



Forest & Wood
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MARKET ACCESS & DEVELOPMENT

PROJECT NUMBER: PNA017-0708

NOVEMBER 2008

Wood recovery and recycling: A source book for Australia

This report can also be viewed on the FWPA website

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Wood recovery and recycling: A source book for Australia

Prepared for

Forest & Wood Products Australia

by

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Publication: Wood recovery and recycling: A source book for Australia

Project No: PNA017-0708

This work is supported by funding provided to FWPA by the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF).

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ISBN: 978-1-920883-48-5

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Final report received by FWPA in August, 2008

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1 INTRODUCTION

1.1 Overview of Source Book

The source book is intended to provide a ‘map’ for transforming wood waste into wood resource. It is broken down into the following sections (as shown in the Figure 1 overleaf). Following this introduction, the source book begins by presenting an overview of wood waste, including the definition of wood waste, types of wood waste materials, different sources of wood waste and the different physical forms of wood waste materials.

Section 3 provides information on the volumes of wood waste in Australia, including a state-by-state breakdown of estimated tonnages of wood waste generation. This is followed by a summary of the various resource recovery opportunities available for value-adding to a waste resource in Section 4. These opportunities encompass re-use, direct recycling into timber products, indirect recycling into other product types (such as mulch and animal bedding), and finally energy generation.

The practical challenges of converting waste wood resources into value-added products are addressed in Section 5. Topics related to the materials handling of wood waste include collection and transport, aggregation and stockpiling, contaminant removal, quality assurance and product testing, wood dust, and treated timber. This is followed by issues related to regulation and wood waste recovery in Section 6. A state-by-state review of legislation is provided. Sustainability benefits and challenges are discussed in Section 7, in particular the focus of increasing value and reducing impact, industrial ecology, cleaner production, extended producer responsibility and highest resource value recovery.

Section 8 works through some of the issues surrounding carbon market opportunities for resource recovery and wood waste. The overall carbon value proposition is presented, followed by the potential to create carbon offsets through wood waste recovery. Key lessons regarding the overall process of resource recovery from wood waste are then highlighted in Section 9.

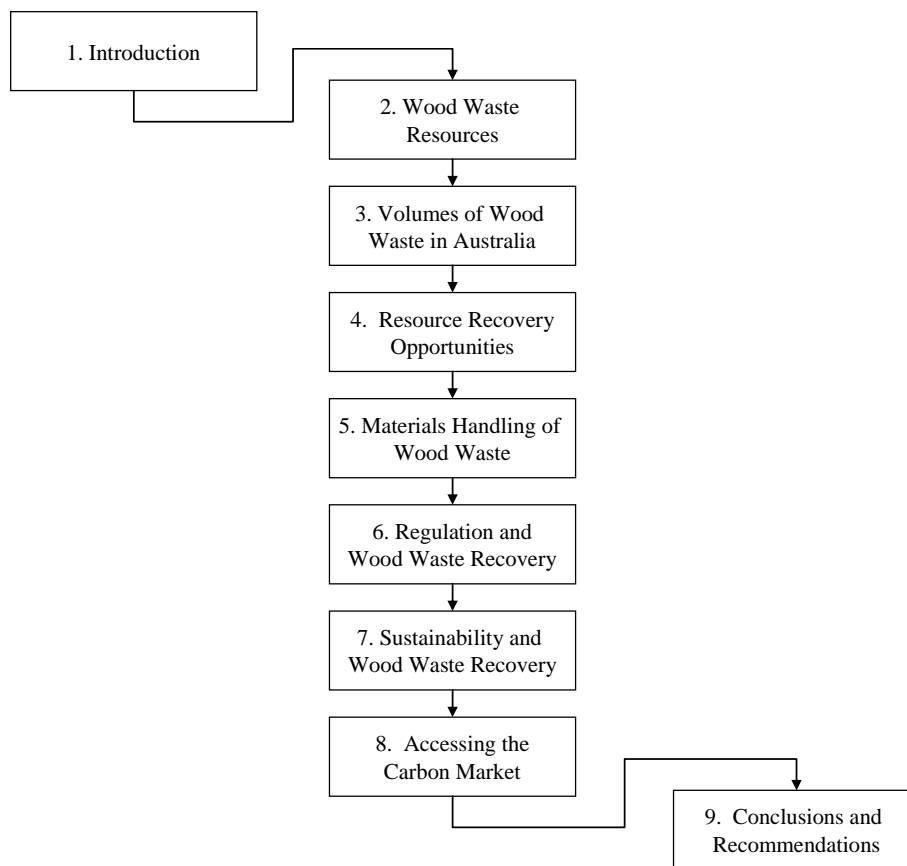


Figure 1 – Structure of report

2 WOOD WASTE RESOURCES

A major issue in wood waste recovery and recycling is that whilst it could be far better leveraged as a valuable resource in society, the nature of the current wood resource system and its flows does not always present a straightforward proposition for increased utilisation. ‘Wood waste’ therefore refers to what effectively can be described as those ‘wrong time and place’ materials that are perceived to have no further value to their owner/generator and thus present a problem of waste management.

The challenge for the growing wood recycling industry is how to successfully transform ‘wrong time and place’ wastes into ‘right time and place resources’. This will be achieved through transformation of these materials as perceived ‘wastes’ to useful ‘resources’ through enhanced redesign of logistics and by creating opportunities for higher value recovery that present a compelling commercial alternative.

