C).

Air emission is also a contentious issue surrounding the burning of wood waste, although most environmental impacts are minimised through strict regulation by the authorising organisation, such as the EPA. Public perceptions and concerns may significantly affect the capacity for large-scale utilisation of waste wood in heat and process heat production.

### **6.3 Energy Production**

Arguments in support of energy from waste wood include the saving of fossil fuels, reduction in overall greenhouse gas emissions by reduction in potential methane from landfilling of the wood waste and, when pre-sorted and burned correctly, a reduction in CO<sub>2</sub> emissions compared to coal power stations (Assurre; Macquarie Generation).

Use of wood for energy production has several advantages over its use for heat, including the ability to transport energy for a wider range of applications. Most technologies for the conversion of wood waste to energy utilise a **steam turbine**. Heat from a combustion unit passes a heat exchanger which changes heat into steam. The steam is then used to drive a turbine which turns the steam to energy through a generator.

**Gasification** is another method of energy production where a flammable gas is the by-product of heating wood waste in the absence of oxygen. The gas is combustible and can be used to drive an engine or turbine. By-products, such as ash, char and liquids are produced which may or may not be utilised in other processes. In some cases, the by-products may have disposal issues.

**Pyrolysis** is the production of liquid fuel by the heating of wood waste in the absence of oxygen. Char and gas are also by-products of the process with the same issues as the by-products of gasification and combustion.

In 1999, Liddell Power Station (Macquarie Generation) became the first coal-fired power station licensed to co-fire untreated waste wood in Australia. It estimates it will produce 50,000 megawatt hours of energy as well as saving about 50,000 tonnes of CO<sub>2</sub> annually by utilising wood waste. This measure will ensure it meets its requirements for 2% energy produced through renewable energy.<sup>30</sup> At the end of 2003 it was still the only company utilising waste wood for renewable energy production.

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<sup>30</sup> <http://www.mretreview.gov.au>

Macquarie Generation produces only 4 MW of energy from wood waste. This is small compared to other emerging and established renewable energy sources, such as bagasse (368 MW), wind (197 MW), landfill gas (100 MW) and hydro (7004 MW).<sup>31</sup>

Delta Electricity is also licensed to co-fire up to 5% by weight (Flood 2003). They currently utilise both non-native forest sawmill residues and C&D wood waste. In order to utilise C&D wood waste, they must perform trace element testing of each batch of waste wood and conduct extensive air emissions testing.

## **6.4 Contamination Issues**

Energy production utilising contaminated waste wood as a resource is fraught with difficulties. The main issue is the containment of emissions and leached by-products of the combustion process. Several researchers have addressed these issues.

Chang-Yu Wu at the University of Florida in Gainesville has developed technologies which bind arsenic emissions into the ash such that they won't leach, making the ash suitable for landfilling (Holton 2001). The technology uses mineral sorbents, limestone powder in particular, in an airflow-controlled muffle furnace. The arsenic chemically binds with the limestone powder to form an insoluble waste ash. This technique is similar to existing commercial technologies which inject limestone into pollution control devices to absorb sulphur dioxide emissions.

Stewart *et al.* (2004) studied the effect of temperature and oxygen levels on the subsequent ash residues and off-gases in the combustion of CCA-treated timber. They found that all metals entering the combustion process were destined to end up either as ash residue or being volatilised as a flue gas. They also found that the end fate of the metals was highly dependent upon the oxygen levels and burn temperatures. All of the copper could be found in ash after combustion, compared to 90% of the chromium and 20-80% of the arsenic. Stewart *et al.* interpreted the results as an indication that there are trade-offs associated with combustion of waste CCA-treated timber, including the efficiency of the energy production, retention of the chromium and arsenic in the ash and stability of the chromium or arsenic in the ash. They concluded that explicit operating conditions for combustion of CCA-treated timbers were impossible to state but that operating conditions could be varied in order to change the variable of operating efficiency and energy recovery, retention of metals in the ash and stability of the metals in the ash residue.

Helsen and Van den Bulck (2005) reviewed disposal options for CCA-treated wood and found that co-incineration and low-temperature pyrolysis or high temperature gasification provided the most appropriate disposal options in the short and long-term. The advantages and disadvantages of each of those technologies are listed in the following table.

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<sup>31</sup> <http://www.bcse.org.au/default.asp?id=257>

**Table 6.1. Heat and Energy Production Technologies (Taken from Helsen and Van den Bulck 2005)**

<b>Technology</b>	<b>Disadvantages</b>	<b>Advantages</b>
<b>Slow pyrolysis</b>	Volatilisation of arsenic (As).	Lower amounts of arsenic (As) volatilised compared to combustion; may be easier to capture; better option with respect to PCDD/F (dioxin and furan) avoidance and metal recovery.
<b>Flash pyrolysis</b>	5-18% As in the pyrolysis oil.	
<b>Incineration</b>	Extensive gas cleaning equipment needed for As and PCDD/F; As <sub>2</sub> O <sub>3</sub> dust; problems with occupational health; ash treatment is needed; no production of secondary fuels; heat has to be used or converted immediately.	Can be coupled with metal recycling processes.
<b>Go-incineration</b>	Absolute amounts emitted are still high; higher As concentration in the bottom ash compared to eg. coal combustion; volatile As has to be removed from larger amount of flue gas; emission is not always allowed.	Economy of scale; low investment cost; short term design and installation; highly flexible with respect to fuel used; As may be scavenged by other compounds; easy to comply with emission legislation (dilution effect)..
<b>Gasification</b>	Appropriate gas cleaning equipment needed; critical point; all As released from metallic form and all As captured; high cost due to the need for high temperature and fine particles; not yet proven at pilot scale.	Higher energetic efficiency; lower amount of gas to be cleaned compared to combustion; no PCDD/F formation; recuperation of metals and fuels possible.

Once again contamination is a major issue for the production of energy from wood waste. Productivity is similarly affected when high levels of chlorine are present resulting in reduced efficiency and subsequent issues with emissions (dioxin) and degradation of equipment (corrosion).

To put the emission of dioxins in perspective, the Australian National Pollution Inventory reports the largest producer of polychlorinated dioxins and furans in Australia in 2003-2004 to be backyard incinerators (0.17kg) compared to electricity

suppliers (0.036kg) (National Pollution Inventory 2003-2004). However, it should be noted that both backyard incinerators and electricity suppliers also burn fuels other than wood which would contribute significantly to the dioxin emissions.

## **6.5 Summary**

A large potential area of use for waste wood in the Australian marketplace is as a fuel for heat or energy production. There are numerous commercial technologies available off the shelf for utilisation of wood waste as a fuel. It would be up to each individual industry to examine the cost and benefits of the particular systems in order to determine which may suit their particular situation and waste wood resource, in particular, sorting of contaminants and ability to burn CCA-treated timber. However, given the potential to claim renewable energy credits when burning waste wood, it is likely to be an option for waste wood utilisation taken up by several major Australian industries in the coming years.

One of the longer-term issues with the utilisation of waste wood for energy and heat production is the long-term sustainability of the resource. There are vast quantities of waste wood at present, but as society complies with the “reduce, reuse, recycle” mantra the reduction in the use of wood for primary production may result in the subsequent reduction in wood waste available for industries which have established themselves based upon availability forecasts. Those industries may again be faced with the challenge of finding an environmentally acceptable resource to utilise in the production of heat and energy as well as changes to the equipment used in the processing of the waste.

## 7.0 CCA-Treated Timber

Most available information regarding preservative-treated waste wood deals with only one preservative, copper chromium arsenic (CCA), because of the vast quantities of this preservative-treated timber that have been created and used over many years.

### 7.1 Australian Legislation on CCA-Treated Timber

In March 2005, the Australian Pesticides and Veterinary Medicines Authority (APVMA) advised industry of a 12 month phase out of the use of CCA as a timber treatment in certain domestic situations, such as playground equipment, garden furniture, patio decking and handrails. Products such as fence posts and telegraph posts were excluded from this ban, as they are not touched regularly.

The impetus for this action arose because APVMA was not satisfied that CCA-treated timber did not present a health risk for people, particularly children who had frequent and close exposure to treated timber products such as decks, garden furniture and playground equipment.<sup>32</sup>

It is a strong belief of several Australian regulatory agencies that treated timber should have priority focus, as there is currently no scheme to reduce the impact of this waste. Impacts include arsenic leaching into soils and underground aquifers when the waste is dumped in unlined landfills and the generation of toxic air emissions and ash concentration when used as a fuel.

The NSW Department of Environment and Conservation (NSW DEC) has further strengthened regulations on CCA-treated timber with the release of the *Environmental Compliance Report: Wood Preservation Industry, Part C Final Report (2004)*. This document has impacted the wood preservation industry in NSW by:

- prohibiting the burning of treated timber,
- requiring CCA fixation to occur while timber remains on a sealed drip pad, and requiring fixation monitoring programs,
- initiating pollution studies of surface and ground water,
- requiring better management of wastes.

Although the document did not rule further on the disposal of CCA-treated timber wastes, NSW DEC has implemented a policy through its National Parks and Wildlife Service and the Botanic Gardens which requires that treated wood waste be disposed of only in solid waste landfills with leachate collection systems.

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<sup>32</sup> <http://www.apvma.gov.au/media/mr0501.shtml>

## **7.2 Leaching of CCA from Landfill**

There are numerous publications covering the subject of arsenic leachate from landfill containing CCA-treated timber. One such paper prepared by the Gradient Corporation claims there is no evidence that CCA-treated wood had an impact on groundwater from unlined C&D landfills in Florida (Gradient Corporation 2002). The main reasons for this claim are that arsenic was undetected in every sample at more than half of the landfills tested and that the average arsenic concentration downstream from the landfills did not exceed the arsenic allowed in the Florida groundwater standard.

A New Zealand investigation into the leaching of the individual metal components of CCA, suggested that landfill disposal is a safe option (Gifford *et al.* 1997). This conclusion was based on the low mobility of copper (Cu), arsenic (As), and chromium (Cr) and the adsorptive capacity of soil in capping layers to minimise concentrations in leachate. Leaching of arsenic into the soil environment from treated timber has been reported as the greatest of the three metals (arsenic, chromium, and copper) (Gifford *et al.* 1996).

Gifford *et al.* (1997) conducted a study to determine the quality of leachate and factors affecting leachate quality when CCA-treated wood was exposed to natural weathering conditions in a simulated land disposal situation. The results of their lysimeter tests indicated that soil attenuates the leachate concentrations of Cu, Cr, and As. They concluded that in well constructed landfills where clay capping layers are placed between waste layers, there is a substantial capacity for the sorption of Cu, Cr, or As and thus reduced the risk of groundwater contamination (Solo-Gabriele *et al.* 1998).

Numerous studies have documented the impacts of heavy metals from CCA- treated timber leaching into surrounding soil and groundwater. The amount of leaching from CCA-treated timber depends on the local conditions and age of the timber. Ultraviolet exposure increases the amount of arsenic removed through rainfall by five times (Lebow *et al.* 2003). Weathered wood leaches more of the toxic trivalent arsenic than unweathered wood (Solo-Gabriele *et al.* 2003).

In 2003, an investigation found that the soil below and around CCA-treated timber decks contained an average arsenic concentration of 28.5 mg/kg, well above average background soil arsenic concentrations of 1.5 mg/kg (Townsend *et al.* 2001). The same researchers found that soil below the CCA-treated timber decks contained an average of 34 mg/kg chromium and 40 mg/kg of copper, in contrast to an average background level of 10 mg/kg for both metals. Townsend *et al.* (2001), found that the highest concentrations of arsenic, chromium, and copper were found within five centimetres of CCA-treated timber, with the soil metal levels decreasing with distance.

Most studies suggest that arsenic leaching reduces with time. However, the Washington DC-based Environmental Working Group (EWG), found that arsenic levels on CCA-treated wood remained high for 20 years, and that sealants are only effective at reducing arsenic levels on the surface of the wood for about six months

(Gray and Houlihan 2002). Other studies, (Lebow 2001) found that certain common paint systems were effective at preventing CCA leaching while the paint system was maintained.

Other studies of CCA-treated wood leaching have found that significant quantities of heavy metals tend to leach from un-weathered specimens, placing un-weathered CCA-treated wood waste in a different risk category to weathered CCA-treated wood (Townsend *et al.* 2004).

Studies on leaching of CCA from treated timber are influenced by many factors including the influence of timber species, size of samples, exposure duration, exposure environment and concentration and nature of the CCA treatment in the timber (Scown 2005). Furthermore, the chemical reactions during fixation of the metal components of CCA in wood mean that the metals may change form and species and it is those (often less hazardous) forms of the metals which may subsequently be leached from the timber.

In the USA, any material that leaches arsenic is prohibited in municipal landfills because it is classified as hazardous waste. CCA-treated timber has been classified as hazardous waste in some countries for several years and use of CCA-treated timber is banned altogether in many countries such as Switzerland and Vietnam (Beder).

### **7.3 Technologies for Remediation of CCA-Treated Timber**

The remediation of CCA-treated timber has been investigated as a management option for mainly because such technologies could prevent the disposal of potentially large volumes of treated timber into landfill. Given that it is estimated that disposal of CCA-treated timber will exceed 16 million m<sup>3</sup> annually in the USA by 2020, any technology which could divert some of that volume from landfill would be promising (Cooper 1994).

Clausen and Kenealy (2004) have recently investigated an oxalic acid extraction and bioleaching remediation methodology. This technology first uses oxalic acid extraction over an 18-hour period to extract the chromium and arsenic. This is followed with a 7 to 9 day bioleaching process utilising a copper-tolerant bacterium to remove the copper. Laboratory trials demonstrated the ability of this process to remove significant amounts of the metals from various forms of CCA-treated timber.

**Table 7.1. % metals removed from particulate, flaked and chipped CCA-treated wood (Taken from Clausen and Kenealy 2004)**

<b>CCA-treated wood</b>	<b>Cu removed (%)</b>	<b>Cr removed (%)</b>	<b>As removed (%)</b>
<b>Particulate</b>	79	70	88
<b>Flaked</b>	83	86	95
<b>Chipped</b>	65	64	81

Another method of bioleaching utilises the oxalic acid created by brown-rot fungi to leach the heavy metals in CCA-treated sawdust. It is surmised that oxalic acid production is responsible for the ability of some brown-rot fungi to display copper-



tolerance. It is also suggested that oxalic acid production by brown-rot fungi results in the degradation of cellulose and hemicellulose of wood because oxalic acid is small enough to pass through the cell walls of wood and also because of the ability to depolymerise cell walls using a Fenton-reaction. Kartal *et al.* (2004) demonstrated a 100% removal of arsenic from treated sawdust over a 10 day period using a fermented broth of the brown-rot fungus *Fomitopsis palustris*. Removal of copper (72%) and chromium (87%) was also significant utilising *F. palustris*.

The absorption of the metals in CCA with biopolymers has been proven in the laboratory using chitin and chitosan (Kartal and Imamura 2005). Chitin occurs naturally in crustacean shells and chitosan is extracted from chitin. Both polymers are high in nitrogen. The chemical structure of each of these biopolymers allows metal chelation to occur at the site of amine and hydroxyl groups. Kartal and Imamura demonstrated that 74% of copper, 62% of chromium and 63% of arsenic could be removed from sawdust of CCA-treated timber using a solution with 2.5g chitin over 10 days.

Another commercial technology, CCA3RT, claims a removal rate of 99.5% of CCA components from waste materials, including wood, soil treatment waste and treatment plant equipment.<sup>33</sup> Details of the process are not known, but it involves an extraction process and a proprietary medium to capture CCA compounds which are then able to be separated into pure compounds and recycled.

A company in the US has recently published information about a new process in which wood waste is chipped and then reacted with a 'lixivient' which "mobilises" the copper, chromium and arsenic and makes them available in the solution (Oskoui 2004). Extraction takes about four hours as the process has several steps including: particle size reduction, hydrolysis and reaction, settling, decanting, solids separation and water treatment. The final cleaned samples passed the EPA SW846-1311 and SW846-531 tests for Toxic Characteristic Leachability.

The metals in CCA have also been removed using extraction by EDTA (ethylenediaminetetracetic acid) (Kartal 2003). EDTA is more commonly used for soil remediation because of its ability to bind metal ions into stable (water soluble) complexes. Kartal found that EDTA extraction of sawdust removed 93% of copper, 36% chromium and 38% of the arsenic. Low rates of chromium and arsenic removal were attributed to the weak chelating effect of EDTA which was unable to break the chemical bonds between the metals and wood components. The author suggests EDTA extraction could be used for removal of copper from wood treated with copper-based preservatives other than CCA, such as ammoniacal copper citrate, ammoniacal copper quat, oxine copper, copper naphthenate, copper azole and copper 8 quinolinolate.

The removal of heavy metals from CCA-treated wood using electro-dialytic remediation has been patented by the Technical University of Denmark (DTU) (Christensen *et al.* 2004). This method is successfully used to remove heavy metal contamination from soils by using a direct electric current with an ion exchange

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<sup>33</sup> <http://www.wcec.com/cca2/>

membrane. Trials on CCA-treated sawdust and wood chips demonstrated removal of 95% Cu, 90% Cr and 96% As and 90% Cu, and 85% Cr and As respectively.

Another commonly recognised technology is the “Chartherm process” (Hery 2004). This process claims to be able to process 1500 kg of wood waste an hour. A by-product of the process is a “clean graphitic carbon powder.” The process incorporates three steps; crushing, thermal process and sorting. The carbon powder by-product can be used as a fuel powder or as carbon black.

Remediation of CCA-treated timber through a physical or chemical process promises two things; the recovery of wood fibre with the potential for re-use, and the recovery of the original treatment chemicals which can be recycled into the production of other chemical products. However, most of the technologies advertised for the bioremediation of CCA-treated timber carry an expensive price tag.

Wood fibre which has undergone chemical remediation for removal of heavy metals may suffer due to changes in fibre strength and form caused by the strong acids used in the remediation process (Clausen 2004). The acids may hydrolyse the carbohydrates, resulting in a subsequent loss of fibre strength. This has been demonstrated by Clausen *et al.* (2001) with particleboard manufactured from remediated fibre. The particleboard suffered a loss of 28% internal bond strength and 13% modulus of rupture as well as an 8% increase in the modulus of elasticity.

Additionally, the chemicals which have been taken from the waste wood may not be immediately utilised in their current form for new preservative formulations and may have to be further processed into a useable form (ex. valence state of arsenic) (Helsen and Van den Bulck 2005).

Copper, in particular, is one of the most commonly used metals in formulations for wood preservation. One positive future attribute of remediation technology is its potential to be utilised far into the future with the newer generation of copper-based preservatives, such as copper azole, long after CCA is out of common use.

## **7.4 Other Timber Treatments**

International regulation and control of timber preservatives other than CCA is slowly beginning to affect the availability of alternative wood preservatives, such as ACQ (alkaline copper quat), LOSP (light organic solvent preservatives) and copper azole. Most of this has been brought about by changes in “chemical” or “toxic” substance regulations (Connell 2004).

In Europe, for example, the *Existing Substances Regulations (793/93/EEC)*, which is a framework for controlling existing chemical substances, has placed chromium compounds under review. This review significantly affects the wood preservatives industry and may lead to a risk reduction strategy and restrictions on use.

The EU *Biocidal Products Directive (98/8/EC)* also has the scope to remove certain wood preservatives from the market by requiring biocidal active substances be reviewed at the EU and national level. Eighty-one wood preservatives have received

notification of review, which has resulted in reduced customer support for chemical actives such as tributyltin oxide (TBTO), ethanol, lactic acid, cetyl/pyridinium chloride, deltamethrin, cyfluthrin, organotin and finopril.

The EU *Marketing and Use Directive (76/769/EC)* has already had an effect on the use and sale of CCA wood preservatives. This directive has also created restrictions on the use of wood preservatives such as creosote and pentachlorophenol.

The EU Directives have been interpreted differently in each member country of the EU, with Denmark being an example of extreme interpretation with the banning of CCA and chromium-based wood preservatives as early as the mid-nineties.

## **7.5 Summary**

A brief review of Australian legislation on CCA-treated timber suggests that the use of CCA-treated timber will decrease significantly in coming years. However, the issue of CCA-treated wood waste will continue in the future as the lifespan of CCA-treated timber is often more than 30 years. Issues with contamination of waste wood with other wood preservatives are also likely to be an issue far into the future.

Technologies have been presented for the remediation of CCA-treated timber by chemical or biological means. Most of the technologies are both expensive and relatively experimental. Longer term issues regarding disposal of liquid wastes, along with the commercial viability of such operations, leaves a question as to their viability in the Australian marketplace.

## 8.0 Engineered Wood Products

There are a variety of considerations relevant to the issue of wood recycling in the context of engineered wood products, and it is pertinent to examine some of these separately. These considerations apply both to the issue of incorporation of recycled material in the production of composites, and to the subsequent end-of-life cycle concerns around disposal of the material.

As part of this discussion, some general background on composite systems and their inputs is presented, and the effect of market forces in the various market segments and the effect of the various binder systems on the regulatory environment are presented.

### 8.1 The Engineered Wood Products Industry

In 2003 the worldwide engineered wood products industry produced almost 200 million m<sup>3</sup> of product, or approximately 2% of world timber production. The most important categories of product and their respective production totals are presented in below. In Australia, composite panels account for <10% of the total volume of wood based product.

**Table 8.1. Worldwide production of composite board products (m<sup>3</sup>) 2000-2003 (Taken from <http://www.faostat.fao.org>)**

Category	2000	2001	2002	2003
Particleboard (includes OSB)	84,818,503	83,111,106	84,847,692	89,784,416
Fibreboard (includes hardboard)	33,554,598	34,790,177	38,631,009	44,103,846
Plywood (includes LVL)	58,208,045	54,580,050	59,512,228	68,401,666
Totals	176,583,146	172,483,334	182,992,931	202,291,931

### 8.2 Types of Composites

#### 8.2.1 Particleboard

Particleboard is produced by coating wood chip with a mixture of thermosetting binder material and some hydrophobic wax and then hot pressing in the presence of a hardener system. Particleboard is generally made as a three-layer matrix, with a layer of coarse chip in the core surrounded by a layer of finer materials on the surfaces. The finer surface material provides the surface properties such as surface soundness and smoothness. Binder is typically formaldehyde-based aminoplastic resin at a loading of 10% w/w (average) on dry wood.

Particleboard is a commodity product, with average prices running in the \$AU 200 – 300 per cubic metre region for standard material. This places a great deal of pressure on manufacturers to use the cheapest available wood sources in manufacture, as they are often competing against producers of higher-value end-products for the same wood source. For a standard particleboard manufacturer in Australia, wood makes up between 8 and 12% of total manufacturing costs.

The final product is primarily used for furniture, particularly kitchens, tables, desks, shelving, or generally any application where routing or machining is not required. Approximately three quarters of particleboard used for this application is laminated post manufacture, usually with impregnated decorative papers of LPM (Low Pressure Melamine) or HPL (High Pressure Laminated) types. A small proportion is also veneered with thin wood veneers, usually hardwood. Particleboard has had until recently only limited use in structural applications, where its most common use is as flooring substrate. This material is generally not laminated, and the carpet or floating floor is usually directly attached to the particleboard.

Wood chip factors such as slenderness ratio, bulk density, and degree of hydrophobicity are critical to the final properties of the panel, in particular modulus of rupture (MOR), and these considerations make it difficult to change wood sources without impacting negatively on properties. Nonetheless, recent trends around the world have made it necessary to use increasing amounts of less favourable feedstock, as the availability of the most highly desired sources are taken by other uses. This has been accompanied by a general trend towards relaxing standards around strength properties.

### **8.2.2 Medium Density Fibreboard (MDF)**

Unlike particleboard, MDF production digests wood chip and then completely defibrates it under conditions of elevated temperature and pressure. The subsequent wood fibre has binder and wax added and is hot pressed like particleboard, but hardener is not required in the pressing process. Compared to particleboard, binder levels (typically formaldehyde-based aminoplastic resin) for MDF are typically higher, with levels at 12-20% w/w, with even higher levels prevalent for thin panel or moisture resistant applications.

Use of recycled feedstock, particularly that with large amounts of extractable material, can cause issues as the water is most commonly disposed of by use in process, and extractive material can cause process issues, particularly in binding.

Although still a commodity product, MDF, particularly thin material (<6.0 mm) is able to obtain a premium in the market compared to particleboard. This is due to the superior machining characteristics of the thicker panel for decorative applications, and the availability of thin material, (<2 mm) which is not so easily achieved with particleboard. This has generally protected MDF from the need to use as much recycled product. MDF is used widely for furniture, for example flat pack furniture and desk tops, and also machined as architraves and ceiling features. A proportion is also veneered or laminated for furniture use, usually with wood grain finishes.

Finally, thin high density material is used extensively in laminate flooring, and also for highly technical applications such as circuit boards.

### **8.2.3 Oriented Strand Board (OSB)**

Oriented Strand Board (OSB) is a material similar to particleboard, but with important mechanical differences. In OSB, the wood particles are larger flat flakes, and they are oriented in the forming process such that those in the surface layers line-up with the long direction of the panel whilst those in the core are oriented in the short direction of the panel. This gives OSB enhanced Modulus of Rupture (MOR) and Modulus of Elasticity (MOE), and makes it more suitable for structural applications. Because of the particular requirements for the OSB flake, it is generally difficult to use heavily recycled feedstock, as it cannot generate good quality large flakes of the type needed for OSB manufacture. However, some European equipment manufacturers have produced prototype equipment which could potentially overcome these difficulties.

Currently there is only one OSB plant in Australia and New Zealand (NZ), the Triboard facility in Kaitaia, Northland, NZ run by Juken Nissho Ltd. Conversely, OSB is widespread in North America and Europe, and in those areas constitutes a rising proportion of composite production.

### **8.2.4 Plywood and Laminated Veneer Lumber (LVL)**

Plywood and LVL are the most structural form of composite wood product, made by gluing together thin (usually 2-3 mm) wood veneers under high temperature and pressure. The veneers are generated by peeling a full size log on a lathe. For this reason, utilisation of a recycled material in production is not possible, though LVL and plywood do constitute a large amount of composite production each year and are therefore important from a recycling and end-of-life standpoint.

### **8.2.5 Beams**

Beams manufactured as engineered wood products include glued laminated timber (glulam), I-beams and finger-jointed members. Glulam consists of wood laminates which are glued together into a structural beam. A resorcinol resin is usually used to glue the laminates together. This results in a deep beam with a high strength rating for use in structural applications.

I-beams are I-shaped structural members which are manufactured using top and bottom flanges (usually sawn timber or LVL), joined in the middle with a “webbing”, usually plywood or OSB. A resorcinol resin is usually used to attach the flanges to the webbing. Internationally isocyanates are becoming more popular for this application, however, issues surrounding acceptance in the relevant standards are inhibiting its use in Australia.

Finger-jointing gives adequate strength but allows for a longer length beam. Finger-jointing can be used in combination with glulam to form long, high strength members.

## 8.2.6 Wood Plastic Composites

Wood-plastic composites (WPC) are materials made by combining fine wood dust (or wood dust pellets) with thermo-plastics and a binding agent. The combined material is heated and compounded into a dough-like material which allows the mix to be extruded into various profiles or moulded into various shapes or components.

The material has benefits over pure wood or plastic. Wood dust is significantly cheaper than plastic and once formed into the WPC, the product has improved stiffness compared with the plastic alone, with acceptable strength and toughness. The finished product is extremely water resistant, so is better suited than pure wood to outdoor or wet applications such as gardens and bathrooms. Any scrap material generated during the working can be ground up and used again (WRAP 2003).

## 8.3 Wood Sources

Most timber species have been utilised for composite production at some stage, and the preferred species are heavily dependant on local factors. Softwoods are generally preferred as a raw material, due to their lower average density, as this is important both for reducing the overall weight of the final product and allowing a greater degree of compressibility without generating either excessive density or excessive internal stresses.

In Australia and New Zealand, *Pinus radiata* (radiata pine) is the more preferred of commonly available softwood species, whereas in Europe, a variety of *Picea* (spruce) and the *Larix* (larch) species are utilised. In South East Asia, tropical species such as *Shorea* (lauan), *Hevea brasiliensis* (rubberwood) and *Acacia* (acacia) predominate. The availability of these resources drives the use or otherwise of recycled material. In parts of Europe, for example, where virgin wood is scarce, it is used almost exclusively for MDF, whilst the bulk of particleboard is made with recycled material. In South East Asia by contrast, where comparatively large natural sources of tropical hardwoods remain, there is less interest in recycled material.

The preferred source of recycled material is offcuts, sawdust and shavings from other primary processing such as sawmilling, as well as unused material from forestry, e.g. tree tops and thinnings. Australian particleboard production is geared heavily towards these sources, with the result that most production lines use exclusively wood sources of this type. Less common in Australia is the use of secondary products such as composite panels, used furniture, pallets and formply, which is more common in parts of Europe. As the availability of even these sources diminish, the next option is to look for similar sources from less desirable wood species (e.g. Eucalypt) and then the need for secondary product recycling will become more acute. Currently in Australia, there is increasing interest in using residues from primary processing, and more extensive use of secondary materials is likely in the future.

The remainder of this section focuses on the issues surrounding the utilisation of secondary products and materials, and both the regulatory and practical issues associated with them.

### 8.3.1 Types of Secondary Product Wood Resources for Recycling in Engineered Wood Product Manufacture

Given the reducing availability of more desired wood sources, the spotlight is falling more firmly on the availability and use of waste wood resources for the engineered wood product industry in Australia.

Potential sources of most interest for composite manufacture, and their main issues are summarised in the table below. Note that the key issues relate to potential contaminants. There is the separate issue of dealing with the many and varied species from which these materials are constructed, often including mixtures of hardwoods.

**Table 8.2. Types of waste available for recycling**

Type of waste	Examples	Issues
<b>Construction &amp; Demolition</b>	Timber framing, weatherboards	Preservatives, nails, other metal contaminants
<b>Pallets</b>	CHEP	Preservative, nails, paint
<b>Decking</b>		Coatings, preservative
<b>Furniture</b>	Bookcases, tables, kitchen cupboards	Laminates, paint, protective coatings, binder
<b>Scaffolding</b>	Timber, or LVL e.g. Hyplank	Preservative, binder for LVL
<b>Plywood</b>	Formply, freeway barrier, braceboard	Binder, laminate
<b>Agricultural Posts</b>	Fence posts Vine posts	Preservative

Efficient utilisation of recycled material requires that it be segregated into different classes of material in accordance with their particular issues (e.g. all CCA preservative-treated material, all material containing phenolic binder, all material with hydrophobic coatings, all material containing metal contaminants) in order for these particular issues to be dealt with in the manufacturing process. Alternatively, if possible, certain classes of waste can be avoided entirely. This is reliant on being able to either source only certain waste streams, or remove them entirely in process. Internationally, many companies such as Fantoni and Sonae, are making use of sophisticated technologies to enable the use of most waste streams. These technologies include electromagnets and eddy current separation to remove metals contamination, wind sifting to remove paper and plastic contaminants and a variety of vibrating screens, disk screens and trommels to remove “hard core” contamination (refer to section 5.2 for further discussion of contaminants removal).

In addition, the extent of the contamination problem depends upon the final application. While the particleboard manufacturing process may be able to deal with a certain amount of intractable material remaining in the wood source, the nature of the MDF refining process requires a higher degree of removal of contaminants. This, combined with the generally higher prices available for MDF, means that companies using large amounts of recycled material tend to direct it towards their particleboard manufacture rather than MDF. Fantoni in Italy is an example of a company that uses this approach.



### **8.3.2 Waste Wood Stream Separation and Preparation for Use**

Generally, in the composite product context, some sorting of the recycled wood streams has occurred prior to introduction to the plant. Technologies for sorting wood streams are dealt with elsewhere in this report. Approaches for dealing with various contaminants in the manufacturing process are examined in this section.

The utilisation of secondary recycled materials in composite manufacture involves two distinct steps:

1. Furnish preparation
2. Separation of undesired materials (e.g. metals) from the furnish

Separation techniques depend on the nature of the recycled material optimum and the degree to which undesirables must be removed. Some may be left in the furnish and can be incorporated in the finished product, with consequences for final product properties.

### **8.3.3 Furnish Preparation and Separation**

The most commonly used technique involves subjecting the material to ring flaking and hammer milling (e.g. those made by Gisiger) to produce smaller more manageable material. At this point, metals can be removed by magnetic separation, and other mobile contaminants such as plastics, paper and grit removed by sifting, air sorting and chip washing. This level of preparation is common in plants utilising recycled material around the world, and in particular sophisticated systems for metal removal are commonplace.

The remaining contaminants at this point would fall into the category of coatings or binders. Wood contaminated with preservative (e.g. CCA) is currently not used for composite manufacture due to the expense involved in removal. Techniques for removing coatings and binders do exist, but are as yet not widely used, mainly due to cost factors. For particleboard manufacture, a certain amount of these materials is acceptable, although increased levels of grit in the final product increase wearing in sanders and saws. For utilisation in fibreboard, more efficient removal of binders and coatings would be required.

The main techniques available today for the breakdown of composite panels involve either thermo-chemical-mechanical treatment or microwaves. They are summarised below. Both have the same aim, that is the breakdown of the panel material to allow easy removal of coating contaminants (laminates, paints, edge banding) and the digestion of the binder material. This produces material suitable for utilisation in the MDF process.

## 8.4 Technologies for Remediation of Engineered Wood Products

The main techniques available today are summarised below. All aim is to breakdown the panel material to allow easy removal of coating contaminants (laminates, paints, edge banding) and the digestion of the binder material. This produces fibrous material suitable for utilisation in the MDF process.

### 8.4.1 WKI

The Wilhelm Klauditz Institute (WKI) in Germany has developed and patented a process involving the use of pressurised steam to break up the composite material, allowing ready separation of coatings and contaminants from the material and separation of the subsequent furnish into different particle sizes.<sup>34</sup>



Figure 8.1. Picture of a pilot scale version of the WKI process.

WKI claim recovery rates of up to 95% of fibre mass from the original product, and reported results show no loss of structural properties in product made with the recovered fibre, compared to industrial board. Formaldehyde emission levels are also unchanged.

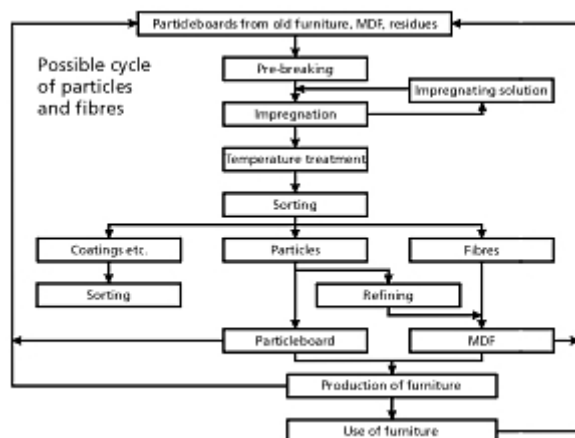


Figure 8.2. Flow chart for recycling process.

The process is covered by European Patent EP0647693, and also US patent 5705542 in which the process is described in detail. The pre-breaking step is followed by a thermo-chemical pulping stage resulting in break-up of the composite structure. Other

<sup>34</sup> <http://www.wki.fhg.de/projekte/wki-6-2e.html>.

materials such as coatings can be removed at this stage by sifting, and the resulting digested fibre made available to MDF manufacture. As an added advantage, waste liquors generated by the process of digestion can be used as a binder in their own right, making the process a closed cycle.

### 8.4.2 Fibresolv

The Fibresolv process was developed in the UK and grew out of an appreciation of the potential use that could be made of the degradation of composite panel due to wetting (Kearly and Goroyias 2004).<sup>35</sup> Unlike the WKI process, the Fibresolv process starts by applying water to the complete panel before chipping or shredding, making it more pliable and reducing wear. The pre-wetted panels are then subjected to an equivalent of a vacuum-pressure soak process to complete wetting of the panel, followed by application of steam and pressure to complete breakdown. Application of pressure and vacuum occurs in a cyclic process, promoting faster break-up, with some work having been done on optimizing the cycle parameters to maximize yield of recovered fibre. Envirofibre claim high recovery rates with optimised cycles, with only 3% of material present as “lumps” as opposed to recoverable fibre. Data presented suggest the level of contamination of the process water is low, with the possibility of discharge to waste water without treatment.

The reaction vessel for this process resembles an autoclave (see pictures below), and the largest vessel made so far is capable of processing up to 1 tonne of material at a time.



**Figure 8.3. Pictures of laboratory scale reactor taken from [www.envirofibre.co.uk](http://www.envirofibre.co.uk)**

### 8.4.3 Micro Release

FIRA (Furniture Industry Research Association) is a UK body funded by the local industry. As part of its research activities, it has several programs looking at issues surrounding recycling and end-of-life disposal of furniture. One program has focused on the use of microwaves or sound waves to break down board materials used in

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<sup>35</sup> [www.envirofibre.co.uk](http://www.envirofibre.co.uk)

furniture manufacture.<sup>36</sup> This project was run in conjunction with the Fibresolv project above, both funded by the UK Department of Trade and Industry

As a result, the Micro Release process has a similar underlying methodology to the Fibresolv process, namely the induction of an accelerated wetting, thickness swell and breakup process within the complete panel. In this case, the swelling and break-up is induced, not by steam and alternating pressure-vacuum cycles, but by subjecting the board to microwaves. The stated benefit of this is the ability of the microwaves to penetrate the board to a greater depth, facilitating swelling and bond breakage more easily throughout the full board thickness. It is believed that this will lead to a lower energy pathway for producing the same feedstock as the Fibresolv process.

To date only small laboratory scale exercises have been completed, which show the feasibility of generating recovered fibre, and that there is no loss of properties from boards manufactured with the recovered fibre. No detailed analysis of the energy demand or cost of the process is presented.

## ***8.5 Recycling of Wastes Generated in Composite Manufacture***

Whilst composite panels can be broken down to yield feedstocks for further composites, and a range of other primary processing wastes can also be used, the process itself generates many sources of waste material, particularly sawdust, reject board, and edge trimmings. The majority of these materials are currently already recycled into the process or used for energy generation on site. However, some material does still represent a waste requiring disposal (Smith 2004).

### Sawdust

The process of sanding and trimming composites generates appreciable amounts of dust, and in most plants the quantity generated exceeds that which can be accommodated back into the process. While much of it can be used in energy generation, some surplus exists and many plants are looking for ways to utilise this material. Use in mulch or fertiliser applications is common, as is pelletising for sale as combustion material. Some, however, inevitably ends up in landfill at a cost to the producer.

### Reject board

While no plant wants to produce reject board, it is an inevitable part of the manufacturing process. Currently, most rejects are either hogged for re-use as chips or are used as cover-boards (packaging) for pallets of good board. Problems can occur if reject levels are excessive during a particular period and the number of rejects cannot be used in cover board nor recycled without causing further process issues. In these circumstances, landfill has been the traditional approach, however some of the techniques noted above for regaining fibre from composites may be useful.

### Binders

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<sup>36</sup> [www.fira.co.uk](http://www.fira.co.uk)

The manufacture of composites invariably involves a binder system, with several systems in use worldwide. The binder system plays a part in the recycling story, both in causing issues in recycling the finished composite product, and also in the latter's ability to handle recycled or inferior material without loss of structural properties. A major component of many binder systems is formaldehyde, which in itself has various regulatory and environmental issues.

## Formaldehyde

Formaldehyde is a basic starting material for a range of chemicals used in components and materials across a broad spectrum of industries from animal nutrition to textiles. It is used as a disinfectant; in the manufacture of dyes; organic chemicals; cellulose esters; printing inks; leather tanning; embalming fluids; in photographic papers, printing and developing; furnishing materials; foam insulation and as a preservative in a large number of consumer products (cosmetics, cleaning agents) and silage, amongst many other uses.

The largest use of formaldehyde has been in the synthesis of aminoplastic and phenolic resins. The aminoplastic resins – urea-formaldehyde (UF), melamine-formaldehyde (MF), melamine-urea formaldehyde (MUF) – are used mainly as adhesives for timber products, textile treatments, foam insulation, and surface coatings. The phenolic resins – phenol formaldehyde (PF), resorcinol-formaldehyde (RF) – are used as adhesives for timber products, binding agents, hard materials as moulds, and foundry resins. Formaldehyde-based adhesives of this type account for by far the majority of binders used in the composites industry.

Urea formaldehyde copolymers are the cheapest and least durable; melamine, phenol and resorcinol add cost, but increase strength and durability, particularly durability to water exposure. Each co-polymer brings with it its own suite of potential VOC emissions from the final product; urea and melamine contribute NO<sub>x</sub> and other nitrogenous materials such as nitrosamines; phenol and resorcinol allow the formation of carcinogenic organics, particularly polycyclic nitrated aromatics.

Further information particular to formaldehyde, its health and safety issues, chemistry and national and international legislation is located in Appendix D.