2.1 Defining Wood Waste

There are numerous and varied definitions of the term “wood waste”. The Environment Protection Authority of New South Wales (NSW EPA) in its 1997 *Green Waste Action Plan* defined “wood waste” as green waste in conjunction with garden waste and food waste. Materials labelled as wood waste consist of sawn untreated timber, spent pallets and crates, wood packaging, and off-cuts. It must be noted that treated timber and waste from engineered timber products were excluded under this definition, and arguably should be included to more accurately reflect total wood waste volumes.¹

Wood waste was also defined as “sawdust, timber offcuts, wooden crates, wooden packaging, wooden pallets, wood shavings and similar materials, and includes any mixture of those materials, but does not include wood treated with chemicals such as copper chrome arsenate (CCA), high temperature creosote (HTC), pigmented emulsified creosote (PEC) and light organic solvent preservative (LOSP)” in the *1997 NSW Protection of the Environment Operations Act (POEO)*.²

The Californian Integrated Waste Management Board (CIWMB) defined urban wood waste as “the portion of the wood waste stream that can include sawn lumber, pruned branches, stumps and whole trees”. The primary constituents are wood waste from construction and demolition (C&D), commercial and industrial (C&I), Packaging and Transport (P&T) and Utilities sources.³ This definition has some advantages over the NSW EPA description, including a more detailed breakdown of the origins of wood wastes, however it does not clearly identify the origin of, and issues associated with, green waste.

The NSW Department of Environment and Climate Change defines wood waste as “wastes referring to the end-of-life products, failed products, off-cuts, shavings and sawdust from all timber products. This excludes both forest residues (often referred to as primary wood waste) and garden organics including branches, bushes and tree stumps”.⁴

The Clean Washington Center (CWC) uses data available from state and local databases to define wood waste and separate the material into the categories of residential urban wood waste in mixed

¹ NSW EPA, 1997, ‘Green Waste Action Plan’, Environment Protection Authority (New South Wales), Sydney.

² NSW EPA (1997) Protection of the Environment Operations Act (POEO). Accessed at: http://www.austlii.edu.au/au/legis/nsw/consol_act/poteoa1997455/sch1.html, August 2008

³ CIWMB, 1998, Urban Wood Waste Fact Sheet, California Integrated Waste Management Board, Los Angeles, accessed at <http://www.ciwmb.ca.gov/publications/condemo/44395057.doc>, August 2007.

⁴ NSWWB, 2000, ‘New South Wales Waste Boards Wood Waste Project – Final Report’, New South Wales Waste Boards, Sydney.

solid waste, commercial/industrial wood waste in mixed solid waste, brush/logs, urban wood waste in construction and demolition, wood pallets, and agricultural wood waste.⁵

For the purpose of this report, it is important to recognise the difference between primary forestry residuals and wood wastes (such as harvesting residues and garden organics), as opposed to the various forms of secondary wood wastes arising from the sources outlined above. The source book covers the latter category only, hence all references to ‘wood wastes’ herein should be assumed to refer to these secondary wood waste streams only.

For the purpose of the source book, the definition of wood waste refers to urban wood wastes which are destined for landfill. As such, the following are included in the definition:

- wood waste from construction and demolition (C&D), commercial and industrial (C&I), Packaging and Transport (P&T) and Utilities sources,
- the above categories include these types of wood waste derived from the above sources; sawdust, timber offcuts, wooden crates, wooden packaging, wooden pallets, wood shavings and similar materials, and
- untreated timber, [preservative] treated timber, timber with coating and/or paint and engineered wood products.

The following are not included in the source book definition of wood waste:

- forest and harvesting residues (often referred to as primary wood waste),
- green waste, garden organics including branches, bushes and tree stumps,
- agricultural wood waste, and
- waste and residues from sawmills or engineered wood product manufacture.

2.2 Types of Wood Waste

2.2.1 *Untreated Timber*

Untreated timber refers to timber that has *not* been treated with a timber preservative, such as copper chrome arsenic (CCA). Common sources of untreated timber are furniture and [some] untreated timber framing for houses. This wood is generally of high quality and is referred to as ‘A’ class.

Timber log products are untreated timbers that are usually categorised as either “softwood” or “hardwood”. In the past, this division referred to the hardness or softness of the timber which led to confusion and the incorrect categorisation of timber. Today, however, softwood is identified as timber that comes from coniferous (cone bearing) trees such as pines or firs. Hardwood comes from trees with broad leaves that produce seeds in an enclosed case, for example eucalypts, oak and walnut.⁶

⁵ CWC, 1997, Best Practices in Wood Recycling – Identifying Generation Streams of Wood Waste Materials, Clean Washington Center, accessed at http://www.cwc.org/wd_bp/wd_bp_pdf/1-01-01.pdf, August 2007.

⁶ TDA, 1989, ‘Introducing Timber - An Introduction to Wood and Timber, Timber Information Leaflet No.1’, Timber Development Association (New South Wales) Ltd, Sydney.

2.2.2 Engineered Wood Products

Engineered wood products are manufactured in a variety of ways using wood (e.g. veneers, flakes, chips and fibres) and resins (adhesives), which bond the pieces together to form a variety of products, including structural applications. Common engineered wood products include plywood, laminated veneer lumber (LVL), glued laminated lumber, particleboard and medium density fibreboard (MDF). Finger-jointed timber is also a common engineered wood product, manufactured by gluing and joining small pieces of timber end to end to form a longer piece of timber. Wood wastes of this nature are referred to as a 'B' class resource in this document.

2.2.3 Preservative Treated and Painted Timber

Finally, treated timber (class 'C' waste wood) refers to timber treated with timber preservatives, or coated or painted to improve the timber products' resistance to attack by biological agents such as fungi, insects and animals. In Australia, treated timber consists primarily of softwood treated with preservatives such as Copper Chromium Arsenic (CCA) (also known as Chromated Copper Arsenate), synthetic pyrethroids as Light Organic Solvent Preservative (LOSP) or creosote. Small volumes of hardwood timber are also preservative treated for various uses, such as marine pilings and poles. A less common treatment was penta-chloro-phenyl (PCP - phased out in 1970s-1980s). Timber painted with lead-based paint, although phased out in Australia in 1970, still appears in the waste stream.