## Formaldehyde Based Binders and Recycling

Formaldehyde based binders are extremely cheap and effective in normal use. Typical benchmark figures of US\$350/wet tonne for binder, and production press cycle rates of 5.5 sec/mm for composite board are part of the reason why these systems are still in such widespread use in spite of the issues around OHS. No other system currently available can duplicate their production efficiency and low cost. Unfortunately, formaldehyde based adhesives create the most issues for recycling.

### **8.5.1 Use of Recycled Material**

As previously noted, use of recycled material generally carries with it some penalty in final properties of the finished article. This is most noticeable when using formaldehyde based adhesives, often due to a particular sensitivity of these binders to changes in pH and buffering conditions. Overcoming some of this property drift is possible with formaldehyde based adhesives, but generally requires the use of more adhesive (thus increasing the loading of formaldehyde in the finished product) or more expensive adhesive, usually with more melamine. Some recycled wood sources, particularly those which have high levels of buffering associated with them or which are at high pH (e.g. phenolic bonded materials, inorganic treated timbers) can be very difficult to use in composite manufacture.

Use of recycled material for particleboard generally results in a loss of modulus of rupture (MOR) and internal bond (IB) in the finished article, with the loss of MOR particularly acute. This is due partly to bonding issues with remaining contaminants, and partly due to the geometric characteristics of the recycled furnish. The process of breaking down most recycled secondary products generates a furnish with cubic characteristics and more fines than would be seen normally, changes which are generally poor or neutral for IB and detrimental for MOR. Most European manufacturers using high levels of recycled material for particleboard aim for a MOR of 11 Mpa in their manufacturing process for a “standard” type board, whereas the Australian standard would require 12 or 13 Mpa, depending upon thickness. This is allowable in the European context, as grading of MDF and particleboard does not require meeting any particular minimum standards to enable sale as a standard product, but merely testing according to certain standard test methods and reporting of some values on the labelling. Thus a manufacturer can sell board for a standard application with any MOR as long as it reports what its minimum standard is (EN 13986:2002).

This causes problems for European manufacturers wishing to export to Australia or Japan, where minimum MOR standards are required.

A company known to use waste wood in manufacture of particleboard is Dongwha Holdings.<sup>37</sup>

### **8.5.2 Use as Recycled Material**

Formaldehyde binder can cause issues in disposal or use of composites as recycled feedstock, mostly due to potential for loss of previously bound formaldehyde from the product during secondary processing. This is most keenly felt with particleboard, where the use of a hardener introduces another potential source of toxins.

The most common hazard is VOC's liberated during heating of the wood during processing, or if it is used as feedstock for heat plant or boilers. Formaldehyde itself is of course a concern, but dioxins and NOx are also potential by-products of heating or combusting composite panels. In particular, use of chloride salts in manufacture (for example as hardeners in particleboard) is known to increase dioxin emission from

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<sup>37</sup> <http://www.dongwha.co.kr/english/>

composite panels. The most commonly emitted dioxin is TCDD, tetrachlorodiphenyl dioxin, which is a suspected carcinogen and neurotoxin. It is for this reason that the use of chlorides in composite panels is banned in the EU, and Australian manufacturers have been forced to find alternatives to chlorides in order to make their product exportable to Europe.

Companies known to utilise waste engineered wood products for the manufacture of particleboard include Fantoni<sup>38</sup>, Gruppo Mauro Savioli<sup>39</sup>, and Sonae Industria<sup>40</sup>.

### 8.5.3 Isocyanates

Isocyanate based binder systems are popular in the Japanese industry and are gaining increasing penetration into the market. The most commonly used compound for adhesives is Methylene diphenyl di-isocyanate (MDI), and it is available as raw polymeric MDI (p-MDI) or as an emulsion in glycols (e-MDI). Isocyanates for composite panels are available from a variety of producers, mainly Japanese (e.g. Nippon Polyurethanes), and are currently sold in New Zealand and Australia by NPU and Huntsman Ltd, under the Rubinate brand name. Toluene di-isocyanate (TDI) is also used, but its generally higher toxicity has seen it largely superseded by MDI.

Methylene di-isocyanate, like all isocyanates, is a highly toxic compound, but is extremely hazardous when inhaled. Its carcinogenic potential is unknown, and it is linked with respiratory sensitisation and impaired lung function, and particularly the development of occupational asthma. In the composites manufacturing context, isocyanates are most hazardous when inhaled as an aerosol or in conjunction with wood dust prior to completion of the press cycle, and without stringent air quality controls, the glue nozzles, spreaders, formers, or mat crosscut saws are potentially very hazardous zones when using isocyanates. Unless there is severe undercure, there should be no unreacted isocyanate present after the press cycle, so the area of the outfeed is generally safe. However, it is wise to test for air quality in that region as well. Airborne levels down to parts-per-billion are still considered hazardous, and current Occupational Safety and Health Administration (OSHA) permissible exposure limits are set at 0.02 ppm. The American Conference of Governmental Industrial Hygienists (ACGIH) recognises 0.0005 ppm as its Threshold Limit Value (TLV) as an 8-hour time weighted average (TWA) and 0.02 ppm as a Short-Term Exposure Limited (STEL) for both TDI and MDI, and the National Institute for Occupational Safety and Health (NIOSH) has the same recommended levels (Anon 1999; US Environmental Protection Agency 1999).

Most plants where isocyanates are used are more modern facilities which have been designed with isocyanates in mind, and where as a consequence more stringent airborne pollutant controls are in place. Even then, frequent monitoring of worker lung function is necessary, and people with a predisposition to respiratory sensitization (e.g. asthmatics) would not be advised to be on site.

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<sup>38</sup> <http://www.ueanet.com/furniturewaste/english/chapter6a.htm>

<sup>39</sup> <http://www.grupposaviola.com/en/home.asp>

<sup>40</sup> <http://www.sonaeindustria.com/ing/index.htm>

Isocyanates are also more expensive than alternative binder systems (currently ~US\$2,800/tonne) and their supply situation is variable with consequent price instability. Prices almost doubled during the course of the second half of 2004 in US\$ terms. In spite of their drawbacks, isocyanates are finding more favour as a binder system for composites, as they provide great strength to the final product without formaldehyde emissions. Certain types of highly durable product, as exterior grade, can only be made reliably with isocyanate binders.

Currently, emissions of isocyanates from finished composites are not considered to be an OHS issue, as conventional wisdom is that all the isocyanate is converted to non-toxic forms during the binding process. Some recent anecdotal evidence has cast doubts on this, however, and stricter regulations relating to both finished products and their recycling are likely in the future.

Isocyanates offer advantages in the utilisation of waste wood streams for composite production, as they tend to be more robust, allowing both more waste material and poorer waste material to be used, without such grave loss of properties. This is particularly important in more durable product categories such as moisture resistance (MR) or flooring. Currently, some European producers (e.g. Sonae in Portugal) use isocyanates for their MR grade particleboard in conjunction with normal formaldehyde-based binders.

Isocyanate-bonded material carries with it similar issues to formaldehyde-bonded systems, i.e. VOC's emitted during heating or combustion. In their favour is the fact that loadings of binder tend to be lower for isocyanates (e.g. 4% for MDF, cf formaldehyde-based systems at 16% or greater for durable products).

#### **8.5.4 Bio-Based Binder Systems**

Biologically derived binder systems have been used in composites for as long as there have been composite products, with casein or ox blood glues constituting some of the earliest binder systems for plywood. More recently, systems based on soy protein, starch and tannin have been used, but only the latter has found extensive use in composite production. Tannin adhesive systems based on *Aspidosperma quebracho-blanco* (quebracho) (South America), *Albizia julibrissin* (mimosa) (South Africa) or *P.radiata* (radiate pine) (Australia) have been extensively trialed, and currently are used mostly in South America and Southern Africa where the plants are close to the source of the tannin. Bondtite 345 (a heavily modified mimosa tannin) is currently in use in Australia, where import statistics show that 10,946 tonnes were imported in 2004.

While using less formaldehyde than conventional binders, formaldehyde is still needed as a cross-linker for these systems, usually provided by hexamine, paraformaldehyde or UF concentrate. Tannin adhesives are thus still formaldehyde-based systems. Little data on tannin toxicity are available.

With the move towards even lower emission standards, it is likely that pressure for use of bio-based adhesive systems not requiring formaldehyde as a cross-linker will become greater. At the moment, economics preclude their rapid uptake.



## **8.6 End-of-Life for Composites**

End-of-life issues are becoming more acute for composite manufacturers. European environmental standards, always at the forefront of world best practice, have impacted on European producers. As a consequence, Australian producers will see the flow-on effects, either through attempting to export to the European market, or through the partial or complete adoption of European standards.

While the previous section has concentrated on the recycling issues around composite materials, it is important to understand the desirability of recycling compared to the other alternative ends for composite materials, and the impact on availability of waste streams.

### **8.6.1 Combustion**

As an alternative for use in composite manufacture, recycled material can be directed towards energy generation. While issues around energy generation and recycled wood generally are dealt with in another part of this report, there are specific issues as they apply to the composite context.

#### **8.6.1.1 Competition for Resource**

Generally, manufacture of composite panel products in Australia is an activity with relatively low profit margins. It is for this reason that composite manufacturers must settle for the more marginal wood resources in the first place, with green wood costs over \$40/tonne being enough to make some lines unprofitable. Increasingly, however, producers are having to compete with power generation for the less desirable wood materials. Indeed, there have been occasions where composite manufacturers have stopped their line and directed all their available wood into power generation for sale to the grid, as the combination of renewable energy credits and high spot prices for power make this a more profitable use of their available wood resource.

It is in this context that some of the expensive techniques for remediating used board for re-use in manufacture need to be considered and can explain their limited uptake. If the same materials can be easily redirected to power generation, and the net cost of finding other wood sources is lower, then these alternatives are unlikely to thrive.

#### **8.6.1.2 Landfill Disposal**

Current regulations in Australian states do not restrict the disposal of engineered wood products in landfills. However, there is potential that there may be some regulation of this in the future.

#### **8.6.1.3 Particulates**

Combustion of board material is usually undertaken on material that has been chipped or pelletised prior to burning. In most panel plants, sawdust, reject board and

hoggings are used for heat production in a standard boiler, with the heat produced used for drying and steam production for the whole process.

Use of these materials usually carries with it the disadvantage of generating large amounts of particulates, which without some form of capture leaves the boiler stack as an ugly brown smear. The best method for dealing with this is a wet electrostatic precipitator (WESP), which though costly, can remove all particulates from the stack emission and replace it with a steam plume. For energy plants looking to use wood waste of this type, a WESP would be highly desirable, and depending on local EPA regulations and local council requirements, may be mandatory if near an inhabited area. Several board plants located in residential areas of rural towns now use WESP to clean up the emissions from their dryer and boiler stacks, and their numbers are likely to grow.

#### **8.6.1.4 Volatile Organic Compounds (VOC's)**

Composite boards contain materials not found in normal wood, and therefore can generate different types of VOC's on combustion.

The most important source of VOC's from combustion are the binders, with different binders giving different VOC profiles. The most common binders, based on urea or melamine and formaldehyde, generate much larger quantities of nitrogen oxides (NO<sub>x</sub>) than for wood alone, and other toxic hydrocarbons such as benzonitrile, not normally found in combustion analysis of timber.<sup>41</sup> Given the highly carcinogenic nature of many nitrated polycyclic aromatic species, and the potential for their generation in an environment rich in nitrogen (urea or melamine resins) and aromatics (wood tannins and lignins), this is an area requiring more study. Currently no data exists on the combustion products of Australian produced composite boards.

As has been noted previously, in addition to the binder there is the question of hardener in particleboard production. Chloride binders are being phased out due to their potential for producing dioxins during combustion, but their replacements are often based on sulphur (such as sodium sulphite) and carry the risk of emission of sulphur oxides (SO<sub>x</sub>) and other sulphur-based contaminants. While not as concerning, this factor does mean that the use of sulphur-based hardeners is probably only a stop-gap measure, and different systems will need to be found.

These issues can be at least partially overcome by design of the combustion chamber, to allow higher temperature combustion and retention of exhaust gases for secondary burning. However, while most boilers are currently not fitted for this, the concern remains. Using composite wood product waste as fuel in cement kilns may be one solution to the problem.

Currently no data on combustion products from isocyanate-bonded panels in Australia exist, however, the potential for emission of methylisocyanates is a concern.

#### **8.6.1.5 Wood Plastic Composites (WPC)**

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<sup>41</sup> [http://www.scerp.org/projects/AQ93\\_4.html](http://www.scerp.org/projects/AQ93_4.html)

PolyTimba® is an example of a composite wood product having properties gained from both raw materials used - wood and plastic. It has a level of stiffness and strength between those of plastic or wood. The manufacturer claims that there are no issues over the disposal of PolyTimba® as it can be recycled into future WPC products. This makes it an inherently environmentally friendly material. However, in reality there will be times when it will be necessary to dispose of WPC's. As it is considered non-hazardous waste, it can simply be disposed of using the standard methods suitable for timber or plastic.<sup>42</sup>

Though WPC's can divert recyclable wood and plastic from the landfill and into durable building applications, additional environmental benefit could be obtained if the composites themselves are recycled at the end of their useful life. The thermoplastic nature of the waste materials used in WPC's facilitates makes this possible (Boeglin *et al.* 1997).

In some cases the WPC producers are existing timber window manufacturers who have access to large quantities of sawdust and scrap wood products from their own manufacturing processes, suitable for treatment and inclusion in this type of product. This means that no wood resources are depleted in producing the WPCs and wood waste disposal concerns are removed.

Andersen Inc. manufactures a wide range of window and door products. Its WPC window profiles use polyvinyl chloride (PVC) as the polymer base and the materials come from waste generated by their other production activities and cladding operations. The company also use virgin PVC. The wood fibre is waste from standard window milling production.<sup>43</sup> Altree manufactures a range of WPC products including decking. The plastic used contains recycled polyethylene milk cartons which are blended with wood fibre from a renewable source.<sup>44</sup>

In general, WPC decking manufacturers are existing manufacturers of wooden decks. Similarly to manufacturers of windows and doors, their waste wood is suitable for wood plastic composites. The main polymer used in the manufacture of WPC decking is low density polyethylene (LDPE) and high density polyethylene (HDPE) from the post industrial and post consumer waste stream (WRAP 2003b).

## **8.7 Summary**

Engineered wood products can be successfully recycled using technologies developed overseas, particularly for use in the manufacture of particleboard and energy production. However, utilisation of waste engineered wood products comes with many technical issues which are both costly and time-consuming to resolve. Most of the issues stem from contamination due to the glues, binders and coatings used in the products. This is one reason why recycled engineered wood products are difficult to incorporate into the MDF manufacturing process.

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<sup>42</sup> See <http://www.timbaplus.com/timbaplus/technical/>

<sup>43</sup> See [www.cwc.or/wd\\_bp?wbp3-03-01.htm](http://www.cwc.or/wd_bp?wbp3-03-01.htm)

<sup>44</sup> See [www.andersenwindows.com](http://www.andersenwindows.com)

Although technologies exist which can overcome the contamination issues, those technologies are expensive and require economies of scale to be successful. It is unlikely that many Australian businesses would be able to incorporate such technologies under their current business and regulatory model and still remain profitable when compared to the cost of utilisation of virgin timber resources.

## 9.0 Conclusions

Public opinion on environmental matters is steadily increasing in Australia. Recent state government steps to increase protection of Australia's wealth of natural resources has seen further reductions to possible areas of timber harvest. As a result, Australia is facing an ever growing trade deficit in timber and paper products (\$1.85 billion in 2004) in an attempt to fulfil our ever-growing need for timber-based products.<sup>45</sup>

Within Australia, legislation is being developed to place more responsibility on producers (manufacturers) of timber-based products to ensure that they reduce waste to landfill. This follows on from legislation in various countries worldwide which provide incentives for recovery, reuse and minimisation of timber-based products and packaging. Most importantly, it reflects changing public attitudes and perceptions surrounding the sustainability of timber-based industries globally.

Regulations are quickly changing in Australia, exemplified by the recent rulings on CCA-treated timber for domestic use. Information current at the time of the writing of this report is likely to change in the future. Accordingly, readers would be wise to check for changes to regulations pertaining to the particular situation.

It is certain that preservative-treated waste wood will come under further restrictions, which may well see it banned from unlined landfills. Recycling of preservative-treated waste wood will also remain difficult, with one of the most likely uses in Australia being heat and energy production by companies willing to invest in appropriate emission control systems. Heat and energy production is currently one of the most underutilised markets for waste wood in Australia. To date, waste wood has made up only 5% of the generated and surrendered renewable energy certificates.<sup>46</sup>

Restrictions on landfilling of "clean" waste wood and engineered wood products will eventually follow, as they are already defined as "wastes of concern" in many state and territory waste management strategies. These restrictions will most likely eventuate as state-driven targets for processing and recovery prior to landfill. Individual states and territories will also eventually implement Extended Producer Responsibility schemes in consultation with industry.

Australian industry currently has a unique opportunity to target the underutilised resource of waste wood for a broad range of end-uses with few regulatory hurdles. There are no restrictions on the use of waste wood, only on the amount of "contamination" within the resource or finished product. Such loose regulation allows the use of waste wood for products ranging from mulch and landscaping materials to raw material for panel manufacture and heat and fuel production.

Given that there is no large demand for waste wood at present, the cost of waste wood is relatively low when compared to the cost of "virgin" timber fibre. However, it must be remembered that transport costs can have a significant effect on the cost of

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<sup>45</sup> [http://www.nafi.com.au/Forest\\_Statistics2005.pdf](http://www.nafi.com.au/Forest_Statistics2005.pdf)

<sup>46</sup> <http://www.nafi.com.au/library/viewarticle.php3?id=101>

raw materials and, in most cases, large volumes of waste wood are found only in major cities.

Any industry interested in utilising waste wood as a resource would necessarily undertake a feasibility study as well as an undertaking to obtain accurate data on wood waste availability in their particular geographic region. It should be noted, however, that such data can be difficult to obtain. They would also need to ensure the quality of the wood waste was adequate for their particular end use.

In the future, a different business model may be established which enables easy and secure wood waste supply to a range of companies via a central “depot”. This scenario was used as the example “Wood Waste Recovery Network” in New South Wales which established a one year trial period of wood waste recycling and separation at a designated landfill in Sydney (NSW Waste Boards 2000). The organisation running the project was restructured and it is difficult to determine the long-term success of such a model but the indication was that the model would overcome many of the identified barriers to success of ongoing long term waste wood resource recovery.

Although technologies have been presented in the report which are able to minimise contamination or remove it entirely, very few small to medium enterprises (SME’s) would be able to afford the emerging technologies. This also holds true for the emerging technologies for breakdown of engineered wood products because their suitability is largely dependent on the scale of the enterprise.

However, as these technologies develop and become commercialised as “off-the-shelf” solutions, more industries will be able to profit from including them in their production process, enabling a broader use of waste wood in manufacturing industries.

## 10.0 Bibliography

Anon (1999) 1999 TLV's and BEI's. Threshold Limit Values for Chemical Substances and Physical Agents. Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Asari, M., H. Takatsuki, et al. (2004) "Wood Waste Recycling as Animal Bedding and Development of Bio-Monitoring Tool Using the CALUX Assay." Environment International **30**(6): 639-649.

Assure. Energy from Waste Fact Sheets. <http://www.assure.org>

Australian Environmental Labelling Association. <http://www.aela.org.au>

Australian Government Formaldehyde CAS No. 50-00-0. National Health and Safety Commission. <http://www.nohsc.gov.au>

Australian Government (2001) State of Knowledge Report: Air Toxics and Indoor Air Quality in Australia. Department of the Environment and Heritage.

Australian Pesticides and Veterinary Medicines Authority. 16 March 2005.  
<http://www.apvma.gov.au/media/mr0501.shtml>

AWPA. 28 February 2005.  
<http://www.woodpanels.org.au/pdfs/AWPAMSDS2004.pdf>

AWPA. (2004) Formaldehyde: Questions and Answers. February 2005.  
<http://www.woodpanels.org.au/pdfs/formaldehydefactsheetoct04.pdf>

Baker, A. (1991) Research on Combustion of Wood Containing Non Wood material. Proceedings of Joint Meeting IEA/BEA Activity 4&5, Danish Forest and Landscape Research Institute.

Beder, S. Timber Leachates Prompt Preservatives Review. 3 May 2005.  
<http://www.uow.edu.au/arts/sts/sbeder/cca.html>

Boeglin, N., P. Triboulot and D. Masson (1997) A feasibility study on boards from wood and plastic waste: Bending properties, dimensional stability and recycling of the board. Holz als Roh- und Werkstoff **55**(1):13-16.