A large quantity of Australian softwood framing is now H2F treated against termites. A recent survey suggested that over 20% of treated pine has been treated for termite resistance.⁷

Common timber preservatives include:

- Copper Chromium Arsenic (CCA), compounds of copper, chromium and arsenic that are recognised by a characteristic green colour in the timber.
- Other water-based treatments such as alkaline copper quaternary (ACQ) and copper azole.
- Light Organic Solvent Preservative (LOSP) incorporating a synthetic pyrethroid, is used to introduce pesticides into the timber, and usually associated with little or no colour change.
- Other chemicals usually used only to produce timber for specific customer needs, including creosote-in-oil, pigment-emulsified-creosote (PEC), double treatment (CCA followed by creosote), treatment with boron compounds and treatment with sodium fluoride.
- Supplementary treatments, which are applied on-site to improve the timber products' resistance to attack by biological agents such as fungi, insects and animals.

2.3 Sources of Wood Waste

There are four sources of urban wood waste: Commercial and Industrial (C&I), Construction and Demolition (C&D), Pallets and Packaging (P&P) and Utilities.

2.3.1 Commercial and Industrial (C&I)

Commercial and Industrial (C&I) activities that generate wood waste include those related to the manufacture of products such as:

- kitchens

⁷ A3P (2007) Sales Statistics Survey. Pers. Comm. P. Juniper, July 2008.

- joinery
- structural components
- furniture
- pallets
- transport packaging
- cabinet making
- construction facings and panels.

Wood waste generation associated with C&I manufacture, in particular from engineered wood products, is mainly due to essential business activities. Essential business activities include, but are not limited to, methods used for cutting, planing, and sanding, which create shavings, sawdust and off-cuts, most of which are disposed of in landfill. Manufacturing timber products to customer specifications when working with fixed dimensioned wood panel products increases the amount of off-cuts created. This is especially the case when manufacturing circular or curved surfaces/products. Furthermore, the cost of labour relative to the cost of timber products is such that it is often “cheaper” to discard a faulty product than to re-work it. Additionally, the over ordering of timber products is typically desirable compared to running out of materials, which further facilitates increased waste generation. In some enterprises, it is difficult to order timber dimensions which closely relate to the product dimensions, creating extra wastage in offcuts as timber is reduced to the size needed for manufacturing. The present methods of timber related manufacturing and application will continue to generate significant amounts of wood waste if processing techniques are left unchanged.⁸

2.3.2 Construction and Demolition (C&D)

Construction and Demolition (C&D) waste includes material generated from residential and commercial building projects. Waste is generated through the construction, maintenance, renovation or deconstruction of the built environment.

With the exception of the *Report into the Construction and Demolition Waste Stream Audit 2000 – 2005*⁹, there is a lack of Australian data on the specific composition of wood waste from C&D sources. This is due to the typical inclusion of all timber recovered from construction sites as generic “wood waste” without discrimination based on type.

The *Report into the Construction and Demolition Waste Stream Audit 2000 – 2005* broke down waste timber into particle-size (large size > 300 mm and medium size 30 – 300 mm) as well as source (i.e. hardwood, softwood, and other). Their study identified that 95,000 tonnes of timber were disposed of to landfill in the Metropolitan Sydney Area in 2004 – 05. This comprised 7.1% of all C&D waste disposed of that year. The study further identified the breakdown timber categories greater than 300 mm as being 14.4% hardwood, 14.4% softwood and 9.1% other timber (engineered wood products).⁹ The remaining percentage of timber (< 300 mm) was not identified into breakdown products in the report, which may be accounted for by the presumed difficulty in recycling small disaggregated wood pieces.

The National Association of Home Builders in America has estimated that from a 185 square metre domestic house, the amounts of wood waste that would be generated from its demolition would be

⁸ SBAEP, 1998, ‘The Research Report of the Small Business Assessment and Education Project’, Blacktown City Council and the Western Sydney Waste Board, Sydney.

⁹ Dept. of Environment and Climate Change NSW (2007) Report into the Construction and Demolition Waste Stream Audit 2000 – 2005. DECC NSW, pp. 21. Accessed at: http://www.environment.nsw.gov.au/resources/warr/2007320_consDEMOWaste_1.pdf, August 2008.

4.5m³ of solid sawnwood and 4m³ of engineered (manufactured) wood.¹⁰

The Australian Greenhouse Office based calculations on the usage and life cycle of wood products on a technical report commissioned for the National Carbon Accounting System in which the assumed wood consumption of an Australian house was estimated at 13m³.¹¹ Assumptions on the life span of timber products were made, assigning a provisional life span of 90 years for wood used in domestic construction. Further assumptions on life span of timber products in the study were as follows:

- 90 years, housing construction and furniture.
- 50 years, preservative treated pine, softwood furniture and hardwood poles.
- 30 years, plywood, particleboard and MDF for cabinetry, preservative treated pine for decking and hardwood sleepers.
- 10 years, hardwood pallets and palings, hardboard packaging and particleboard and MDF shop fitting.
- 3 years, softwood pallets, plywood formwork and paper products.

One factor that may alter this proportion, however, is the life span (or stock life) of the manufactured product. The anecdotal estimated mean life of products manufactured from timber panels such as particleboard is approximately 10 to 15 years, whereas sawnwood products in construction could have a mean life of 50 to 70 years. The shorter lifespan of engineered wood products such as particleboard may be due to the “lifecycle” of the products in the house. For example, kitchens and bathrooms, which use substantial amounts of engineered wood products for cabinetry, are replaced several times throughout the lifespan of the house; whereas the timber framing for the house may never be replaced unless damaged or altered as per an extension. For this reason, and as more engineered timber products are used as substitutes in solid timber applications, it is anticipated that a higher volume and proportion of engineered timber products will enter the C&D waste stream over time.