Christensen, I., A. Pedersen, et al. (2004) Electrodialytic Remediation of CCA-Treated Wood in Larger Scale. Proceedings of Environmental Impacts of Preservative-Treated Wood Conference, Orlando, FL.  
<http://www.ccaresearch.org/Pre-Conference/pdf/Christensen.pdf>

Clausen, C. (2004) "Improving the Two-Step Remediation Process for CCA-Treated Wood: Part 1. Evaluating Oxalic Acid Extraction." Waste Management **24**: 401-405.

Clausen, C., S. Kartal, et al. (2001) "Particleboard Made from Remediated CCA-Treated Wood: Evaluation of Panel Properties." Forest Products Journal **51**(7/8): 61-64.

Clausen, C. and W. Kenealy (2004) Scaled-Up Remediation of CCA-Treated Wood. Proceedings of Environmental Impacts of Preservative-Treated Wood Conference, Orlando, FL. [http://www.fpl.fs.fed.us/documnts/pdf2004/fpl\\_2004\\_clausen001.pdf](http://www.fpl.fs.fed.us/documnts/pdf2004/fpl_2004_clausen001.pdf)

Connell, M. (2004) Issues Facing Preservative Suppliers in a Changing Market for Treated Wood. Final Workshop COST Action E22 "Environmental Optimisation of Wood Protection" Portugal: pp.8.

Cooper, P. (1994) Disposal of Treated Wood Removed from Service. Proceedings Environmental Considerations in the Manufacture, Use and Disposal of Preservative-Treated Wood, Madison, WI, Forest Products Society.

Cretney, M. (2005). M. Warnken. Personal Communication.

Death, D. (2004). J. Taylor. Personal Communication.

DEFRA. (2004) Information Bulletin: Consultation on Landfill Regulations 2005. 21 January 2005. <http://www.defra.gov.uk/news/2004/041215g.htm>

Department of Environment and Conservation NSW (2004) Waste Avoidance and Resource Recovery in NSW – A Progress Report.  
[http://www.resource.nsw.gov.au/data/strategy/Progress%20report\\_web\\_inc%20cover\\_V2.pdf](http://www.resource.nsw.gov.au/data/strategy/Progress%20report_web_inc%20cover_V2.pdf)

Department for Environment Food and Rural Affairs (2004) Government Interpretation of the Landfill (England and Wales) Regulations 2002 (As Amended). <http://www.defra.gov.uk/environment/waste/topics/landfill-dir/pdf/reg-interpret.pdf>

Department of Environment and Conservation New South Wales (2004) Public Consultation Report Extended Producer Responsibility Priority Statement 2004. Department of Environment and Conservation.

Department of Primary Industries Water and Environment. Tasmanian Waste Recovery and Recycling Directory.  
<http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-53LUW4?open>

Department of the Environment Transport and the Regions (DETR) (2000) Building a Better Quality of Life - A Strategy for More Sustainable Construction.

EcoRecycle Victoria. Data and Statistics.  
<http://www.ecorecycle.vic.gov.au/aboutus/statistics.asp>

EcoRecycle Victoria. EcoRecycle Timber Recovery Website.  
<http://www.ecorecycle.vic.gov.au/www/default.asp?casid=3503>



EcoRecycle Victoria. Timber Recovery.  
<http://203.147.170.129/www/default.asp?casid=3278>

EcoRecycle Victoria. What is Product Stewardship.  
<http://www.ecorecycle.vic.gov.au/www/default.asp?casid=2564>

EcoRecycle Victoria (2003) Towards Zero Waste – Appendix A: Supporting Analysis to the Strategy and Plan.  
[http://www.ecorecycle.vic.gov.au/asset/1/upload/TZW\\_-\\_Appendix\\_A\\_-\\_Supporting\\_Analysis\\_to\\_the\\_Strategy\\_&\\_Plan\\_\(2003\).pdf](http://www.ecorecycle.vic.gov.au/asset/1/upload/TZW_-_Appendix_A_-_Supporting_Analysis_to_the_Strategy_&_Plan_(2003).pdf)

EcoRecycle Victoria (2002) Supplementary Report to Solid Waste Strategy Discussion Paper 2002.

English, B. (1994) "Wastes into Wood: Composites are Promising." Environmental Health Perspectives **102**(2).

EPA Germany EPA Sourcebook, 3.14 DSD: Industry Run Packaging Waste Reduction System. <http://www.epa.be/workbooks/sourcebooks/3.14.html>

EU (1975) Council Directive of 15 July 1975 on Waste (75/442/EC).

EU (1991) Council Directive 91/689/EEC of 12 December 1991 on Hazardous Waste.

EU (1994) Council Directive 94/62/EC of 15 December 1994 on Packaging and Packaging Waste.

EU (1996) Council Directive 96/61/EC of 24 September 1996 Concerning Integrated Pollution Prevention and Control.

EU (1999) Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste.

EU (2000) Directive 2000/76/EC of the European Parliament and the Council of 4 December 2000 on the Incineration of Waste.

EU (2003) Commission Directive 2003/2/EC of 6 January 2003 Relating to Restrictions on the Marketing and Use of Arsenic (tenth adaptation to technical progress to Council Directive 76/769/EEC).

Europa. 22 February 2005.  
<http://www.europa.eu.int/comm/enterprise/construction/internal/cpd/cpd.htm>

European Commission (2000) "EC 1980/2000."  
[http://europa.eu.int/comm/environment/ecolabel/pdf/regulation/001980\\_en.pdf](http://europa.eu.int/comm/environment/ecolabel/pdf/regulation/001980_en.pdf)

European Commission. (2003) Draft Commission Decision of 10 December 2003 Establishing Ecological Criteria for the Award of the Community Eco-Label to Furniture.

Feldhoff, R., T. Huth-Fehre, et al. (1998) "Detection of Inorganic Wood Preservatives of Timber by Near Infrared Spectroscopy." Journal of Infrared Spectroscopy **6A**: 171 - A173.

FIRA. <http://www.fira.co.uk>

Flood, J. (2003) "Developing Biomass Fuel Supplies" Bioenergy Australia 2003 Conference, Brighton Beach, NSW.

Foster, D. and R. Collins (2004) "Closing the Loop on Building Waste." Inside Waste **4** (14).

Gifford, J. S., N. A. Marvin, et al. (1996) Options for the Disposal of CCA Treated Timber. 25th Forest Products Research Conference.

Gifford, J. S., N. A. Marvin, et al. (1997) Composition of Leachate from Field Lysimeters Containing CCA Treated Wood. Annual Meeting of the American Wood-Preservers Association.

Government of Western Australia, Waste Management Board (2003) Summary Report of Waste to Landfill, Perth Metropolitan Region, Western Australia (1 July 1998 – 30 June 2002).

<http://www.wastewa.com/Uploads/Images/Waste%20to%20Landfil%20-%20Perth%20Metropolitan%20Region.pdf>

Gradient Corporation (2002) White Paper on Groundwater at Florida's Unlined Construction and Demolition Debris Landfills Related to CCA-Treated Wood Disposal. American Chemistry Council Biocides Panel

Gray, S. and J. Houlihan. (2002) All Hands on Deck.  
<http://www.ewg.org/reports/allhandsondeck/AllHandsOnDeck.pdf>

Helsen, L. and E. Van den Bulck (2005) "Review of Disposal Technologies for Chromated Copper Arsenate (CCA) Treated Wood Waste, With Detailed Analysis of Thermochemical Conversion Processes." Environmental Pollution **134**: 301-314.

Hery, J. (2004) A Complete Industrial Process to Recycle CCA-Treated Wood. Proceedings of the Environmental Impacts of Preservative-Treated Wood Conference, Orlando, FL.

Holton, W. (2001) Disposing of CCA-Treated Wood.  
<http://ehp.niehs.nih.gov/docs/2001/109-6/innovations.html>

Homan, W. and H. Militz Evaluation of Rapid Methods for Detecting Wood Preservatives in Wood Waste, International Research Group on Wood Preservation.

IARC Monographs Programme. (2004) Formaldehyde CAS 50-00-0. 16 February 2005. <http://www-cie.iarc.fr/htdocs/monographs/vol88/formal.html>

International Agency for Research on Cancer. (2004) Press Release No. 153 "IARC Classifies Formaldehyde as Carcinogenic to Humans". 2 February 2005.  
<http://www.iarc.pr/pageroot/preleases/pr153a.html>

IPCS INCHEM. (1989) Environmental Health Criteria: Formaldehyde. 31 January 2004. <http://www.inchem.org/documents/ehc/ehc/ehc89.htm>

IPCS INCHEM. (1991) Formaldehyde, Health and Safety Guide. 15 February 2004.  
<http://www.inchem.org/documents/hsg/hsg/hsg057.htm>

IPCS INCHEM. (2002) Formaldehyde. 15 February 2004.  
<http://www.inchem.org/documents/cicads/cicads/cicad40.htm>

Irle, M., K. Maher, et al. (2004) Development Methods and Sampling Protocols for Measuring Contaminants in Recycled Wood for Use in the Panelboard Sector. T. W. a. R. A. P. (WRAP)

Junsun Instruments.  
<http://www.jusun.com.tw/IMS%20Application%20for%20CEM.pdf>

Kartal, S. (2003) "Removal of Copper, Chromium and Arsenic from CCA-C Treated Wood by EDTA Extraction." Waste Management **23**: 537-546.

Kartal, S. and Y. Imamura (2005) "Removal of Copper, Chromium and Arsenic from CCA-Treated Wood Onto Chitin and Chitosan." Bioresource Technology **96**: 389-392.

Kartal, S., E. Munir, et al. (2004) "Bioremediation for CCA-Treated Wood by Brown-Rot Fungi *Fomitopsis palustris*, *Coniophora puteana* and *Laetiporus sulphureus*." Journal of Wood Science **50**: 182-188.

Kearly, V. and G. Goroyias (2004) Wood Panel Recycling at a Semi Industrial Scale. Proceedings of the 8th European Panel Products Symposium.  
<http://www.envirofibre.co.uk>

Kelley, S., B. Hames, et al. Use of Near Infrared Spectroscopy for Characterisation of Wood. National Renewable Energy Laboratory, National Bioenergy Center

Lebow, S. (2001) Techline: Durability. "Coatings Minimise Leaching from Treated Wood". US Department of Agriculture, Forest Products Laboratory.  
<http://www.fpl.fs.fed.us/documnts/techline/iii-4.pdf>

Lebow, S., R. Williams, et al. (2003) "Effect of Simulated Rainfall and Weathering on Release of Preservative Elements from CCA Treated Wood." Environmental Science & Technology **38**: 4077-4082.

Macquarie Generation. Biomass Co-Firing.  
[http://www.greenhouse.gov.au/challenge/members/success-stories/mac\\_gen.html](http://www.greenhouse.gov.au/challenge/members/success-stories/mac_gen.html)

Magin, G. (2001) An Introduction to Wood Waste in the UK. Cambridge, UK, Flora and Fauna International.

Maruhon. JAS Certification of Formaldehyde. 18 February 2005.  
<http://www.maruhon.com/business/formaldehyde.htm>

Merl, A. (2001) Waste Management Options in Europe - Information Compiled in COST Action E9: 35

Moskal, T. and D. Hahn (2002) "On-Line Sorting of Wood Treated with Chromated Copper Arsenate Using Laser-Induced Breakdown Spectroscopy." Applied Spectroscopy **56**(10): 1337-1344.

National Pollution Inventory. (2003-2004) Substance Emissions - All Sources: Australia. <http://www.npi.gov.au>

Nolan-ITU Pty. Ltd. (2001) Re-Use and Recycling of Clean Fill and Building and Demolition Waste. EcoRecycle Victoria. Melbourne

NSW Waste Boards (2000) "Wood Waste Project Final Report."

NSW Waste Boards (2001) A Survey of Infrastructure for the Receiving and Processing of Wood Waste

OECD SIDS. (2002) Initial Assessment Report for SIAM 14. Formaldehyde. January 2005. <http://www.chem.unep.ch/irptc/sids/oecdsids/Formaldehyde.pdf>

Oskoui, K. (2004) Recovery and Reuse of the Wood and Chromated Copper Arsenate (CCA) from CCA Treated Wood - A Technical Paper. Proceedings of Environmental Impacts of Preservative-Treated Wood Conference, Orlando, FL.  
<http://www.ccaresearch.org/Pre-Conference/pdf/Oskoui.pdf>

Plywood Association of Australia (2004) Formaldehyde Emissions from Plywood and Laminated Veneer Lumber. February 2005.  
<http://www.plywood.assn.com.au/pdf/form%202.pdf>

Queensland EPA (1999) State of the Environment.

Resource NSW (2003) The NSW Waste Avoidance and Resource Recovery Strategy.  
<http://www.resource.nsw.gov.au/strategy.htm#download>

Robson, D., L. Cookson, et al. (2002) Quantifying the Availability and Quantities of Wood Waste Resource. Conference on Wood Wastes - 2002 - Residues to Revenues, Melbourne.

Rochester, I. (2004) Rapid Identification and Sorting of Preservative Treated Wood. The Waste and Resources Action Programme (WRAP)

Russell, M. (2001) Wood Waste Generation in the Extended Sydney Region by the Commercial and Industrial Sector

Schröder, W., J. Kübler, et al. Measurement Strategies for Fast On-Site Separation of Waste Wood Treated with Wood Preservatives. Germany, Technical University of Hamburg-Hamburg.

Scown, D. (2005). J. Taylor. Personal Communication.

Smith, D. (2004) Forest Products Journal **54**(2): 8.

Solo-Gabriele, H., J. Pena, et al. (1998) "Generation, Use, Disposal and Management Options for CCA Treated Wood."

Solo-Gabriele, H., T. Townsend, et al. (2001) On-Line Sorting Technologies for CCA Treated Wood.

[http://www.dep.state.fl.us/waste/quick\\_topics/publications/shw/recycling/InnovativeGrants/IGyear3/finalreports/sarasota.pdf](http://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGyear3/finalreports/sarasota.pdf)

Solo-Gabriele, H., T. Townsend, et al. (2003) Environmental Impacts of CCA-Treated Wood: A Summary from Seven Years of Study Focusing on the U.S. Florida Environment. International Research Group on Wood Preservation, Brisbane.

South Australia EPA (2000) South Australia Landfill Audit 2000.

Southern Waste Strategy Authority of Tasmania.

<http://www.southernwaste.com.au/WasteComposition.pdf>

Statutory Instrument 1996 No. 1527. The Landfill Tax Regulations 1996.

[http://www.legislation.hmso.gov.uk/si/si1996/Uksi\\_19961527\\_en\\_1.htm](http://www.legislation.hmso.gov.uk/si/si1996/Uksi_19961527_en_1.htm)

Statutory Instrument 2002 No. 1559. The Landfill (England and Wales) Regulations 2002.

Stewart, M., J. Rogers, et al. (2004) Thermal Processing of CCA Treated Timbers for Energy Recovery and Environmental Protection: A Focus on Metals Deposition and Management of Metals Containing By-Products - Part 1. Forest and Wood Products Research and Development Corporation, CRESTA

Townsend, T., B. Dubey, et al. Assessed Potential Waste Disposal Impact from Preservative Treated Wood Products. University of Miami. Miami, FL, University of Florida and Department of Civil, Architectural and Environmental Engineering

Townsend, T., K. Stook, et al. (2001) New Lines of CCA-Treated Wood Research: In-Service and Disposal Issues. Florida Center for Solid and Hazardous Waste Management. Florida

Townsend, T., T. Tolaymat, et al. (2004) "Leaching of CCA-Treated Wood: Implications for Waste Disposal." Journal of Hazardous Materials **B114**: 75-91.

Trossero, M. Survey of Energy Resources: Wood (Including Charcoal).

<http://www.worldenergy.org/wec-geis/publications/reports/ser/wood/wood.asp>

U.S. Environmental Protection Agency (1999) Integrated Risk Information System (IRIS) on 4,4'-Methylenediphenyl Isocyanate. Office of Research and Development.

Uhl, A., K. Loebe, et al. (2001) "Fast Analysis of Wood Preservers Using Laser Induced Breakdown Spectroscopy." Spectrochimica Acta Part B **56**: 795-806.

Urban Harvest (2004) Characterisation of Emerging Higher Value Markets for Recycled Wood Products, The Waste and Resources Action Programme (WRAP)

US EPA (1996) Test Methods for Evaluating Solid Waste, SW 846,3. Washington D.C., Office of Solid Waste and Emergency Response

US EPA (2000) RCRA Orientation Manual EPA 530R-00-006. Office of Solid Waste and Emergency Response. Washington D.C.

Waste and Resources Action Programme (WRAP) (2003) Wood Waste Recycling in Furniture Manufacturing – A Good Practice Guide.  
<http://www.wrap.org.uk>

Waste and Resources Action Programme (WRAP) (2003b) Wood Plastic Composite Study – Technologies and UK Market Opportunities.

Warnken, M. (2001) Utilisation Options for Waste Wood: A Review of European Technologies and Practices. Gottstein Fellowship Report. Melbourne, CSIRO

Warnken, M. (2001b) Wood Waste in New South Wales: Analysis, Current Projects and Future Directions. 27th Forest Products Research Conference, Melbourne, CSIRO.

Wasteline. (2004) Wasteline Information. 26 May 2004.  
<http://www.wasteline.org.uk/resources/InformationSheets/Legislation.htm>

Western Australia Department of Environment and Waste Management Board (2003) Strategic Direction for Waste Management in Western Australia.  
[http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE\\_ADMIN/POLICY\\_REPOSITORY/TAB1144266/1862\\_STRATEGIC\\_WASTE\\_0308.PDF](http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/POLICY_REPOSITORY/TAB1144266/1862_STRATEGIC_WASTE_0308.PDF)

WHO Regional Publications (2000) European Series, No. 91: Air Quality Guidelines for Europe.

Wood Recycling. <http://www.dti.gov.uk/sustainability/downloads/wood.pdf>

Wright, T., C. Zoi, et al. (2000) Report of the Alternative Waste Management Technologies and Practices Enquiry

Zimms, M. and S. Barnett (2004) Managing Industrial Wood Wastes: Sumter County Wood Reuse and Exchange Centre. Environmental Impacts of Preservative-Treated Wood Conference, Orlando, FL. <http://www.ccaresearch.org/Pre-Conference/pdf/Zimms.pdf>

Zero Waste South Australia (2004) Background Paper to South Australia's Waste Strategy 2005-2010.  
[http://www.zerowaste.sa.gov.au/pdf/0510\\_strategy\\_background.pdf](http://www.zerowaste.sa.gov.au/pdf/0510_strategy_background.pdf)

## **Appendix A   Recycling Case Studies**



<b>Title</b>	<b>Year</b>	<b>Summary</b>	<b>Website</b>
Clean Pine Wood Waste Recycling	1997	Use of lightweight skips to collect 700 tonnes of pine wood to be recycled into particleboard. Due to not being economically viable, it was recycled into mulch	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Clean_Pine_Wood_Waste_Recycling_(1997).pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Clean_Pine_Wood_Waste_Recycling_(1997).pdf</a>
Collection of Waste Timber from Melbourne Businesses	1998	Survey indicates that 92300m <sup>3</sup> of timber off cuts and 47300m <sup>3</sup> of sawdust generated	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Collection_of_Waste_Timber_from_Melbourne_Businesses_Part_One.pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Collection_of_Waste_Timber_from_Melbourne_Businesses_Part_One.pdf</a>
Collection of Waste Timber from Melbourne Businesses Part 2: Infrastructure Requirements	1999	Found opportunities and constraints for timber recycling to include: contamination, lack of awareness, lack of financial incentive, and lack of suitable infrastructure.	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Collection_of_Waste_Timber_from_Melbourne_Businesses_Part_Two.pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Collection_of_Waste_Timber_from_Melbourne_Businesses_Part_Two.pdf</a>
Recycling Post-Industrial Composite Wood Waste Material Within The Commercial Furniture Industry	1998	Explored whether waste could be turned into productive material. Panels made from re-grind particleboard had adequate internal bond strength, but low bending strength even at high densities. Panels made from re-grind MDF were totally unacceptable in performance, this may be due to damage done to the fibres during attrition.	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Recycling_Post_Industrial_Composite_Wood_Waste_Material_Withi.pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Recycling_Post_Industrial_Composite_Wood_Waste_Material_Withi.pdf</a>

Expansion of the Pallet and Timber Recycling Industry in the Barwon Region	2000	Identified a pallet recycling facility would not be beneficial due to: low margins, cost of collecting waste pallets, labour intensive business, and cost of disposal of timber waste from process	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Expansion_of_the_Pallet_and_Timber_Recycling_Industry_in_the_.pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Expansion_of_the_Pallet_and_Timber_Recycling_Industry_in_the_.pdf</a>
Victorian Case Study 1: Western Link Construction		4000m <sup>3</sup> timber recycled which made up 26% of total waste recycled from the project	<a href="http://onsite.rmit.edu.au/case/case001V.htm">http://onsite.rmit.edu.au/case/case001V.htm</a>
Joinery - saving on timber waste disposal and heating costs	2004	Agreements with local farmers (taking wood chip) and investment in a wood fuelled boiler saved over £5,000/year on skip costs. Installing the boiler also reduced heating costs by approximately £1,200/year and improved working practices and environmental health and safety.	<a href="http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(J%20Hodson)%20web.pdf">http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(J%20Hodson)%20web.pdf</a>
Recycling of Timber Used in Plastic Packaging Industry	2003	5 semi trailers of timber removed for recycling (cost saving of 75% over landfill)	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/CS_ACItimber2003.ppt#3">http://www.ecorecycle.vic.gov.au/resources/documents/CS_ACItimber2003.ppt#3</a>
Furniture Industry Waste Minimisation	1998		<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Furniture_Industry_Waste_Minimisation_(1998).pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Furniture_Industry_Waste_Minimisation_(1998).pdf</a>
Reuse and Recycling of Timber Window Frame	1995	Potential for reuse of windows is limited due the perceived opinion of substandard products being used.	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Reuse_and_Recycling_of_Timber_Window_Frames_(1995).pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Reuse_and_Recycling_of_Timber_Window_Frames_(1995).pdf</a>

Waste Generation and Recycling in the Residential Demolition Sector		Diversion varied significantly from 17% to 63% with location, range of materials and condition of house being the key influencing factors. Reuse of bricks, windows, doors, tiles and flooring is generally worthwhile compared to the cost of land filling in Melbourne.	<a href="http://www.ecorecycle.vic.gov.au/resources/documents/Waste_Gen_and_Recycling_in_the_Residential_Demolition_Sector.pdf">http://www.ecorecycle.vic.gov.au/resources/documents/Waste_Gen_and_Recycling_in_the_Residential_Demolition_Sector.pdf</a>
Recycling wood waste: how furniture manufacturers can cut costs and boost profits		Wood waste is costing manufacturers up to 10% of turnover in the charges made for disposing of its waste to landfill and improvements made in waste reduction, reuse and recycling can generate up to 1% of turnover, or as much as 10% of profits.	<a href="http://www.wrap.org.uk/templates/temp_publication.rm?id=698&amp;publication=466">http://www.wrap.org.uk/templates/temp_publication.rm?id=698&amp;publication=466</a>
Saving on waste disposal - through waste segregation in construction		Over a three-year period at its central offices the total waste, total cost of waste and waste to landfill were reduced by 73%, 76% and 87% respectively, while waste recycled was increased to 125 tonnes from 0.	<a href="http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Simons)%20web.pdf">http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Simons)%20web.pdf</a>
Avoiding landfill through effective wood waste disposal & a shift in product focus	2004	Input Joinery is a privately owned company that has gone from strength to strength over the last 25 years. However, with the expansion of the business has come an increase in wood waste output.	<a href="http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Input)%20web.pdf">http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Input)%20web.pdf</a>

The Eden Project - a waste neutral strategy in construction and operation	2004	The Eden Project has always maintained a policy to undertake all its construction projects in an environmentally sustainable fashion. Through the development and implementation of a new Waste Neutral Strategy, the capacity of the project to recycle and reuse materials while avoiding landfill is being increased.	<a href="http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Eden)%20web.pdf">http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Eden)%20web.pdf</a>
Environmentally responsible construction: Community wood recycling	2004	The Brighton & Hove Wood Recycling Project works closely with Integra and helps to reduce the costs of wood waste disposal, and divert timber waste from landfill throughout the Brighton area	<a href="http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Bright-Integ)%20web.pdf">http://www.recycle-it.org/news/downloads/WM-construction%20sector%20(Bright-Integ)%20web.pdf</a>
Wood waste footprint for the M62 (west) corridor	2004	This project carried out a detailed study of the M62 (west) corridor region establishing volumes and types of wood waste generated and the opportunities for recycling this material.	<a href="http://www.wrap.org.uk/templates/temp_publication.rm?id=698&amp;publication=455">http://www.wrap.org.uk/templates/temp_publication.rm?id=698&amp;publication=455</a>
Simons Construction Site: Sherwood Park, Annesley, Nottingham		Simons attempted to reduce total waste, waste to landfill and waste costs, while increasing on site segregation.	<a href="http://www.wastecycle.co.uk/resourcefs/145.pdf">http://www.wastecycle.co.uk/resourcefs/145.pdf</a>

Local authority: Greater Manchester Waste Limited		Household Waste Recycling Centres collecting and disposing/recycling timber products	<a href="http://rpg.nwra.gov.uk/uploads/rpg_docs/rp_Fpje_WRAP_M62_SUMMARY_Case_Studies.pdf">http://rpg.nwra.gov.uk/uploads/rpg_docs/rp_Fpje_WRAP_M62_SUMMARY_Case_Studies.pdf</a>
Wood processor supplying the particleboard industry: Armstrong's Environmental Services Ltd		An average of about 2,000 tonnes of waste wood is processed per week and turned into particleboard	<a href="http://rpg.nwra.gov.uk/uploads/rpg_docs/rp_Fpje_WRAP_M62_SUMMARY_Case_Studies.pdf">http://rpg.nwra.gov.uk/uploads/rpg_docs/rp_Fpje_WRAP_M62_SUMMARY_Case_Studies.pdf</a>
Boulderstone Hornibrook		The successful implementation of the waste management program resulted in a 77% (28.8% timber) recycling rate and a 40% cost saving.	<a href="http://www.resource.nsw.gov.au/data/wpgboulderstone.pdf">http://www.resource.nsw.gov.au/data/wpgboulderstone.pdf</a>
Abigroup Constructions		Waste diversion of 82% (45% timber)	<a href="http://www.resource.nsw.gov.au/data/wpgabigroup.pdf">http://www.resource.nsw.gov.au/data/wpgabigroup.pdf</a>
Multiplex Constructions		An 86% (34% timber) recycling rate resulted in a 30% saving in waste costs.	<a href="http://www.resource.nsw.gov.au/data/wpgmultiplex.pdf">http://www.resource.nsw.gov.au/data/wpgmultiplex.pdf</a>

## **Appendix B Australian Environmental and Waste Related Legislation**

## Australia – Department of Environment and Heritage (DEH) Relevant Acts:

- Environment Protection and Biodiversity Conservation Act 1999 (<http://scaleplus.law.gov.au/html/pasteact/3/3295/pdf/EnvProtBioDivCons1999Vol01.pdf>)
  - aims to promote ecologically sustainable development and environmental responsibility
- National Environment Protection Council (NEPC) Act 1994 (<http://scaleplus.law.gov.au/html/pasteact/2/1168/pdf/NatEnvProCou1994.pdf>)
  - provides for the establishment of a National Environment Protection Council (NEPC) that has the power to make national environment protection measures
- National Environment Protection Measures (Implementation) Act 1998 (<http://scaleplus.law.gov.au/html/pasteact/3/3254/pdf/NatEnvProtMeasImp98.pdf>)
  - makes provision for the implementation of environment protection measures relating to Commonwealth activities
- Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 (<http://scaleplus.law.gov.au/html/pasteact/1/680/pdf/OzProSynGreenGasMan1989.pdf>)
  - relates to a system of controls on the manufacture, import and export on ozone depleting substances
- Renewable Energy (Electricity) Act 2000 (<http://scaleplus.law.gov.au/html/pasteact/3/3431/pdf/174of2000.pdf>)
  - establishment and administration of a scheme to encourage additional electricity generation from renewable energy sources
- Renewable Energy (Electricity)(Charge) Act 2000 (<http://scaleplus.law.gov.au/html/pasteact/3/3408/pdf/RenEnergyElectCharge2000.pdf>)
  - relates to the imposition of the renewable energy shortfall charge. This occurs when an entity does not meet the renewable energy quota as outlined in the Renewable Energy (Electricity) Act 2000
- Product Stewardship (Oil) Act 2000

## Key Initiatives:

- National Pollution Inventory (NPI) (<http://www.npi.gov.au>)
  - emission data are reported in terms of substance, source, facility and/or location. The intent is to provide a better understanding of emissions

with a view to using this information to develop ways to reduce emissions

- It is implemented by the states and territories through their environmental legislation.
- National strategy for ecologically sustainable development - <http://www.deh.gov.au/esd/national/nsesd/>
- National waste minimisation strategy –
- National Strategy for the Management of Scheduled Waste - <http://www.deh.gov.au/industry/chemicals/scheduled-waste/strategy.html>
- The Green and Organic Waste Management Strategy [http://ngs.greenhouse.gov.au/action\\_plans/module7/measure7.3/index.html](http://ngs.greenhouse.gov.au/action_plans/module7/measure7.3/index.html)
- National Packaging Covenant

NEW SOUTH WALES – DEPARTMENT OF ENVIRONMENT AND CONSERVATION (DEC)

### **Relevant Acts:**

- Environmental Trust Act 1998  
(<http://www.legislation.nsw.gov.au/fullhtml/inforce/act+82+1998+first+0+N>)
- National Environment Protection Council (New South Wales) Act 1995
  - provides for the establishment of a National Environment Protection Council (NEPC) that has the power to take national environment protection measures
- Ozone Protection Act 1989  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/act+208+1989+first+0+N>)
  - this act may be used in the control or prohibition of substances that deplete stratospheric ozone when emitted to the atmosphere or articles that contain those substances in their operation
- Protection of the Environment Administration Act 1991  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/act+60+1991+first+0+N>)
  - outlines the objectives of the EPA as well as establishing environmental education and awareness programs –
- Protection of the Environment Operations Act 1997 (POEO) Act  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/act+60+1991+first+0+N>)
  - this act is concerned with environment protection licenses, notices and offences. It also includes powers regarding tradeable emission schemes
- Waste Avoidance and Resource Recovery Act 2001  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/act+58+2001+first+0+N>)



- relates to extended producer responsibility with regards to process wastes. A biomass power station may be able to utilise wastes from residential, commercial and/or industrial processes. There is also funding available for such schemes under this Act.

### **Relevant Regulations:**

- Clean Air (Plant and Equipment) Regulation 1997  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+365+1997+first+0+N>)
- Clean Waters Regulation 1972  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+010+1972+first+0+N>)
- Ozone Protection Regulation 1997  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+369+1997+first+0+N>)
- Protection of the Environment Administration Regulation 2002  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+589+2002+first+0+N>)
- Protection of the Environment Operations (Clean Air) Regulation 2002  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+642+2002+first+0+N>)
- Protection of the Environment Operations (Control of Burning) Regulation 2000  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+487+2000+first+0+N>)
- Protection of the Environment Operations (General) Regulation 1998  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+720+1998+first+0+N>)
- Protection of the Environment Operations (Noise Control) Regulation 2000  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+537+2000+first+0+N>)
- Protection of the Environment Operations (Penalty Notices) Regulation 2004  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+601+2004+first+0+N>)
- Protection of the Environment Operations (Savings and Transitional) Regulation 1998  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+718+1998+first+0+N>)
- Protection of the Environment Operations (Waste) Regulation 1996  
(<http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+541+1996+first+0+N>)

## Relevant Policies:

VICTORIA – ENVIRONMENT PROTECTION AUTHORITY (VIC EPA)

## Relevant Acts:

- Environment Protection Act 1970  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/a12f6f60fbd56800ca256de500201e54/fa2474e284a739d7ca256ebb0010677e/\\$FILE/70-8056a143.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/a12f6f60fbd56800ca256de500201e54/fa2474e284a739d7ca256ebb0010677e/$FILE/70-8056a143.pdf))
  - key aims of the Act include sustainable use and holistic management of the environment, ensuring consultative processes are adopted so that community input is a key driver of environment protection goals and programs and encouraging a co-operative approach to environment protection
- Environment Protection (Resource Efficiency) Act 2002  
([http://www.epa.vic.gov.au/Publications/Legislation/Resource\\_Efficiency\\_Act/default.asp](http://www.epa.vic.gov.au/Publications/Legislation/Resource_Efficiency_Act/default.asp))
  - this Act made amendments to the Environment Protection Act 1970 to encourage more innovative ways to increase the efficiency of resources and reduce the ecological impact.
- National Environment Protection Council (Victoria) Act 1995  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/a12f6f60fbd56800ca256de500201e54/53cdcb0ec2abee62ca256e660008b515/\\$FILE/95-10a002.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/a12f6f60fbd56800ca256de500201e54/53cdcb0ec2abee62ca256e660008b515/$FILE/95-10a002.pdf))
  - this Act seeks to protect people from air, water and soil pollution no matter where in Australia they reside. It is a framework of national objectives to ensure the standards are similar in each state and territory. In this case it would make certain that residents in the vicinity of EfW facilities were not subject to sub-standard environmental conditions

## Relevant Regulations:

- Environment Protection (Fees) Regulations 2001  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/5eb1eb0a77dc28baca256ec400045fe1/\\$FILE/01-119sr004.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/5eb1eb0a77dc28baca256ec400045fe1/$FILE/01-119sr004.pdf))
- Environment Protection (Prescribed Wastes) Regulations 1998  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/30b0d6a43958f7f5ca256f0a0016694f/\\$FILE/98-95sr010.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/30b0d6a43958f7f5ca256f0a0016694f/$FILE/98-95sr010.pdf))

- Environment Protection (Residential Noise) Regulations 1997  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/ac0312815158ff2fca256e5b0003a25f/\\$FILE/97-120sr001.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/ac0312815158ff2fca256e5b0003a25f/$FILE/97-120sr001.pdf))
- Environment Protection (Scheduled Premises and Exemptions) Regulations 1996  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/2dff630cd3746bb0ca256f0a0016ce03/\\$FILE/96-66sr002.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/2dff630cd3746bb0ca256f0a0016ce03/$FILE/96-66sr002.pdf))
- Environment Protection (Vehicle Emissions) Regulations 2003  
([http://www.dms.dpc.vic.gov.au/Domino/Web\\_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/91afc3be22d6375bca256ec400047c57/\\$FILE/03-10sr002.pdf](http://www.dms.dpc.vic.gov.au/Domino/Web_Notes/LDMS/PubLawToday.nsf/b12e276826f7c27fca256de50022686b/91afc3be22d6375bca256ec400047c57/$FILE/03-10sr002.pdf))

## Relevant Policies:

- State Environment Protection Policy (SEPP) (Ambient Air Quality)  
(<http://www.gazette.vic.gov.au/Gazettes1999/GG1999S019.pdf>)
  - May indirectly influence ability of potential wood waste industry through emission monitoring (more likely Air Quality Management Policy (below) will have greater influence).
  - Sets air quality targets for ambient air, including standards and monitoring policies for CO, NO<sub>2</sub>, photochemical oxidants (ozone), SO<sub>2</sub>, lead and particles.
- State Environment Protection Policy (SEPP) (Air Quality Management)  
(<http://www.gazette.vic.gov.au/Gazettes2001/GG2001S240.pdf>)
  - Framework for managing emissions from all sources
  - This framework allows EPA to monitor and serve infringement notices on industry breaking emission standards and therefore will influence the ability to utilise waste wood, particularly as an energy source.
- State Environment Protection Policy (SEPP) (Prevention and Management of Contamination of Land)  
(<http://www.gazette.vic.gov.au/Gazettes2002/GG2002S095.pdf>)
- State Environment Protection Policy (SEPP) (Groundwaters of Victoria)  
(<http://www.gazette.vic.gov.au/Gazettes2002/GG2002G012.pdf>)
- State Environment Protection Policy (SEPP) (Control of Noise From Commerce, Industry and Trade)  
(<http://www.gazette.vic.gov.au/Gazettes2001/GG2001S183.pdf>)
- State Environment Protection Policy (SEPP) (Waters of Victoria)  
(<http://www.gazette.vic.gov.au/Gazettes2004/GG2004S210.pdf>)
- Industrial Waste Management Policy (Prescribed Industrial Waste) 2000  
(<http://www.gazette.vic.gov.au/Gazettes2002/GG2002G044.pdf>)

- Industrial Waste Management Policy (Siting, Design and Management of Landfill) 2004  
(<http://www.gazette.vic.gov.au/Gazettes2005/GG2005G016.pdf>)
- State Environment Protection Policy (SEPP) (Used Packaging Materials)  
<http://www.gazette.vic.gov.au/Gazettes2000/GG2000S088.pdf>
  - Aims to reduce volumes of used packaging material disposed of to landfill and to reduce the raw materials which go into making those packaging materials
  - Supports the voluntary *National Packaging Covenant*
  - Those industries/companies that sign on then take over responsibility for product over length of its lifecycle (Extended Producer Responsibility (EPR))

#### QUEENSLAND - ENVIRONMENT PROTECTION AGENCY (QLD EPA)

#### Relevant Acts:

- Environmental Protection Act 1994  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen2](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen2))
  - the Act defines what is meant by terms such as contamination and waste etc. It also regulates “environmentally relevant activities” and categorises them depending on the potential environmental harm from released contaminants
- National Environment Protection Council (Queensland) Act 1994  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen11](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen11))
  - this Act seeks to protect people from air, water and soil pollution no matter where in Australia they reside. It is a framework of national objectives to ensure the standards are similar in each state and territory.