2.3.3 Pallets and Packaging (P&P)

The reuse possibilities of wood waste from packaging and transport sources are significant. Wood waste from packaging and transport sources includes end-of-life pooled pallets (usually hardwood), one-way pallets (usually softwood) and one-way crates and boxes. The significance of this wood waste type is seen in the U.S.A, as pallet recycling is rapidly taking market share from new pallets made from virgin resources.¹²

2.3.4 Utilities & Civil Infrastructure

Wood waste from utilities and civil infrastructure includes power and telephone poles, railway sleepers, bridge and jetty supports and planking. For instance, within NSW alone there are an estimated 2 million power poles (and possibly 150,000 Telstra poles).¹³ Approximately one per cent of poles are replaced annually, which is equivalent to the replacement of around 20,000 poles per annum. At least 95 per cent are derived from hardwood eucalyptus species, which are treated before installation as well as during their service life. Issues with the management of power poles include

¹⁰ Yost (1998) “C&D Wood Debris Management Trends”, *Resource Recycling November 1998, Vol. XVII, No. 11*.

¹¹ Jaakko Poyry Consulting (1999) Usage and Life Cycle of Wood Products. National Carbon Accounting System Technical Report No. 8. Australian Greenhouse Office. Pp. 88. Accessed at: <http://www.climatechange.gov.au/ncas/reports/pubs/tech08.pdf>, August 2008.

¹² Bush, R.J., Reddy, V.S. and Araman, P.A., 1997, ‘Pallets: a growing source of recycled wood’. In Falk, R.H. (ed) ‘The Use of Recycled Wood and Paper in Building Applications’. Forest Products Society, Proceedings No. 7286 24-28.

¹³ EANSW (1999). ‘Old Power Poles – Wood Waste or Wasted Wood?’, Draft Position Paper of the Electricity Association of NSW (EANSW).

preservative treatments, in particular the butt of the pole where remedial preservative treatment rods have been installed during the service life, and contamination with metal spikes (EANSW 1999).¹⁴

Aging bridges and jetty supports constitute a significant source of wood waste once decommissioning takes place, with much of it ending up in landfill. Old railway lines also supply a large quantity of sleepers, as wood is slowly replaced by concrete across the country in this application. There is already an established market for 2nd hand sleepers in gardening and landscaping applications, however there may be alternative uses for this waste stream. A summary of types and sources of waste wood is included in the table below (Table 1):

Table 1 – Summary of the different types and sources of wood waste

<i>Type of Wood Waste</i>	<i>Main Source</i>
Untreated timber	– commercial and industrial manufacturers, pallets and packaging
Engineered wood products	– construction and demolition, municipal solid waste, commercial and industrial manufacturers
Treated timber	– construction and demolition, municipal solid waste, utilities (power poles)

2.4 Physical Form of Wood Waste

Wood waste from timber related manufacturers (excluding wood waste from sawmills and particleboard/medium density fibreboard manufacturers) is primarily disposed of directly to landfill, owing to a lack of processing and collection infrastructure for alternative uses. This is slowly changing in the Australian context, with the impact of higher landfill fees and incentives such as the Mandatory Renewable Energy Target influencing greater levels of resource recovery.

The physical form of wood waste presents various challenges for resource recovery. For example, fastenings (nails, hinges, gangplates) will typically need to be removed before the waste can be utilised. Depending on the nature of the material and how deeply imbedded in the wood, it may be difficult to automate this process, resulting in additional labour cost. Shavings of wood can range in size and can also include splinters. Sawdust particles are also highly variable and range from coarse particles to flour that can present a health and/or an explosion hazard.

‘Off-cuts’ refers to the pieces of wood created in manufacturing that are superfluous to requirements either due to irregularity of form or unsuitability for reuse. The collection, transportation and storage of this type of wood waste occupies a large volume due to the irregularity and lack of uniformity in shape or structure of the recovered material.

Some forms of wood waste, such as shavings and sawdust, have a tendency to absorb moisture from the air due to the relatively high surface area of the individual particles, potentially complicating their reprocessing. Stockpiles of these materials can also be subject to wind dispersal and so must be covered or contained in some way.

¹⁴ EANSW, 1999, ‘Old Power Poles – Wood Waste or Wasted Wood?’ Draft Position Paper of the Electricity Association of NSW (EANSW), Sydney.

The inherent challenges of dealing with wood waste in all of its various physical forms means that innovative solutions are required to recover maximum value from this resource. Solutions may be technical in nature and involve significant amounts of capital. However, there are opportunities for synergistic utilisation of wood wastes, either on-site (for example co-generation of heat and power) or nearby in co-operation with partners (for example as inputs for added-value products) that may only require improved planning related to the design of the manufacturing process or storage site itself.

3 VOLUMES OF WOOD WASTE IN AUSTRALIA

The following section provides a comprehensive update of wood waste volumes which are both recycled and disposed of to landfills in Australia. The information has been provided by various state-based agencies, such as the Environmental Protection Authority, or relevant Department of Environment in each state. Where possible, data have been verified with the agency conducting the most recent audit.

3.1 Production and Consumption of Wood Products in Australia

The Australian Bureau of Agricultural and Resource Economics (ABARE) provides the most recent data on Australian production and consumption of timber products.¹⁵ Statistics covering the 2006 – 2007 financial year indicate that in 2006-07, sawnwood production increased slightly in Australia. This is despite a downturn in the domestic housing market and is attributed to the continuing growth of the Asian export market.¹⁵

Sawnwood production in 2006-07 was over 5.064 million m³. Production of wood-based panels decreased, to 1.743 million m³. At the same time, imports of sawnwood decreased markedly, down to 611,000 m³. Imports of wood-based panels increased from 365,000 to 424,000m³.

Consumption of sawnwood appears to have declined, following a decline in housing starts, and was reported to be 5.248 million m³, down from 5.402 million m³ the previous year. Wood-based panel consumption appears to have also decreased for 2006-07, to 1.794 million m³.