#### Relevant Regulations:

- Environmental Protection Regulation 1998  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen3](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen3))
- Environmental Protection (Waste) Policy and Regulation 2000  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen4](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen4))
- Environmental Protection (Interim Waste) Regulation 1996  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen5](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen5))

#### Relevant Policies:

- Environmental Protection (Water) Policy 1997  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen6](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen6))
- Environmental Protection (Noise) Policy 1997  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen7](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen7))
- Environmental Protection (Air) Policy 1997  
([http://www.epa.qld.gov.au/about\\_the\\_epa/legislation/environmental\\_protection/#gen8](http://www.epa.qld.gov.au/about_the_epa/legislation/environmental_protection/#gen8))

## WESTERN AUSTRALIA – DEPARTMENT OF ENVIRONMENT

### Relevant Acts:

- Environmental Protection Act 1986  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Environmental+Protection+Act+1986>)
  - this Act relates to the Precautionary Principle<sup>47</sup> which means a relatively new process such as the one developed by EfW processors may come under extra scrutiny. However, it does also focus on waste minimisation, intergenerational equity and extended producer responsibility
- Rights in Water and Irrigation Act 1914  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Rights+in+Water+and+Irrigation+Act+1914>)
  - relates to the supply of water. Applicability to EfW depends on the source of water for the operations
- Country Areas Water Supply Act 1947  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Environmental+Protection+Act+1986>)
  - similar to Rights in Water and Irrigation Act 1914
- Environmental Protection (Landfill) Levy Act 1998  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Environmental+Protection+\(Landfill\)+Levy+Act+1998](http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Environmental+Protection+(Landfill)+Levy+Act+1998))
  - relates to levies at landfill sites. May be used by EfW to encourage potential suppliers of fuel by offering a more economical disposal alternative.
- Swan River Trust Act 1998  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Swan+River+Trust+Act+1988>)

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<sup>47</sup> Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation

- only applicable if considering a site along the Swan River or in its catchment area.
- Water Boards Act 1904  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Water+Boards+Act+1904> )
  - relates to the supply and distribution of water
- Water and Rivers Commission Act 1995  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Water+and+Rivers+Commission+Act+1995>)
  - relates to the use of water resources
- Waterways Conservation Act 1976  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Water+and+Rivers+Commission+Act+1995> )
  - management and protection of waterways (rivers, inlets etc) and associated water bodies (lakes, canals etc)
- Water Agencies (Powers) Act 1984  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Water+Agencies+\(Powers\)+Act+1984](http://www.slp.wa.gov.au/statutes/av.nsf/SlpActV?openagent&act=Water+Agencies+(Powers)+Act+1984) )
  - relates to water services

### **Relevant Regulations:**

- Clean Air (Determination of Air Impurities in Gases Discharged to the Atmosphere) Regulations 1983  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Clean+Air+\(Determination+of+Air+Impurities+In+Gases+Discharged+to+the+Atmosphere\)+Regulations+1983](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Clean+Air+(Determination+of+Air+Impurities+In+Gases+Discharged+to+the+Atmosphere)+Regulations+1983))
- Environmental Protection Regulations 1997  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+Regulations+1987> )
- Environmental Protection (Controlled Waste) Regulations 2001  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(Controlled+Waste\)+Regulations+2004](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(Controlled+Waste)+Regulations+2004) )
- Environmental Protection (Kwinana)(Atmospheric Wastes) Regulations 1992  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(Kwinana\)+\(Atmospheric+Wastes\)+Regulations+1992](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(Kwinana)+(Atmospheric+Wastes)+Regulations+1992) )
- Environmental Protection (NEPM – National Pollution Inventory) Regulations 1998  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(NEPM+-NPI\)+Regulations+1998](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(NEPM+-NPI)+Regulations+1998) )

- Environmental Protection (Noise) Regulations 1997  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(Noise\)+Regulations+1997](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(Noise)+Regulations+1997))
- Environmental Protection (Rural Landfill) Regulations 2002  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(Rural+Landfill\)+Regulations+2002](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(Rural+Landfill)+Regulations+2002))
- Environmental Protection (Unauthorised Discharges) Regulations 2004  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+\(Unauthorised+Discharges\)+Regulations+2004](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Environmental+Protection+(Unauthorised+Discharges)+Regulations+2004))
- Noise Abatement (Noise Labelling of Equipment) Regulations (No. 2) 1985  
([http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Noise+Abatement+\(Noise+Labelling+of+Equipment\)+Regulations+\(No+2\)+1985](http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Noise+Abatement+(Noise+Labelling+of+Equipment)+Regulations+(No+2)+1985))
- Rights in Water and Irrigation Regulations 2000  
(<http://www.slp.wa.gov.au/statutes/av.nsf/SlpRegV?openagent&act=Rights+in+Water+and+Irrigation+Regulations+2000>)

SOUTH AUSTRALIA - ENVIRONMENT PROTECTION AUTHORITY (SA EPA)

### Relevant Acts:

- Environment Protection Act 1993  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Acts/e/1993.76.un.htm>)
  - relates to the principles of ecologically sustainable development. Also includes monitoring and reporting standards.
- National Environment Protection Council (South Australia) Act 1995  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Acts/n/1995.1.htm>)
  - this Act seeks to protect people from air, water and soil pollution no matter where in Australia they reside. It is a framework of national objectives to ensure the standards are similar in each state and territory. In this case it would make certain that residents in the vicinity of EfW facilities were not subject to sub-standard environmental conditions
- Water Resources Act 1997  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Acts/w/1997.27.un.htm>)
  - relates to the use and management of water resources throughout the state
- Development Act 1993  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Acts/d/1993.55.un.htm>)
  - regulates the use and management of land and buildings, and the design and construction of buildings. It also makes provision for the maintenance and conservation of land and buildings where appropriate

## Relevant Regulations:

- Environment Protection (Exempt Classes of Persons and Activities) Regulations 2001  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Regulations/e/2001.39.htm>)
- Environment Protection (Fees and Levy) Regulations 1994  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Regulations/e/2001.39.htm>)
- Environment Protection (General) Regulations 1994  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Regulations/e/1994.183.un.htm>)
- Environment Protection (Ozone) Regulations 1994  
(<http://www.parliament.sa.gov.au/Catalog/legislation/Regulations/e/1994.182.htm>)

## Relevant Policies:

- Environment Protection (Air Quality) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epp\\_air.pdf](http://www.epa.sa.gov.au/pdfs/epp_air.pdf))
- Environment Protection (Burning) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epp\\_burning.pdf](http://www.epa.sa.gov.au/pdfs/epp_burning.pdf))
- Environment Protection (Industrial Noise) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epp\\_noise\\_ind.pdf](http://www.epa.sa.gov.au/pdfs/epp_noise_ind.pdf))
- Environment Protection (Machine Noise) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epp\\_noise\\_mach.pdf](http://www.epa.sa.gov.au/pdfs/epp_noise_mach.pdf))
- Environment Protection (Waste Management) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epp\\_waste.pdf](http://www.epa.sa.gov.au/pdfs/epp_waste.pdf))
- Environment Protection (Water Quality) Policy 1994  
([http://www.epa.sa.gov.au/pdfs/epwq\\_policy.pdf](http://www.epa.sa.gov.au/pdfs/epwq_policy.pdf))

TASMANIA – DEPARTMENT OF PRIMARY INDUSTRIES, WATER AND ENVIRONMENT  
(DPIWE)

## Relevant Acts:

- Environmental Management and Pollution Control Act 1994  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=44%2B%2B1994%2BAT%40EN%2B20050323080000;histon=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=44%2B%2B1994%2BAT%40EN%2B20050323080000;histon=;prompt=;rec=;term=))
  - focuses on the prevention, reduction and remediation of environmental harm.



## Relevant Regulations:

- Environmental Management and Pollution Control (Environment Improvement Program Fees) Regulations 1994  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B219%2B1994%2BAT%40EN%2B20050323080000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B219%2B1994%2BAT%40EN%2B20050323080000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (Ozone Protection Authorisation Fees) Regulations 1995  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B62%2B1995%2BAT%40EN%2B20050323080000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B62%2B1995%2BAT%40EN%2B20050323080000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (General Fees) Regulations 1995  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B165%2B1995%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B165%2B1995%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (Transitional) Regulations 1995  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B166%2B1995%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B166%2B1995%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (Infringement Notices) Regulations 1996  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B77%2B1996%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B77%2B1996%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (Waste Management) Regulations 2000  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B218%2B2000%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B218%2B2000%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=))
- Environmental Management and Pollution Control (Miscellaneous Noise) Regulations 2004  
([http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc\\_id=%2B50%2B2004%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=](http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=%2B50%2B2004%2BAT%40EN%2B20050323090000;hison=;prompt=;rec=;term=))

## AUSTRALIAN CAPITAL TERRITORY – ENVIRONMENT ACT

### Relevant Acts:

- Environment Protection Act 1997 (<http://www.legislation.act.gov.au/a/1997-92/current/pdf/1997-92.pdf>)
  - focuses on the general reduction of environmental impacts

### Relevant Regulations:

- Environment Protection Regulations 1997  
(<http://www.legislation.act.gov.au/sl/1997-36/current/pdf/1997-36.pdf>)

## Relevant Policies:

- Environment Protection (General) Policy 1998  
(<http://www.environment.act.gov.au/Files/genepp.PDF>)
- Environment Protection (Waste Water Reuse) Policy 1999  
(<http://www.environment.act.gov.au/Files/wastewaterreuseforirrigationepp.pdf>)
- Environment Protection (Air) Policy 1999  
(<http://www.environment.act.gov.au/Files/airenvprotectionpolicy.pdf>)
- Environment Protection (Noise) Policy 1998  
(<http://www.environment.act.gov.au/Files/noisepp.PDF>)
- Environment Protection (Water) Policy 1999  
(<http://www.environment.act.gov.au/Files/waterpollutionepp.pdf>)

# Waste Management Legislation

NEW SOUTH WALES

## Relevant Legislation:

- Waste Avoidance and Recovery Act 2001
- Protection of the Environment Operations Act 1997

## Key Policies/Programs:

- NSW Waste Avoidance and Resource Recovery Strategy 2003
- Extended Producer Responsibility Priority Statement 2004
- Waste Reduction and Purchasing Policy
- Industry Waste Reduction Plan

VICTORIA

## Relevant Legislation:

- Environment Protection Act 1970
- Environment Protection (Prescribed Waste) Regulations 1998

## Key Policies/Programs:

- State Environment Protection Policy (Used Packaging Material) 2000
- State Environment Protection Policy (Ambient Air Quality)
- State Environment Protection Policy (Air Quality Management)
- Industrial Waste Management Policy (National Pollution Inventory) 1998
- Industrial Waste Management Policy (Prescribed Industrial Waste) 2000
- Industrial Waste Management Policy (Siting, Design and Management of Landfill) 2004
- Waste Management Policy (Solid Fuel Heating)
- Towards Zero Waste Strategy

EcoRecycle Victoria has developed a *Toward Zero Waste: A Materials Efficiency Strategy for Victoria, Draft March 2003* concurrently with *Towards Zero Waste: A Solid Industrial Waste Management Plan for Victoria, Draft March 2003* draft strategy which sets specific targets for waste recovery and diversion from landfill. Specific targets are to:

#### *Reduction of Solid Waste Target*

- Reduce solid waste by 1.5 million tonnes by 2013

#### *Recovery of Solid Waste Target*

- Increase recovery of solid waste from 48% to 75% by 2013
- 45% recovery household waste 2008
- 65% recovery household waste 2013
- 65% recovery industrial waste 2008
- 80% recovery industrial waste 2013

#### *Proposed Strategy*

- By 2005 – All construction and demolition (C&D) waste in metropolitan and provincial areas processed for resource recovery prior to landfill.
- By 2009 – All commercial and industrial (C&I) waste in metropolitan areas processed for resource recovery prior to landfill.
- By 2011 – All commercial and industrial (C&I) waste in provincial areas processed for resource recovery prior to landfill.
- By 2012 – all household waste in metropolitan and provincial areas processed for resource recovery prior to landfill.

There are several priorities established in the strategy, including a product stewardship priority, priority waste materials and industry sectors on importance to reducing waste to landfill. Consumer packaging and treated timber are on the list of 12 focus products for implementation of IPR. Timber is also on the list of 6 priority materials for increased recovery. Additionally, the construction and demolition (C&D) and Timber and Furniture Manufacturing Sectors are on the list of 5 priority industry sectors for reduction of waste to landfill.

The strategy has outlined proposed measures and provisions to achieve the targeted recovery goals. These include:

- Support and assistance programs, funding for infrastructure, review of local planning laws, improving Government sector recovery, market development initiatives, research new processing technologies.
- Improved drop-off and processing capacity for C&D waste.
- Expanded recycling services to C&I sectors
- C&D sector may “experience some prohibitions as to which materials can be sent to landfill such as concrete and timber.”
- Model cost increases for landfilling to rise to between \$10-\$20/tonne for C&D wastes by \$40-\$70/tonne for C&I wastes by 2013.

#### QUEENSLAND

#### **Relevant Legislation:**

- Environmental Protection Act 1994
- Environment Protection (Waste Management) Regulation 2000

### **Key Policies/Programs:**

- Environment Protection (Waste Management) Policy 2000
- Waste Management Strategy for Queensland 1996 (new policy under development)

#### WESTERN AUSTRALIA

### **Relevant Legislation:**

- Environmental Protection Act 1986
- Environmental Protection (Landfill Levy) Act 1998
- Environmental Protection (Controlled Waste) Regulations 2004
- Environmental Protection Regulations 1987

### **Key Policies/Programs:**

- Strategic Direction for Waste Management in Western Australia

#### SOUTH AUSTRALIA

### **Relevant Legislation:**

- Environment Protection Act 1993
- Environment Protection (General) Regulations 1994
- Environment Protection (Beverage Container) Regulations 1995

### **Key Policies/Programs:**

- Environment Protection (Waste Management) Policy 1994
- Environment Protection (Used Packaging Materials) Policy 2001
- South Australia's Waste Strategy 2005 – 2010

#### TASMANIA

### **Relevant Legislation:**

- Environmental Management and Pollution Control Act 1994

### **Key Policies/Programs:**

- Tasmanian Waste Management Strategy (under development)

- Hazardous Waste Management Strategy 1994

#### AUSTRALIAN CAPITAL TERRITORY

- No Waste by 2010 – A Waste Management Strategy for Canberra

#### NORTHERN TERRITORY

- Litter Abatement and Resource Recovery Strategy

**Appendix C USA State Recycling Goals & Mandates  
(courtesy of the American Forest and Paper  
Association)**

<b>State</b>	<b>Mandate/Goal</b>	<b>Mandate</b>	<b>Penalty</b>
<b>Alabama</b>	1989 law, Act 89-824, established a 25% waste reduction and recycling goal; No due date for goal; no formal requirements for localities to report recycling information to state, statistics on recycling unavailable, but there has been a dramatic increase in curbside and drop off centre recycling. 1990 law, Act No.90-564 requires all state agencies, schools (K-12), and public colleges and universities to implement recycling programs	No	No
<b>Alaska</b>	No laws imposing statewide recycling mandates/goals exist, only declaration from the governor encouraging recycling. This is mainly due to transportation logistics and the lack of infrastructure in many smaller communities and villages. In 2000, the Assembly adopted for Anchorage municipalities the following goals. 30% of population to recycle (21% currently recycle but is not mandated); 1% of tipping fees go towards funding recycling.	No	No
<b>Arizona</b>	Title 49 contains recycling statutes; state has no established recycling goals; state monitors municipalities and counties and is responsible for engaging them in recycling and waste reduction	No	No
<b>Arkansas</b>	1991 law, Act 749, established recycling goals of 30% by 1995 and 40% by 2000; state met the 1995 goal and exceeded the 2000, 40% goal. The 1999 recycling rate was 44%. Act 94 of 2001 amended Arkansas code 8-9 101 to establish recycling goals of 40% by 2010. The 2002 recycling rate was 34%.	No	No
<b>California</b>	The Integrated Waste Management Act of 1989, AB 939, requires local governments to prepare plans and implement programs to achieve 50% waste reduction by the year 2000. AB 2494, passed in 1992, refined and standardized methodologies to measure and report waste disposal reduction via a jurisdiction's Annual Report. AB 75, passed in 1999, requires state agencies to meet a waste diversion goal of 50% by 2004 and to document efforts in meeting these goals. In 2001, the state's Integrated Waste Management Board established as one of seven strategic goals, the promotion of a "zero-waste" California. State agencies must meet recycled content procurement goals in 12 product categories with varying minimum content levels specified.		
<b>Colorado</b>	No recycling laws, however governor issued a challenge for citizens to divert 50% of the waste by 2000. 1991 law, HB 1245, created an incentive for companies to recycle, giving them tax credits for equipment necessary for recycled materials. 1992 laws, HB 1318, created a recycling processing/manufacturing loan and market development program	No	No



<b>Connecticut</b>	1987 law, PA-544 set 25% recycling goal by 1991. 1993 law, PA 93-423, raised goal to 40% recycling/source reduction in 2000. Current 2002 recycling/source reduction rate was 26.4%.	Yes	Yes
<b>Delaware</b>	Executive Order No.82 issued in 2000, established a state goal of 30% diversion of recyclables from the residential solid waste stream. There is no target date. The Executive Order also created a Recycling Public Advisory Council to advise the state on all aspects of recycling. The State also has a recycled product procurement law: for those products for which EPOA has established Comprehensive Procurement Guidelines, Delaware agencies are to purchase the products with post-consumer recycled content meeting or exceeding the guidelines when it is technically and economically feasible to do so.	No	No
<b>Florida</b>	1988 law sets county recycling goals of 30% of all solid waste and 50% of each of five of all solid wastes and 50% of each of five material groups (glass, newspaper, aluminium, steel and plastic) by 1994. In 2002, the statute was amended to read a “significant portion of at least four of the following materials from the solid waste stream prior to final disposal at a solid waste disposal facility and to offer these materials for recycling: newspaper, aluminium cans, steel cans, glass, plastic bottles, cardboard, office paper and yard trash.” Counties with populations less than 50,000 are excluded from these requirements provided that they offer the opportunity to recycle. In 2002, the Legislature changed the statute to exclude counties with populations less than 100,000. Most counties met the 30% goal, however, no county met the 50% goal in ALL given material groups. In 1998, the State changed the way construction and demolition was reported. Since that time, with the decrease in the amount of construction and demolition debris allowed to count toward the recycling goal and the increase of tonnes disposed, only about one-third of the counties met the 30% goal in 2002. There are penalties for large counties that do not meet the 30% goal. In 1997, a bill was passed awarding \$1.7 million pa for innovation grants. Counties compete for the grants by responding to EDEP criteria. As of spring 2004, \$9.8 million has been awarded for innovative grant projects.		
<b>Georgia</b>	1990 law, SB553 requires 25% recycling goal by July 1, 1996 per capita; 1993 law, HB257, updates the law requiring the state to reduce the amount of waste received by 25% by 1996. State did not meet 25% recycling goal, fell short at approximately 21%. State did not meet waste reduction goal. Recycling rate in 1995 was 33%.	No	No
<b>Hawaii</b>	Chapter 34 of the Hawaii Revised Statutes sets a 25% waste reduction goal before 1995 (state did	No	No

	not reach that goal). A 50% goal by 2000 was set that will likely be extended to 2005; state did not meet the 2000 goal and no penalty was, or could be imposed. 1999 recycling rate was 24%.		
<b>Idaho</b>	No law, however there is a non-binding resolution that was passed encouraging state achievement of 25% waste reduction goal. Legislation has given a 5% purchasing preference to those items meeting recycled content standards	No	No
<b>Illinois</b>	State procurement code mandates that whenever, it is economically and practically feasible, 40% of the dollar amount of paper purchased by the state be recycled. The aggregate rate increased to 50% by July 1, 2000. For high grade printing and writing paper to qualify as recycled, it must contain at least 50% recovered material, 30% of which must be postconsumer waste. Beginning July 1, 1998, the postconsumer content requirement increased to 40% and again to 50% by July 1, 2000.	No	No (except for newsprint)
<b>Indiana</b>	Goal to reduce waste 35% by January 1, 1996; 50% by 2001; counties must make 20 year plans; state did not meet the 1996 or 2001 goals. The 2002 waste diversion rate was 40%.	No.	No
<b>Iowa</b>	1988 law established 25% waste reduction goal by July 1, 1994 and 50% by July 1, 2000; 25 of 45 planning areas have met the 25% reduction goal and 5 of the 45 have reached the 50% reduction goal. Landfills are required to collect a fee on each tonne of non-exempt disposed waste based on their planning area's diversion goal. Planning areas under the 25% diversion goal must collect \$4.75 per ton and retain \$1.45 to be used locally and remit \$3.30 to the state. Planning areas over the 25% and under the 50% diversion goal must collect \$3.65 per ton and retain \$1.45 to be used locally and remit \$2.20 back to the state. Planning areas over the 50% diversion goal must collect \$3.25 per ton and retain \$1.95 locally and remit \$1.30 back to the state. Waste management assistance programs and environmental protection programs involving waste are financed through the portion of the fee remitted to the state	no	No (bottle bill)
<b>Kansas</b>	There are no specific statewide recycling or waste reduction goals. A 1990 law requires all counties or groups of counties to submit solid waste management plans to the Department of Health and Environment, Bureau of Waste Management. These plans must address waste reduction efforts and each planning entity must submit annual solid waste management plan updates. Some counties have numerical goals or directions to increase participation in their programs, while others have little required. A state grant program provides \$1 million a year to cities, counties and the private sector for recycling, composting, waste reduction and public education projects. The Kansas recycling	No	No

	rate for municipal solid waste in 2002 was approximately 18%.		
<b>Kentucky</b>	1991 bill, SB2, set a policy to reduce waste and set a goal of 25% by 1997. The state did not meet the 1997 goal. 2002 bill, HB 174 amended parts of the waste reduction policy, but failed to set a new goal. Counties are required to provide access to recycling for their residents. Each county sets its own waste reduction goal and finds ways to finance its own programs. Kentucky's recycling rate in 2003 for household (post consumer) material is about 11%.	No	No
<b>Louisiana</b>	laws set goal of reducing waste landfilled by 25%; state has not met this goal. Recycling rates averaged approximately 15-17% in 2002.	No	Yes (no more than 20 cents per ton)
<b>Maine</b>	1989 law established a 50% recycling goal for Maine municipalities. The 50% goal "date" has been extended twice and now is 2003. The statewide recycling rate is calculated every two years, using municipal solid waste program management date from both the public and private sectors. The state's definition of municipal solid waste includes construction and demolition waste, unlike the EPA's definition of municipal solid waste. Maine's statewide recycling rate in 2001 was 37.3%. However, if the EPA definition was used, the statewide recycling rate was 42.6%. Assistance to Maine communities, who are responsible for management of solid waste, is provided through the state's Planning Office, Waste Management and Recycling Program.	No.	No
<b>Maryland</b>	1988 law set 20% waste reduction goal by January 1, 1994; 15% for smaller counties; all counties in the state met 1994 goals. In 1999, 36% rate was reached and goal was increased to 40%	Yes	No
<b>Massachusetts</b>	In its Beyond 2000 Solid Waste Master Plan, Massachusetts adopted a 70% waste reduction goal by 2010. This goal includes source reduction, recycling, composting and other diversion of both municipal solid waste and non-municipal solid waste (primarily construction and demolition debris). The 2001 waste reduction rate is 57%, up from 51% in 1999. Nearly 90% of the population has the ability to participate in a comprehensive program. The Beyond 2000 Solid Waste Master Plan includes an increased emphasis on source reduction and product stewardship, a goal to substantially reduce the use and toxicity of hazardous products and provide for statewide collection access and stringent regulations to ensure that waste that is not diverted is safely disposed.	No	No
<b>Michigan</b>	1988 policy encourages by 2005; waste reduction by 8-12%, reuse rate of 4-6%, composting rate of 8-12%; recycling rate of 20-30%, waste-to-energy goal for incineration of 35-45%, and landfill rate of 10-20%.	No.	No

<b>Minnesota</b>	1989 law set a 35% recycling goal by December 31, 1996, for the Greater Minnesota (outside the 7-county metro area of Minneapolis and St. Paul) area and a 50% recycling goal for the metro area. Source separation plans are required for each SWM district. All counties must provide the opportunity to recycle to residents, which means they must have one recycling centre available that collects four broad types of materials. The county must also have curbside pickup (in cities with a population of 5,000 or more) and collection centres that are convenient for people to use. 40% of waste was recycled in 1998 (46% with waste reduction and yard waste credits). For 2002, the state recycling rate was 39% (47% with waste reduction and yard waste credits). Individual counties have set their own goals in the planning process.	No	No
<b>Mississippi</b>	1991 law, SN2984, creates authorities – nonhazardous waste fee collection, 25% recycling goal by 1996, department must submit report to legislature by July 1, 1996, detailing the current recycling rate and why the goal was not attained. State has not met the original goal – the 2000 rate of recycling averaged 11-12% statewide. The 2003 recycling rate was approximately 14%. There are no penalties for not meeting the goal; recycling is not mandatory	No.	No
<b>Missouri</b>	1990 law, SB530, established a 40% waste diversion goal by 1998. State increased the percent of solid waste recovered from 10% in 1990 to 26% in 1995 to 33% in 1996. In 2001, the diversion rate reached 41% and in 2002 the diversion rate was 43%. Diversion includes waste reduction, recycling and composting. Goal still stands at 40 for the state. There is no mandate to meet this goal and no penalties for non-achievement. The goal has been met and surpassed. The Department of Natural Resources is continuing to make efforts to increase the diversion rate for the state of Missouri.	No	No
<b>Montana</b>	1991 law establishes a 25% recycling goal by December 31, 1996. There are no reporting requirements, hence there are no estimations on recycling rates. A proposed rewrite of the Integrated Waste Management Act hopes to provide more accurate data on the state's recycling rate.	No	No
<b>Nebraska</b>	1992 law, LB1257, sets 25% waste reduction goal by 1996, 40% by 1999, 50% by 2002. State met 1996 goal. Some counties probably met 40% goal in 1999, but most probably did not. The goals are not mandated, and there is no waste reduction tracking or reporting	No	No
<b>Nevada</b>	1991 law, AB320, set a 25% recycling goal by 1995. The state did not meet the 1995 recycling goal but no penalties were imposed. Tyre fee to fund solid waste regulation, including recycling coordination; counties must submit plans. 1995	No	No

	law weakened the recycling requirement – municipalities and counties over 100,000 as opposed to 40,000 are required to provide curbside recycling. Statutes have been amended (for 2000 on) to include public buildings in recycling programs. The state’s municipal solid waste recycling rate was 15% in 2000 and 16% in 2002.		
<b>New Hampshire</b>	The Legislature set a 40% waste reduction goal for 2000, and has yet to take any specific action to update this goal. The state had a 27% recycling rate in 2002.	No	No
<b>New Jersey</b>	1992 revisions to the recycling goals in the Recycling Act established a 50% municipal solid waste recycling goal by December 31, 1995; and a 60% total recycling goal by December 31, 1996. State failed to meet the municipal solid waste-recycling goal of 50% in 1995. State did meet overall recycling goal, with a recycling rate of 61% in 1996.	Yes	No
<b>New Mexico</b>	1990 law, SB2, sets 25% waste diversion goal by 1995 and 50% goal by 2000; mandates solid waste program by 1993; requires procurement of recycled products; state did not meet 1995 goal; in 1994, state at 12%, no penalties imposed.	No	No
<b>New York</b>	1987 Solid Waste Management Plan established a 50% waste reduction/recycling goal by 1997; not mandatory. 50% recycling goal is broken down into two categories: 8-10% waste reduction goal and 40-42% recycling goal. The state has met these goals with a recycling rate of 42% in 1997 and 1998. Executive Order No.142, issued in 1992, requires state agencies and public authorities to engage in certain recycling and waste reduction practices.	No	Yes
<b>North Carolina</b>	1989 Solid Waste Management Act established a 25% waste reduction goal by June 30, 1993. State did not meet the 1993 goal. 1991 amendment added a 40% waste reduction goal by June 30, 2001. The statewide goal was not met, although several counties achieved the state’s waste reduction goal. By June 1, 2001, each local government must have submitted a plan that includes a goal for the reduction of municipal solid waste and a further goal of continued reduction by 2006. 2002-2003 recovery rates for different programs include 38% for curbside, 44% drop-off, 1% mixed waste, and 17% for other programs.	Yes	No
<b>North Dakota</b>	1991 law established a 10% waste diversion goal by June 30, 1995; 20% waste reduction goal by June 30, 1997; 40% waste reduction goal by June 30, 2000. State met 1995 and 1997 goals. 1999 had a 27% recycling/composting/diversion rate.	No	No
<b>Ohio</b>	The state’s 88 counties are organised into 52 solid waste management districts (SWMDs). Each SWMD must prepare a solid waste management plan, approved by the Ohio EPA, demonstrating how it will achieve the state’s	No.	No

	<p>mandated recycling goals. A new state solid waste management plan was adopted in 2001, consisting of 8 recycling goals, in which 2 of these goals are considered “main” goals.</p> <p>SWMDs, in their solid waste management plans, have the option of picking whether they want to meet goal 1 or goal 2. They can try to meet both goals, but they are only required to meet one or the other. Goal 1 focuses on providing access to municipal solid waste recycling opportunities, such as drop-offs and curbside programs, to at least 90% of the residential population in each county of the SWMD. Goal 2 states that SWMDs have to reduce and/or recycle 25% of municipal solid waste and 66% of industrial waste. SWMDs have to meet the goals within three years after obtaining approval of their solid waste management plan for the Ohio EPA. Ohio’s statewide diversion goal is 50% by 2005. In 2002, the state recycled 44.59% of waste generated (21.48% of municipal solid waste and 63.69% of industrial waste).</p>		
<b>Oklahoma</b>	Oklahoma State Recycling and Procurement Act; no mandate, it is voluntary. State government agencies, entities, and schools receiving funding must create a waste reduction program, if it is economically feasible.	No	No
<b>Oregon</b>	In 2001, under HB 3744, Oregon’s recovery goals were revised to set a 45% recovery goal for 2005 and 50% recovery by 2009. Previously, legislation adopted in 1991 had set a goal of 50% recovery by 2000. In 2002, the statewide recovery rate was 46.6%. Under the 2001 law, each county or “wasteshed” has separate recovery goals for 2005 and 2009. The goals range from a low of 8% in 2005 and 10% in 2009 to a high of 62% in 2005 and 64% in 2009. These goals are required, but if a wasteshed fails to achieve its 2005 or 2009 goal, the only requirement is that the wasteshed must conduct a technical review of existing policies or programs and determine changes needed to meet the recovery goals.	Yes	No
<b>Pennsylvania</b>	1988 law, Act 101, required state to recycle 25% of municipal waste by January 1, 1997. 1997 goal was met. No new legislation, but the governor announced a new goal of 35% of municipal waste by 2005. 1998 recycling rates averaged 25.6% for the state.	No	Yes (civil and criminal)
<b>Rhode Island</b>	1989 law established a 70% recycling rate with no deadline for achievement. The 2002 recycling rate was approximately 17% and the diversion rate was 22.5%. Regulations have changed since their inception. The state mandatory list of recyclables was increased in the 1997 municipal recycling revision, commercial recycling regulations were revised in 1996. Composting regulations require composting facilities to register with the state and submit background information and	Yes (for mandatory recyclables outlined in regulations)	Yes (administrative penalties)

	operating plans.		
<b>South Carolina</b>	1991 law, SB366 set a 30% waste reduction goal and a 25% recycling goal by 1997. Recycling goal was met but waste reduction was not. In 1999, Bill 3927 increased the state recycle goal of municipal solid waste to 35% and a waste reduction goal of 3.5 pounds per person per day by June 30, 2005. So far, neither of these goals have been met. In FY 2002, South Carolina recycled 28.7% of its municipal solid waste and generated 4.2 pounds per person per day.	No.	No
<b>South Dakota</b>	South Dakota codified law 34A-6-60 sets a recycling goal rate of 50% by July 1, recycling rate for 1997 was 42%. October of 1999 reports a source reduction rate of 43%. The recycling rate for 2001 was 37%. Certain items such as yard waste, lead acid batteries, appliances and waste motor oil are banned from landfills. Waste tyres are banned from landfills unless they are quartered or shredded prior to disposal. Any other recycling is up to individual municipalities and is not mandated by the state.	No	No
<b>Tennessee</b>	The state's solid waste management act mandates a 25% reduction rate of solid waste. Solid waste management regions are required to submit a plan for management of their solid wastes for 10 years in the future. Each year, the regions are required to submit a progress report on their solid waste plan. The state reviews the plans to determine if progress is being made to meet the state's 25% diversion goal. The state showed a 20.3% per capita waste reduction in 2002, as compared to the 1995 base year.	No	No
<b>Texas</b>	1991 law, SB1340, sets a 40% recycling goal of solid waste by 1994; 1993 legislation, SB1051, amended it to become a waste reduction goal; state did not meet the 1994 goal and no penalty was imposed. 1997 survey estimated a 35% recycling rate (including scrap steel and concrete)	No	No
<b>Utah</b>	No recycling laws/goals	No	No
<b>Vermont</b>	40% waste reduction goal after 2000. State expects to meet the 40% goal. 1998 recycling rate was 36%. State Solid Waste Management Plan sets a diversion goal of 50% by 2005. There is no mandate for recycling or diversion, and no penalties.	No.	No
<b>Virginia</b>	1995 law requires localities to maintain a 25% recycling rate and to have a solid waste management plan that specifies methods for maintaining the required 25% recycling rate. Reporting by localities to the Department of Environmental Quality is required annually. 2002 statewide recycling average was 36.75%.	Yes (Code of Virginia Section 10.1.1411)	Yes (Possible civil and permit penalties)
<b>Washington</b>	Mandatory recycling goal of 50% by 1995 was changed to 2007. Loans and grants available to local government for waste reduction, recycling programs, composting, and education; waste tax funding goals; parks, airports and marinas separate two recycling materials; recycling litter	Yes	No

	tax now applies to by-products produced by some manufacturers and food processors (1992). Business waste tax on trash sent to landfills. Local governments cannot institute bans, but the ban on bans was lifted in 1993. State did not meet 1995 goal – all funding ended in 1995 but goal still exists (year changed to 2007). The recycling rate for 2002 was 34.8%.		
<b>West Virginia</b>	1991 law established recycling goals of 20% by 1994; 30% by 2000; 50% by 2010; state did not meet 1994 goal and no penalty was imposed. The average recycling rate was approximately 13% for 1998 and 35% for 2002.	Mandatory for cities with populations larger than 10,000 and for counties that adopt a mandate provision	No
<b>Wisconsin</b>	No recycling goals. However, in 1989, Department of Natural Resources regulation (Chapter NR 544) set a standard for a recyclable collection measured in pounds per person per year. Recyclables include newspaper, magazines, aluminum, steel, bi-metals, tyres, plastic and glass containers and foam polystyrene packaging. In rural counties, each person should recycle 82.4 pounds per year. In other counties, 106.2 pounds per year. Due to market fluctuation, an exemption exists for recycling polystyrene. In 2002, the statewide per capita average for recycling of the materials from residential collection programs was 141.57 pounds per person. There is also a ban on oils, batteries, major appliances, and yard waste to landfills. The statewide per capita average for recycling from residential collection programs for all banned materials was 261.33 pounds per person in 2002. The statewide waste diversion rate for all recyclables in 2002 was 40.4% (including recycling in the non-residential sectors).	No	No
<b>Wyoming</b>	There is no recycling mandate or requirement for municipalities, only guidelines to help the municipalities set up recycling programs. The average state rate for recycling is listed at between 3 and 5%. There are some municipalities that document upwards of 10% and quite a few that document 0%. This disparity is due to some municipal subsidies and close proximity to a market for recyclable materials resulting in a higher than state average rate, and remote locations with low populations resulting in a lower than state average rate.	No	No



## Appendix D Formaldehyde

## Formaldehyde and OH&S

In June 2004 the International Agency for Research on Cancer (IARC), part of the World Health organisation, released the conclusions of its re-evaluation of formaldehyde as a carcinogen. The Working Group, comprised of 26 scientists from 10 countries, concluded that on the basis of past evidence and on information from new studies of human exposure to formaldehyde, that formaldehyde should be reclassified from a *probable* (Group 2) carcinogen to a *known* (Group 1) carcinogen (International Agency for Research on Cancer 2004).

A growing public concern over a number of years is the perception that the use of composite wood panel products leads to formaldehyde emissions indoors with possible long-term health effects. This has led to guidelines, codes, or legislation being initiated in a number of countries. Occupational formaldehyde emission controls have been established in most industrialised nations for many years, and in many the emission limits have gradually been tightened. Indoor air emissions of formaldehyde have come under increasing scrutiny and several countries have adopted voluntary systems of environmental labelling that limit total or product specific emissions. That formaldehyde is now classed as a known carcinogen by IARC may see further tightening of formaldehyde emission limits for ambient air, indoor air, and in the workplace.

### CHEMISTRY AND PHYSICAL PROPERTIES

Formaldehyde is noted for its reactivity and versatility as a chemical reagent. It is a pungent colourless gas at room temperature with a highly irritating odour. The gas is readily soluble in water, lower aliphatic alcohols and other polar solvents. In solution it readily polymerises with time to paraformaldehyde, although the addition of methanol and other materials slows this reaction. Formaldehyde vaporises readily from solution and is flammable in air. It is most commonly available as a 30-50% aqueous solution (formalin) and as a solid polymer (paraformaldehyde).

### ENVIRONMENTAL SOURCES AND HUMAN EXPOSURE

Formaldehyde is present in the environment from both man-made and natural processes and materials. Sources in ambient air include engine exhaust, tobacco smoke, incomplete combustion of hydrocarbons (gases including methane, wood, coal, and tobacco), and releases that occur during manufacturing and processing of intermediate and end products containing formaldehyde. Formaldehyde occurs naturally in the environment from processes such as plant decay and from the conversion of methane in the high altitude atmosphere (troposphere). Concentrations of formaldehyde in ambient air were found to be highest at sites of human activity, with vehicles providing the greatest contribution and releases from industrial activity substantially less (IPCS INCHEM 2002). For most people, non-occupational exposure from concentrations in ambient air is at levels below that associated with sensory irritation and has been found by a number of studies to be in the range of 0.05-14  $\mu\text{g}/\text{m}^3$  (IPCS INCHEM 1991).

Data concerning concentrations of formaldehyde in indoor air have been gathered over at least the last 30 years (IPCS INCHEM 1989). Primary sources of formaldehyde emission have been associated with particleboard and other wood panel furniture products, tobacco smoke, furnishing fabrics such as carpet, flueless gas heating/cooking systems, paints, coatings, and disinfectants. Formaldehyde emissions are mainly associated with wood-based panel products made with UF, MF, and MUF resins, due to the slightly reversible chemical reaction of the components and the presence of uncured free formaldehyde. Panels made with PF resins are not a source of formaldehyde emission in use, as the chemical nature of the cured resin prevents a reversible reaction. However, new PF-bonded panels may release small amounts of formaldehyde from the out-gassing of minute amounts of residual free formaldehyde.

Indoor air quality is affected not only by the source and concentration of the emission, but also by the quantity and frequency of ventilation, temperature, and humidity. It was found in Canada that concentrations of formaldehyde indoors are higher than in ambient air (IPCS INCHEM 2002). In Australia, concentrations have been found to be lower than in North American homes, and this has been linked to better ventilation in this country, or at least inadequate ventilation in North America, where energy conservation concerns are high. Data from Australian studies in the 1990's have found that mean concentrations of formaldehyde indoors in conventional dwellings was 26 ppb. This was far lower than the mean values of emissions in caravans and mobile homes, which peaked at 310 ppb (Australian Government 2001). These levels of emissions may not apply today, as resin technology has advanced, reducing formaldehyde emissions from wood-based panels such as particleboard and MDF by approximately 90% (Plywood Association of Australia).

The effects of formaldehyde on human health have been well established by many clinical studies and observations over a number of decades. The focus of many of these studies has been airborne exposure due to the lack of representative data on concentrations in media other than air, and limited data on the effects following ingestion. In a review of a number of clinical studies, a WHO IPCS report noted "mild to moderate sensory eye, nose and throat irritation was experienced by volunteers exposed for short period to levels of formaldehyde ranging from 0.25 to 3ppm" (IPCS INCHEM 2002). The same review reported the acute health effects of high levels of formaldehyde ingestion with resultant damage "along the aerodigestive tract". The WHO summarised the health effects of formaldehyde after short-term exposure in its Air Quality Guidelines for Europe (Table 1).

It has long been thought that formaldehyde was a possible or probable carcinogen. Nasopharyngeal tumours have been causally linked to chronic or high (10ppm and higher) formaldehyde inhalation, although these same studies in general find only weak links to other cancers not affected by direct contact with formaldehyde. An OECD report found there was "no increased incidence of tumours ... in other organs after inhalation, and administration routes other than inhalation did not result in local or systemic tumour formation" (OECD SIDS 2002). Nevertheless, the recent IARC review concluded from the overall weight of evidence, including recent studies, that there is a statistical link between nasopharyngeal cancers and formaldehyde strong enough to warrant re-classifying the chemical from a probable to a known carcinogen (IARC Monographs Programme 2004). The same IARC report found insufficient

evidence for a link between formaldehyde and leukaemia, and limited evidence of links to sinonasal and other site specific cancers.

**Table 1. Health effects of formaldehyde in humans after short-term exposure (Taken from WHO 2000)**

Concentration range or average (mg/m <sup>3</sup> )	Time range or average	Health effects in general population
0.03	Repeated exposure	Odour detection threshold (10 <sup>th</sup> percentile)
0.18	Repeated exposure	Odour detection threshold (50 <sup>th</sup> percentile)
0.6	Repeated exposure	Odour detection threshold (90 <sup>th</sup> percentile)
0.1-3.1	Single & repeated exposure	Throat & nose irritation threshold
0.6-1.2	Single & repeated exposure	Eye irritation threshold
0.5-2.0	3-5 hours	Decreased nasal mucus flow rate
2.4	40 minutes in 2 successive days	Post exposure (up to 24 hours) headache
2.5-3.7	30 minutes	Tolerable for 30 minutes with lachrymation
12-125	Unspecified	Strong lachrymation, pulmonary oedema, pneumonia, death

## LEGISLATION

Facilities that produce or consume formaldehyde where emissions may occur inadvertently or through occupational use must control exposure to workers using appropriate control measures. Formaldehyde exposure in the workplace is now controlled by some form of legislation, regulation, code, or guideline in most industrialised nations. In Australia the NOHSC has set safe working limits at 1ppm TWA (time weighted average) over an 8 hour period with a 2ppm STEL (short term exposure limit) (Australian Government Formaldehyde). Australia's National Industrial Chemicals Notification and Assessment Scheme (NICNAS) began a review of formaldehyde in March 2002, but put it on hold pending the completion of the IARC review. Now that IARC has completed its work and reclassified formaldehyde as a Class 1 carcinogen, NICNAS is expected to release its findings shortly. Its recommendations, expected to lower levels to 0.3 ppm TWA and 0.5 ppm STEL, will assist NOHSC in reviewing its occupational exposure limits. In 2000, the WHO revised its guidelines for air quality in Europe and recommended an air quality guideline of 0.1 mg/m<sup>3</sup> (0.1ppm) as a 30 minute average (Who 2000).

Internationally, growing public concern over formaldehyde emissions indoors and the possible long term health effects of low level exposure has led to a number of countries adopting standards and 'eco-labels' that are product specific.

In the European Union (EU) a CE mark placed on a product signifies a manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation (Product Directives) and may legally be placed on the market within the European Economic Area (EEA). The letters "CE" come from the French "Conformité Européene" meaning "European Conformity". Under the Construction Products Directive (89/106/EEC), "any product which is produced for incorporation in a permanent manner in construction works," including both interior and exterior products must have a CE mark (Europa). Wood-based panels used in construction products must meet European standard EN 13986 which mandates a formaldehyde release Class E1 ( $\leq 0.1$  ppm).