3.2 Summary of National Wood Waste Generation

The following table (Table 2) provides a summary of annual data relating to landfill, recycled and/or total generated wood waste across Australia. It should be noted that these figures are purely indicative and do not in any way represent a final estimate, reflecting only the existing (incomplete) data sets that are available. The authors have proposed improved quantification of these figures, both in terms of methodology and frequency.

Table 2. Previous and updated wood waste estimates (tonnes)				
<i>State</i>	<i>Previous Landfilled</i>	<i>Updated Estimate</i>	<i>Previous Recycled</i>	<i>Updated Estimate</i>
New South Wales	315,000	345,000	131,000	
Victoria	470,000		153,000	230,000
Queensland	~267,000	*48,000		*20,000m ³
Western Australia	~147,000	150,000- 180,000		10,170
South Australia	~173,000			255,728
Tasmania	~20,000			
Australian Capital Territory	~39,000	17,259		2,359
Northern Territory	~26,000			

~ Estimated by Taylor et al.³²

* Brisbane only

¹⁵ ABARE (2008) Australian Forest and Wood Products Statistics. September and December Quarters 2007. Canberra, May, accessed at <http://www.abareconomics.com/>, December 2007

Working from the broad assumption that 5.5% of the total waste generated is composed of wood waste (from a combined aggregate of domestic, construction & demolition, and commercial & industrial wastes), 2007 data from the ABS points to a figure of around 1,781,000 tonnes of wood waste being generated in Australia per annum.¹⁶

Results of a recent national survey of selected landfills throughout Australia identified that the type of wood most commonly observed in landfill waste was untreated softwood and untreated hardwood, which when combined, represent approximately two-thirds of the total wood waste volume and mass being landfilled.¹⁷ The main origins of untreated hardwood were construction and demolition waste, broken pallets, fencing, and off-cuts.

Untreated softwood was the second highest wood waste in terms of both volume and mass, followed by particleboard and medium density fibreboard (MDF). Across all states (of the surveyed landfills), wood waste represented approximately 12.5 percent by volume of all waste going to landfill, and approximately 5.5 percent by mass.

3.2.1 New South Wales

New South Wales has undertaken the most detailed studies on wood waste of all of the states in Australia. Most of the studies were conducted with a detailed breakdown regarding the types of waste. For example, a separate category exists for wood waste, as opposed to including wood waste with other wastes (such as building and construction wastes). This has enabled more detailed data to be collated which differentiate wood wastes from other waste categories.

Numerous reports written since 2000 have estimated the volumes of wood waste in the greater Sydney region.^{18,19,20,21} The most recent document in the public domain is “Waste Avoidance and Resource Recovery in NSW – A Progress Report 2004”.²² The “Report into the Construction and Demolition Waste Stream Audit 2000 – 2005” also identified wood waste from the C&D waste stream disposed of to landfill in the Sydney Metropolitan Area.⁹ To the authors’ knowledge, there have been no further detailed (published) studies in NSW that estimate wood waste volumes.

The 2004 “Waste Avoidance and Resource Recovery in NSW – A Progress Report 2004” report estimated that in NSW, 315,000 tonnes of wood is disposed of to landfill. A further 131,000 tonnes of wood is recycled, meaning that some 446,000 tonnes of wood waste is generated annually in NSW.²² Given that the NSW estimate on total annual waste generation is approximately 12 million tonnes, wood makes up approximately 4% of this total.

Further estimates of timber waste in 2004 suggested that wood waste volumes in the Sydney metropolitan area make up 6% of total C&I waste generation annually. This accounts for

¹⁶ The Australian Bureau of Statistics, 2007. *Year Book Australia*

¹⁷ Taylor and Warnken (2008) Unpublished data. “Renewable Energy Atlas” Website when live.

¹⁸ Wright, T., C. Zoi et al. (2000) “Report of the Alternative Waste Management Technologies and Practices Enquiry”.

¹⁹ Russell, M. (2001) “Wood Waste Generation in the Extended Sydney Region by the Commercial and Industrial Sector”.

²⁰ NSW Waste Boards (2000) “Wood Waste Project Final Report”.

²¹ NSW Waste Boards (2001) “A Survey of Infrastructure for the Receiving and Processing of Wood Waste”.

²² NSW Department of Environment and Conservation (2004) “Waste Avoidance and Resource Recovery in NSW – A Progress Report”

approximately 174,000 tonnes of wood waste a year.²² 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.

A report from September 2007 outlined the volumes of waste sent to landfill for several different material types in the Sydney Metropolitan Area for 2004/05. This study stated that about 90,000 tonnes of timber was disposed of to landfill in mixed C&D waste.²³

The Department of Environment and Climate Change NSW has recently completed an unpublished estimate of wood waste, trees and timber disposed of to landfill in the Greater Sydney region. The results of the study suggest that in 2006, 345,000 tonnes of waste wood, timber and trees were disposed of to landfill in Sydney.²⁴ The study encompassed only the Greater Sydney region, which is assumed to contribute 75% of all waste landfilled in NSW.

3.2.2 Victoria

Data relating to waste and landfill are collected as part of the Victorian Landfill Levy, which was introduced by the *Environmental Protection Act in 1992*.²⁵ The data on volumes of waste to landfill are then collected by Eco Recycle Victoria (now Sustainability Victoria). 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).

In 2003, Eco Recycle Victoria released a report *Towards Zero Waste - Supporting Analysis to the Strategy & Plan*, as part of the development of its waste strategy.²⁶ This report is still regarded as the most up to date in terms of published information on wood waste volumes in Victoria. It 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 mass, and is enough timber to fill the Melbourne Cricket Ground 1.5 times.²⁷

The volumes of wood waste recycled each year in Victoria have slowly increased, assisted by initiatives such as the Wood Waste Network, supported by Eco Recycle Victoria (now Sustainability Victoria), and established in 1998. Recent figures quoted by Sustainability Victoria suggest that the amounts of wood directed to landfill have reduced significantly, with about 40% of waste wood now being recycled.²⁸ That equates to about 230,000 tonnes of waste wood recovered annually.

The most significant generation of waste wood is from the C&I waste stream, which produces approximately 325,000 tonnes of waste wood annually.²⁹ 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, with the remaining 13% from roads, civil construction and demolition.²⁹

²³ Department of Environment and Climate Change NSW (2007) Report into the Construction and Demolition Waste Stream Audit 2000-2005, Sydney Metropolitan Area. Located at: www.environment.nsw.gov.au/education/cndwastestream.htm. Accessed Sept. 2007.

²⁴ Pers. Comm., Department of Environment and Climate Change NSW. Aug 2007.

²⁵ <http://www.ecorecycle.vic.gov.au/aboutus/statistics.asp>. Accessed 2005.

²⁶ EcoRecycle Victoria (2003) "Towards Zero Waste - Supporting Analysis to the Strategy & Plan"

²⁷ <http://203.147.170.129/www/default.asp?casid=3278>

²⁸ Pers. Comm. Bill Grant, Sustainability Victoria, Aug. 2007.

²⁹ EcoRecycle Victoria (2002) "Supplementary Report on Solid Waste Strategy Discussion Paper 2002".

3.2.3 Queensland

A recent document, *The State of Waste and Recycling in Queensland*, has presented some updated information on wood waste recycling in Queensland.³⁰ A state-wide survey was conducted of both council and private waste operators. The private landfill respondents were the only group to separate waste wood from other waste streams in the survey. The report stated that, of participating private landfill respondents, 9,000 tonnes of waste wood was recycled off-site, with a further 105 tonnes recycled on-site.

Some relevant data are also available from the local government respondents, although these data were not broken down into wood waste as a separate category. The study found that councils disposed of 274,000 tonnes of C&D waste and recycled 127,000 tonnes. The study also listed data for C&I waste, green and organic waste and biosolids. The data are included in the table below (Table 3):

Secondary Resource Stream	Landfilled	Recovered
Construction and Demolition	274	127
Commercial and Industrial	420	23
Green and Organic	44	621
Biosolids	7	32
Total	745	804

Although wood waste data are not explicitly defined in the above information, it can be assumed that a percentage of each of the above categories consisted of wood waste that was either disposed of to landfill or recycled by local councils in Queensland.

Previous studies, including 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 2001-2002.³¹ Of this total, C&D waste accounted for 645,000 tonnes and C&I waste 577,400 tonnes.

A recent publication by Taylor *et al.* interpreted the recycling data to estimate 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).³² Thus for Queensland, the total annual waste generation is 4,859,100 tonnes. Applying the average rate of wood waste generation in NSW and Victoria to this total (5.5%), there is an estimated 267,000 tonnes of wood waste generated annually in Queensland.

³⁰ The State of Queensland Environmental Protection Agency (2006) "The State of Waste and Recycling in Queensland".

³¹ Queensland EPA (1999) State of the Environment.

³² Taylor, Mann, Reilly, Warnken, Pincic, and Death (2005) "Recycling and End-of-Life Disposal of Timber Products" Forest and Wood Products Research and Development Corporation.

The Recycled Timber Industry in Queensland prepared a report in 2007 which quoted the above estimate of 267,000 tonnes of waste wood as that destined for landfill in Queensland each year.³³ It cited a Brisbane City Council figure of 48,000 tonnes of wood waste disposed of to landfill in Brisbane in 2004. The report also estimated that the wood waste sector recycled about 20,000 m³ of timber a year.

The report highlighted the need for further data, and in particular resource mapping, in order to improve on the “crude assumptions” based on Taylor *et al.* (2005), so that actual volumes of waste wood and its potential for recovery can be determined.

3.2.4 Western Australia

The landfill data for Perth have been collected by The Western Australia Department of Environment and Waste Management Board.³⁴ In 2002, the C&D waste stream contributed to over 50% of waste to landfill (by volume), where the estimated total waste to landfill was 2,541,165 tonnes.³⁵ The *Construction and Demolition Waste: Sector Actions* document estimated that about \$10 million worth of materials are salvaged from construction and demolition sites around Perth annually.³⁶ The total waste generation for Western Australia is estimated at 2,675,055 tonnes.³⁵ The report by Taylor *et al.* (2005) applied the average wood composition rate of 5.5%, resulting in a wood waste generation estimate of 147,000 tonnes per annum.³²

A recent consultant report from March 2007 suggests that even the figures above may be underestimating wood waste quantities. Recent disposal-based audits at landfill sites in WA list wood/timber as a separate category in the audits of both C&I and C&D waste. The audits found that the wood component of C&I waste accounted for 291 tonnes (15% of total) and C&D waste accounted for 49 tonnes (2% of total) during the duration of the study at the audited landfills.³⁷

Recent communication with the Department of Environment and Conservation, Waste Management Branch in Western Australia (DEC WA) has suggested that the above calculation may have underestimated total wood waste generation, which has been calculated (using the recent disposal-based audits) to be closer to 160,000 to 190,000 tonnes.³⁸

DEC WA has stated that 10,170 tonnes of wood waste were recycled in 2005/06 (not including composting and mulching).³⁹ The estimated volume of wood waste going to landfill would therefore be between 150,000 and 180,000 tonnes per annum.³⁸

³³ DSDTI Industry Sustainability (2007) “Recycled Timber Industry in Queensland – Industry Development Plan”.

³⁴ Western Australia Department of Environment and Waste Management Board (2003) “Strategic Direction for Waste Management in Western Australia”

³⁵ Government of Western Australia, Waste Management Board (2003) “Summary Report on Waste to Landfill, Perth Metropolitan Region, Western Australia”.