In 2000 the European Union revised its eco-labelling scheme, which had been in operation since 1993 when the first product groups were established. The new Regulation (EC) No 1800/2000 is a voluntary code whose object is to stimulate demand and promote products that have a lower environmental impact (European Commission 2000). Compliance with the code's criteria will allow a product to be awarded the EU Eco-label (a flower). The Eco-label gives consumers the means to make informed purchasing choices and provides manufacturers and retailers with the ability to market their product through the EU under one eco-label. Under EC 1800/2000, for eco-labels, total formaldehyde emissions for products indoors must not exceed limits set in European standard EN 13986 ( $\leq 0.1$  ppm, Class E1) (European Commission 2003). Retailers and wood panel manufacturers may apply for this voluntary eco-label for their products where they are used for non-construction purposes e.g. modular shelving or furniture.

The EU Eco-label does not over-ride similar environmental schemes operating at national levels within member states of the EU, but rather operates in parallel with them for example the German Blue Angel. EC 1800/2000 in Article 11 specifically states that where a product carries both a Community eco-label and a national label that both shall be displayed on the product "side-by-side" (European Commission 2000).

Reiterating, a CE mark identifies that a product has conformed to relevant European standards and may be legally placed on the market in the EU. An EU eco-label identifies the product as having met higher optional, environmental standards. A CE Mark on wood-based panels used in permanent construction identifies the product as meeting the E1 emission requirement which is coincidentally the same limit required for voluntary eco-label placement on all other wood-based panels. Wood-based panels not used in permanent construction, and not opting for an eco-label, are required to meet formaldehyde release Class E2. The relationship of EU requirements and test methods to the equivalent Australian standards is summarised in the table below.

**Table 2. Relationship of harmonised Australian/New Zealand standards with the European Union Standards.**

	Australia			European Union		
	AS/NZS 1859.1* particleboard	AS/NZS 1860.1* particleboard flooring	AS/NZS 1859.2* fibreboard		EN 120*	EN 717-1#
Super EO	pending	pending	pending		NA+	NA+
EO	pending	pending	pending		NA+	NA+
E1	≤8.0mg/100g	≤10.0mg/100g	≤9.0mg/100g	E1	≤8.0 mg/100g	≤0.13 mg/m <sup>3</sup> (0.1ppm)
E2	>8.0,≤30.0 mg/100g	>10.0,≤30.0 mg/100g	>9.0,≤30.0 mg/100g	E2	>8, ≤30 mg/100g	>0.13,≤1.11 mg/m <sup>2</sup> (1ppm)

NA+ denotes not applicable

\* By CEN test standard EN 120: Wood based panels – Determination of formaldehyde content – Extraction method called the perforator method.

# By CEN test standard EN 717-1: Wood based panels – Determination of formaldehyde release – Part 1: Formaldehyde emission by the chamber method.

The many Australian wood products manufacturers that export to Japan are most interested in the nation's Building Standards Law implemented in mid 2003. Japan has three kinds of formaldehyde certification: Japanese Agricultural Standard (JAS), Japanese Industrial Standard (JIS) and Ministerial Approval. The changes to Japan's building construction regulations now require that all laminated/pre-finished building products must be JAS certified. Previously JAS was a voluntary standard for wood quality and applied to products including plywood, flooring, LVL, and structural panels. JIS applies to such products as MDF, glue, and finish among others (Maruhon). Under the Building Law, Japan awards an F star (F 1 star -F 4 star) to products certified under JAS or JIS, according to their formaldehyde emission rate under limits established in JIS5905 (fibreboards) and JISD A5908 (particleboards). F 4 star is the most desirable and has an emission limit of ≤0.3 mg/L, permitting such materials to be used indoors without restriction. Products with an F 3 star and F 2 star also meet the requirements of the Building Law, but some restrictions on their use indoors apply. Wood-based panels meeting F 1 star criteria may not be used indoors. The AS/NZS do not yet include the criteria for wood-based panels to meet the stringent requirements of the Japanese Building Law, but it is expected that amended standards in the near future will do so. The Australian and New Zealand Standards Associations (AS/NZS) have harmonised their standards with the Japanese, and the relationship is presented in the table below.

**Table 3. Relationship of harmonised Australian/New Zealand standards with the Japanese standards**

	Australia			Japan	
	AS/NZS 1859.1* particleboard	AS/NZS 1860.1* particleboard flooring	AS/NZS 1859.2* fibreboard		JIS A5905** JIS A5908**
Super EO	pending	pending	pending	F 4 star	≤0.3 mg/L
EO	pending	pending	pending	F 3 star	>0.3, ≤0.5mg/L
E1	≤1.5 mg/L	≤1.8mg/L	≤1.0mg/L	F 2 star	>0.5, ≤1.5 mg/L
E2	>1.5, ≤5.4mg/L	>1.8, ≤3.3mg/L	>1.0, ≤3.3mg/L	F 1 star	>1.5, ≤5.0 mg/L

\*Australian/New Zealand Standard AS/NZS 4266.16.2004 Reconstituted wood- based panels- Methods of test. Method 16: formaldehyde emission – Desiccator method. This standard is equivalent to the industrial Standard harmonized between the wood panel industries in Australia, Japan and New Zealand, known as HANS 16.

\*\*Japanese Industrial Standard JIS A.1460:2001 Building Boards Determination of formaldehyde emission – Desiccator method.

In Australia, whilst various government agencies at both state and federal level have examined the issue of indoor air quality, there are currently no specific controls. A report by the Department of Environment and Heritage in 2001 surveyed the available knowledge on air toxics and indoor air quality in the nation (Australian Government 2001). The report noted the recommended level for formaldehyde emissions indoors for domestic buildings and schools to be 120µg/m<sup>3</sup>. This is an interim limit, first recommended by the National Health and Medical Research Council (NHMRC) in 1982 for ambient air and extended to indoor air in 1989.

Australia has a voluntary eco-label program which awards independently tested products an Environmental Choice Label (Australian Environmental Labelling Association). A draft Standard has been produced for floor coverings (excluding carpet) that contain at least 10% of wood-based material. Formaldehyde content and emission criteria in this Draft Standard are aimed at particleboard and MDF. Emissions from the finished product must be less than 0.13 mg/m<sup>3</sup> in air or free formaldehyde content during the production of the panels for the flooring product (≤8 mg formaldehyde per 100g adhesive solids and ≤6.5 mg over a 6 month average). Further the Draft *recommends* the use of the European Standards for emission tests (Standard series EN 717). The AELA also has an Environmental Choice Label standard for furniture currently under development.

Australia also has several environmental building rating programs. Green Star rates office buildings according to criteria that include the use of low or zero VOC emitting products, low formaldehyde emission wood composites or no wood composites used. The National Australian Built Environment Rating Scheme avoids product specifications by, instead, applying a total formaldehyde emission score based on physical measurements. The formaldehyde emission rating on a 0-5 scale measures formaldehyde emission over a 30 minute period corresponding to 0.4 to 0.1 ppm (NHMRC recommended limit is 0.1 ppm). Thus at ≤0.4ppm the building would exceed the NHMRC recommendation.

## RESPONSE TO IARC

The Plywood Association of Australasia (PAA) response to the IARC's change of formaldehyde classification has been to reassure users of PAA certified products. The PAA claims that in ongoing testing and a recent survey of emissions from all PAA certified producers, the average emission from all *new* phenol formaldehyde bonded panels was only 0.006 ppm. With time these emissions would reduce to zero. The PAA also assert that emissions from new UF-bonded panels meet the European E1 limit (Plywood Association of Australasia 2004). Plywood produced under the PAA would therefore exceed the most stringent requirements of the Japanese Building Law.

The Australian Wood Panels Association (AWPA) states that MDF and particleboard produced in Australia to Australian Standards are Low Formaldehyde Emission (LFE), panels releasing formaldehyde below the NOHSC's workplace exposure limit (AWPA 2004). The AWPA also claims in its product MSDS that formaldehyde emissions are unlikely to exceed the WHO recommendation of 0.1ppm.<sup>48</sup>

Several Australian MDF panel producers are already meeting the stringent EO/F 3 star and 'Super EO'/F 4 star emission limits of the Japanese Building Law as well as meeting the European and Australian E1 requirements.

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<sup>48</sup> <http://www.woodpanels.org.au/pdfs/AWPAMSDS2004.pdf>



## **Appendix E List of Contact Details for Report References**

<b>Company</b>	<b>Contact</b>	<b>Address</b>	<b>Phone</b>	<b>Email/web site</b>
American Conference of Governmental Industrial Hygienists (ACGIH)		1330 Kemper Meadow Drive Cincinnati, Ohio 45240, USA	Customers/Members Ph.: (+1 513) 742 2020 Administrative Phone: (+1 513) 742 6163 Fax: (+1 513) 742 3355	Email: mail@acgih.org  Web: www.acgih.org
Australian Government Department of Environment & Heritage		John Gorton Building King Edward Terrace Parkes ACT 2600 Australia  GPO Box 787 Canberra ACT 2601 Australia	Ph.: (+61 02) 6274 1111 Fax: (+61 02) 6274 1666	Web: www.deh.gov.au/
Australian National Pollution Inventory, DEH	Jenny Boshier, Director (Australian Government)	Environment & Sustainability Reporting Department of the Environment and Heritage GPO Box 787 Canberra ACT 2601	Ph: 1800 657 945	Email: npi@deh.gov.au  Web: http://www.npi.gov.au
Australian Pesticides & Veterinary Medicines Authority		John Curtain House 22 Brisbane Avenue Barton ACT 2600 Australia	Ph: (+61 02) 6272 5852 Fax: (+61 02) 6272 4753	Email: contact@apvma.gov.au  Web: www.apvma.gov.au
Australian Wood Panels Association (AWPA)		PO Box 158 Coolangatta QLD 4225 Australia	Ph: (+61 07) 5523 1588 Fax: (+61 07) 5523 1589	Email: via website link  Web: www.woodpanels.org.au

Carter Holt Harvey		<p>New Zealand Head Office: Carter Holt Harvey Ltd 640 Great Southern Road Manukau City Private Bag 92106</p> <p>Australian Head Office: Carter Holt Harvey Ltd Como Office Tower Level 16 644 Chapel Street Melbourne 3141</p>	<p>NZ Ph: (+64 09) 262 6000 Fax: (+64 09) 262 6099</p> <p>Australia Ph: (+61 03) 9823 1600 Fax: (+61 03) 9823 1620</p>	<p>Email: chhcontact@chh.com</p> <p>Web: www.chh.co.nz</p>
Chartherm		<p>THERMYA Parc Scientifique UNITEC 1 2 allée du doyen Georges Brus 33600 PESSAC – France</p>	<p>Ph: (+33 05) 5645 0716 Fax: (+33 05) 5645 1997</p>	<p>Email: info@thermya.com</p> <p>Web: www.chartherm.com</p>
DEPARTMENT for the Environment, Food and Rural Affairs (DEFRA)		<p>Defra Information Resource Centre Lower Ground Floor Ergon House c/o Nobel House 17 Smith Square London SW1P 3JR</p>	<p>Ph: (+44 020) 7238 6951 Fax: (+44 020) 7238 6609</p>	<p>Email: helpline@defra.gsi.gov.uk</p> <p>Web: www.defra.gov.uk</p>
EcoRecycle		<p>Level 2, 478 Albert Street East Melbourne VIC 3002 Australia</p>	<p>Ph: (+61 03) 9639 3322 Fax: (+61 03) 9639 3077</p>	<p>Email: mailbox@ecorecycle.vic.gov.au</p> <p>Web: www.ecorecycle.vic.gov.au</p>

Environmental Biotechnology CRC (Formerly CRC for Waste Management & Pollution Control)	Dr David Garman - CEO	Environmental Biotechnology CRC Suite G01 Bay 3, Locomotive Workshop Building Australian Technology Park Eveleigh NSW 1430	Ph: (+61 02) 9209 4970 Fax: (+61 02) 9209 4980	Email: ebcrc@ebcrc.com.au  Web: www.ebcrc.com.au
Environmental Protection & Heritage Council Waste Working Group (EPHC)	Mr D Borthwick-Chair. Commonwealth Dept. Environment & Conservation	Level 5 81 Flinders Street Adelaide SA 5000 Australia	Ph: (+61 08) 8419 1200 Fax: (+61 08) 8224 0912	Email: exec@ephc.gov.au  Web: www.ephc.gov.au
Environmental Working Group (EWG)		1436 U St. N.W., Suite 100 Washington DC 20009 USA	Ph: (+1 0202) 667 6982	Email: via web site  Web: www.ewg.org
FIRA International		Maxwell Road Stevenage Hertfordshire SG1 2EW England UK	Ph: (+44 014) 387 77700 Fax: (+44 014) 387 77800	Email: info@fira.co.uk  Web: www.fira.co.uk
Fraunhofer Wilhelm-Klauditz-Institut (WKI)	Prof. Dr Rainer Marutzky - Director	Bienroder Weg 54 E D-38108 Braunschweig Germany	Ph: (+49 05) 31 21 55 0 Fax: (+49 05) 31 35 15 87	Email: info@wki.fhg.de  Web: www.wki.fhg.de
International Agency for Research on Cancer (IARC)		150 Cours Albert-Thomas 69372 Lyon Cedex 08 France	Ph: (+33 04) 727 38485 Fax: (+33 04) 727 38575	Web: www.iarc.fr

Juken Nissho Ltd		Juken New Zealand Ltd Triboard Mill PO Box 153 Kaitaia New Zealand	Ph: (+64 09) 408 9167 Fax: (+64 09) 408 2979	Web: www.triboard.com
LLA Instruments GmbH		Schwarzschildstrasse 10 12489 Berlin-Aldershof Germany	Ph: (+49 30) 6719 8376 or (+49 30) 6392 4760 Fax: (+49 30) 6392 4766	Email: mail@LLA.de  Web: www.lla.de/english/
Macquarie Generation	Mr John Marcheff – Manager Liddell Power Station	PO Box 3416 Hamilton Delivery Centre NSW 2303 Australia	Ph: (+61 02) 4968 7499 Fax: (+61 02) 4968 7433	Web: www.macgen.com.au
National Health & Medical Research Council (NHMRC)		Office of NHMRC (MDP 100) GPO Box 9848 Canberra ACT 2601 Australia	Ph: (+61 02) 6289 9184 or 1800 020 103 (inside Australia) Fax: (+61 02) 6289 9197	Email: exec.sec@nhmrc.gov.au  Web: www.nhmrc.gov.au
National Occupational Health & Safety Commission (NOHSC)		Alan Woods Building Level 6, 25 Constitution Avenue Civic, Canberra GPO Box 1577 Canberra ACT 2601 Australia		Email: info@nohsc.gov.au  Web: www.nohsc.au

Expert Reference Group on Extended Producer Responsibility (ERG EPR), NSW Department of Environment & Conservation (NSW DEC)	Alex Young, ERG EPR	NSW DEC 59-61 Goulburn Street Sydney NSW PO Box A290 Sydney South NSW 1232 Australia	ERG EPR Ph: (+61 02) 8837 6025  NSW DEC Ph: (+61 02) 9995 5000 Fax: (+61 02) 9995 5999	Email: info@environment.nsw.gov.au  Web: ERG EPR www.environment.nsw.gov.au/waste/epr.index.htm  NSW DEC www.environment.nsw.gov.au
People's Environment Protection Alliance	Mr Warren Godson	C/- Mr G Goland Secretary RSD Brookman Road Meadows SA 5201 Australia		
Plywood Association of Australia (PAA)		'Plywood House' 3 Dunlop Street Newstead QLD PO Box 2108 Fortitude Valley M.A.C. QLD 4006 Australia	Ph: (+61 07) 3854 1228 Fax: (+61 07) 3252 4769	Email: folk@plywoodassn.com.au  Web: www.plywoodassn.com.au
SITA (UK)		Head Office: SITA House Grenfell Road Maidenhead, Berkshire, SL6 1ES	General Enquiries Ph: (+44 08) 704 21 1122  Head Office Ph: (+44 08) 628 51 3100	General enquiries Email: enquiries@sitaco.uk  Web: www.sitaco.uk

TRADA Technology (fibresolve)	Vic Kearley Stephen Riddiough	Chiltern House, Stocking Lane, Hughenden Valley, High Wycombe Buckinghamshire, HP14 4ND United Kingdom	Ph: (+44 01) 494 56 9600 Fax: (+44 01) 494 56 5487	Email: information@trada.co.uk  Web: www.trada.co.uk www.envirofibre.org.uk
U.S. Environmental Protection Agency		Environmental Protection Agency Ariel Rios Building 1200 Pennsylvania Avenue N.W. Washington, DC 20460 (202) 272-0167	Ph: Various phone numbers, email addresses and web sites. See "Contact Us" on web site listed here.	Web: www.epa.gov/epahome/
Waste & Resources Action Programme (WRAP)		The Old Academy, 21 Horse Fair, Banbury, Oxon OX16 0AH England	Ph: (+44 08) 08 10 020 40 Fax: (+44 08) 29 581 9911	Email: helpline@wrap.org.uk  Web: www.wrap.org.uk
World Health Organisation (WHO)		Headquarters: Avenue Appia 20 1211 Geneva 27 Switzerland	Ph: (+41 22) 791 2111 Fax: (+41 22) 791 3111	Email: info@who.int  Web: www.who.int

## **Appendix F    Glossary of Abbreviations and Acronyms**



ACGIH	American Conference of Governmental Industrial Hygienists
ACQ	Alkaline copper quat
ACT	Australian Capital Territory
AF&PA	American Forest and Paper Association
ANZSIC	Australian New Zealand Standard Industry Classifications
APVMA	Australian Pesticides and Veterinary Medicines Authority
As	Arsenic
USDA	United States Department of Agriculture
AUD	Australian Dollars
AWD	Australian Waste Database
B&D	Building and Demolition waste
C&D	Construction and Demolition waste
C&I	Commercial and Industrial waste
CCA	Chromated copper arsenate
CIWMB	Californian Integrated Waste Management Board
Cr	Chromium
Cu	Copper
DEFRA	Department for Environment, Food and Rural Affairs, UK
DSD	Duales System Deutschland
DTI	The Department of Trade and Industry, UK
DTU	Technical University of Denmark
EDTA	Ethylenediaminetetracetic acid
EN	Electronic nose
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility

EPHC	Environmental Protection and Heritage Council
ERG	Expert Reference Group
ERRCO	Environmental Resource Return Corporation
EU	European Union
EWG	Environmental Working Group
FIRA	Furniture Industry Research Association
HDPE	High density polyethylene
HPL	High pressure laminated
IB	Internal bond
IMS	Ion mobile spectroscopy
LDPE	Low density polyethylene
LDR	Land disposal restriction
LIBS	Laser induced breakdown spectroscopy
LOSP	Light organic solvent preservatives
LPM	Low pressure melamine
LVL	Laminated veneer lumber
MDF	Medium density fibreboard
MDI	Methylene diphenyl di-isocyanate
MF	Melamine-formaldehyde
MOE	Modulus of elasticity
MOR	Modulus of rupture
MR	Moisture resistance
MSW	Municipal solid waste
MUF	Melamine-urea formaldehyde
NIOSH	National Institute for Occupational Safety and Health

NIR	Near infrared
NO <sub>x</sub>	Nitrogen oxides
NSW	New South Wales
NSW DEC	Department of Environment and Conservation, New South Wales
NT	Northern Territory
OHS	Occupational Health and Safety
OSB	Oriented strand board
OSHA	Occupational Safety and Health Administration
PCDD/F	Dioxin and furan
PF	Phenol formaldehyde
PPA	Pollution Prevention Act
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
REC	Renewable Energy Certificates
RF	Resorcinol-formaldehyde
SEPP's	State Environmental protection Policies
SO <sub>x</sub>	Sulphur oxides
STEL	Short-term exposure limit
SWSA	Southern Waste Strategy Authority (Tasmania)
TDI	Toluene di-isocyanate
TLV	Threshold limit value
TWA	Time weighted average
UF	Urea-formaldehyde
UK	United Kingdom
US	United States of America

VOC	Volatile organic compounds
WAC	Waste Acceptance Criteria
WESP	Wet electrostatic precipitator
WKI	Wilhelm Klauditz Institute
WMP's	Waste Management Policies
WPC	Wood plastic composites
WRAP	Waste Resources Action programme
WTE	Waste-to-energy
XRF	X-ray fluorescence

**Disclaimer:**

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