³⁶ http://www.environ.wa.gov.au/downloads/1040_W20200301.pdf (no longer available)

³⁷ Golder Associates and Waste Audit and Consultancy Services (Aust) Pty Ltd (2007) “Disposal based Audits of the C&I and C&D Waste Streams for the Department of Environment and Conservation”.

³⁸ Pers. Comm. A. Bremner, DEC WA, August 2007.

³⁹ Cardno BSD (2007) Review of Total Recycling Activity in Western Australia 2005/06. Prepared for WA Department of Environment and Conservation, June 2007. Located at: www.zerowastewa.com.au/documents/rec_activity_review_0506.pdf. accessed Sept. 2007.

3.2.5 South Australia

The Environmental Protection Authority in South Australia (SA EPA) does not require compositional reporting at landfills, hence data sets on wood waste are unavailable in this state. Zero Waste South Australia has previously commissioned audits to determine the composition of waste to landfill. The most recent of those was in 2004.⁴⁰ This report cited that 278 tonnes of wood/timber were recorded during the week of the audit. Based upon the total waste to landfill during the audit, this figure represented 3.77% of total metropolitan generated waste to landfill. The 1998 audit recorded the percentage of wood waste to be 6.82%.⁴¹

The 2004 report specified the percentage of waste wood in the C&I waste stream to be 6.5%.⁴⁰ Pallets made up the largest category of wood type, and it was recorded that about 14% of the total number of pallets in the waste stream were recycled.

A more recent report from 2005 listed recovered quantities of timber (from the organics waste stream) to be 255,728 tonnes in 2005-06.⁴²

A survey conducted in 2007 has been published by Zero Waste SA and is available on the internet.⁴³ The survey was conducted across seven landfills and transfer stations around Adelaide. The results of the study were broken into waste stream (C&I, C&D) and waste type, including timber. A summary of the results is presented below (Table 4).

Table 4 – Zero Waste SA Survey Results Summary

	Wood/Timber Weight (% of total)	Wood/Timber Weight (tonnes)
Commercial and Industrial	7.94%	444.30
Construction and Demolition	7.67%	118.05

The study further elucidated the source of the waste wood material (by manufacturing industry sector) as well as composition of the loads. It was also found that the majority of the wood waste (78.97%) came from C&I waste, with C&D waste contributing 21.03% of the wood waste audited.⁴³

Aside from these estimates based upon compositional studies, no other specific data on wood waste volumes are available for South Australia.⁴¹

⁴⁰ Waste Audit and Consultancy Services (Aust) Pty Ltd (2004) "Landfill Survey Zero Waste South Australia".

⁴¹ Pers. Comm. Ian Harvey, Zero Waste SA, Aug. 2007.

⁴² Hyder Consulting (2005) "Recycling Activity in South Australia 2005-06".

⁴³ Waste Audit and Consultancy Services (Aust) Pty. Ltd. (2007) Disposal Based Survey, Zero Waste SA, Oct. Nov. 2007. pp. 133. Accessed at: http://www.zerowaste.sa.gov.au/pdf/reports/landfill_audit_report_2007.pdf, Accessed Aug. 2008.

3.2.6 Tasmania

The most recent data from Tasmania that have been summarised for public release were from July to December 2006 (Table 5).⁴⁴ The waste data were reported from the 14 most significant landfills in Tasmania, so total volumes for the state are underrepresented.

No specific data are available for wood waste, so information on actual volumes is imbedded in the C&D and C&I data in each of the three regions below. Again, based on the estimated ratio of 5.5% wood waste in total waste volume, this would suggest Tasmanian wood waste volumes to be of the order of 18,350 tonnes.

Table 5 - Six month waste data across waste streams in the three regions in Tasmania. Data represent reporting from 14 of the 20 landfills (tonnes).

	North West	North	South
Municipal	41,066	60,058	76,411
Commercial and Industrial	18,303	1,590	37,048
Construction and Demolition	10,236	300	88,088
Total	69,605	62,478	201,547

3.2.7 Australian Capital Territory

Data on waste wood in the Australian Capital Territory are not currently published. However, recent conversations suggest that if previous studies are extrapolated, a total of 292,000 tonnes of waste could be assumed to have been disposed of to the only major metropolitan landfill in Symonston in 2005/06.⁴⁵ Using data from the last inventory of waste disposal from 1996/07, and applying the same percentage of wood compared to total waste, it is estimated that approximately 10,000 tonnes of timber are disposed of to the Symonston landfill annually.⁴⁵

Other information, sourced from Canberra Concrete Recyclers, suggests that from July 2004 to June 2007, about 3% of total construction and demolition waste received at its gate was timber. This mixed timber waste was disposed of to landfill due to sorting difficulties. Actual figures from Canberra Concrete Recyclers indicate that 7,259 tonnes of waste wood from the construction and demolition recycling operation are disposed of to landfill.⁴⁶ A further 2,396 tonnes of waste wood are recovered and converted to mulch products and sold.

When the above figures are combined, the Australian Capital Territory estimate of wood waste to landfill is about 17,259 tonnes per annum, with a further 2,359 tonnes of waste wood recycled.

⁴⁴ Pers. Comm. Mark Cretney, Environment Tasmania, Aug. 2007.

⁴⁵ Pers. Comm. Graham Mannall, ACT NOWaste, Aug. 2007.

⁴⁶ Pers. Comm. Tony Buchanan, General manager Canberra Concrete Recyclers, Aug. 2007.

3.2.8 Northern Territory

There are no published data specifically on wood waste for the Northern Territory. Although green waste is not included in this document's definition of wood waste, the data available from the Alice Springs Town Council lists volumes of certain types of green waste for the Alice Springs area from July 2006 to June 2007 (Table 6).

Table 6 - Transactions by product by Alice Springs Town Council 2006/07		
Category	Description	Weight (tonnes)
Green - Charged	Timber unsuitable for mulching and branches greater than 250 mm diameter	70.78
Green - Commercial	Green waste suitable for mulching/composting brought by commercial operators	2,636.23
Green - Domestic	Green waste suitable for mulching/composting brought by residents	541.20
Demolition - Mixed		4,416.16

4 RESOURCE RECOVERY OPPORTUNITIES

The predominant recovery opportunities for waste wood include re-use (original form and function), direct recycling into other timber products (for example demolition timber into particleboard), indirect recycling into non-timber products (such as landscape mulch) and energy generation (process heat and/or electricity).

4.1 Re-use

The re-use of wood products refers to instances where there is minimal processing of the waste material or alteration of original product function prior to redeployment. Re-use options for wood waste primarily exist outside the point of manufacture (such as the re-use of floorboards or timber pallets), since any wood waste generated by definition during manufacture has little/no value or re-use potential as a quality production input.

4.1.1 *Pallets and Packaging*

Retrieval of pallets and packaging material from source separated ‘wood only’ loads and from the tip faces of landfills can be made profitable through the resale of materials. Industry has already established the value of re-use through its adoption of standardised pallet designs. Such pallets are designed for the purposes of making multiple trips. To increase longevity, damaged components can be replaced, and it is not uncommon for large volume users of pallets to have their own in-house pallet repair operation.

Pallet loss is endemic in the building industry, with many tens of thousands of pallets going missing each year. A large proportion of these “lost” pallets end up in landfill. To counter this, many companies have introduced financial incentives, such as deposits on pallets, to encourage the return of pallets.

The value of pallets translates into several commercial opportunities, such as the provision of retrieval services for the owners of “branded” pallets (for example Chep and Loscum), the resale of pallets in good condition and the repair and resale of damaged pallets. A pallet retrieval service would encourage the salvage of pallets in source separated wood loads and their removal from tip faces. There is the potential to directly resell pallets that are not “brand named” on a wholesale basis and/or repair and sell them to pallet brokers, manufacturers, freight and distribution businesses.

Other options include the preparation and sale of pallet materials for the pallet repair process. These materials include pallets that can be cut to length to act as feedstock for the remanufacture of ‘new’ pallets. Anecdotal evidence indicates that the materials reclaimed from this process can be worth up to 50% of the retail price of new pallets. Use of mechanised processes to reduce labour costs serves as a viable option and is often employed throughout the U.S.A. and Western Europe.

4.1.2 *Building Materials*

The demand for second-hand building materials is derived from various sources, including architects, home renovators, and hobbyists/craftspeople, all of whom are looking for a readily available and cost effective source of second-hand raw materials.

While there is high potential for re-use of used timber, the initial set-up for this type of business is dependent upon several factors, such as transport costs, and the space available for receiving, sorting and display of the wood materials. Shelter is also required for most materials, in addition to providing display and storage facilities.

Recovery of floorboards is potentially profitable. With trends for restoring and renovating old houses using ‘original’ or ‘antique’ materials, some floorboards are viewed as more valuable in their second-hand state.

Supply of schools with materials for their manual arts class projects is also another possible market at a national level. Materials, with fastenings attached, can be supplied to schools with little processing, since their major interests is in getting as much quality material as possible, often within tight budget constraints.

Value-adding of such timber is also possible, ranging from low technology processes such as de-nailing and cutting the timber to marketable lengths, to higher technology processes such as nail detection, thickening and planing.

A novel possibility being explored in California is the employment of inspectors, tasked with touring construction and demolition sites to assess timber materials that have been reclaimed from buildings. The materials are certified as to their specifications and appropriate applications in construction⁴⁷.

To date this level of operation occurs in Australia by a handful of major operators, such as Kennedy’s Aged Timber in Queensland and Urban Salvage in Melbourne. There are also web sites available to assist in finding wood waste recyclers, such as the “Search for Recycling Services” website, an internet service provided by Sustainability Victoria that aims to provide information on the procurement of recycled timber and other recyclable products.⁴⁸

4.2 Direct Recycling into Engineered Wood Products

Direct recycling of wood waste involves processing the material to manufacture a new solid wood-based product. Composite wood products can be made using wood waste as the feedstock. Examples of these products include composite pallets, door cores, new medium density fibreboard (MDF) and new particleboard.

One such process has been developed by the Fraunhofer Institute for Wood Research in Germany.⁴⁹ This operation extracts wood particles and fibre from timber panel products through a combination of mechanical breakdown, heat and water. The particles and fibres are then able to be used in the manufacture of new panel products.

Other opportunities include the use of untreated wood waste in the manufacture of oriented strand board (OSB). There are, however, currently no manufacturers of OSB in Australia.

4.3 Indirect Recycling

Indirect recycling refers to the manufacture of new products from wood waste. Example products include (amongst others) mulch, compost, potting mix and animal bedding. These products have traditionally used untreated wood waste as the primary feedstock. There is currently uncertainty and a lack of information about the possible effects and impacts of ‘contaminants’ such as formaldehyde-

⁴⁷ CIWMB, 1998, Urban Wood Waste Fact Sheet, California Integrated Waste Management Board, Los Angeles, accessed at <http://www.ciwmb.ca.gov/publications/condemo/44395057.doc>, August 2007.

⁴⁸ <http://www.sustainability.vic.gov.au/>

⁴⁹ Erbreich, M., 2000. *Holzrecycling: Wiedergewinnung von Spänen und Fasern aus Altholzmöbeln und Holzwerkstoffen*. WKI-Mitteilung 755/2000. WKI Holzforschung, Braunschweig Germany.

based resins and preservative treatments on these “indirect” products. For example, reports indicate that chickens prefer to eat resin coated wood fibre rather than their normal diet – often with fatal results.⁵⁰ In contrast, however, such resins may have a beneficial effect in recycled organic media such as compost by acting as a slow release fertiliser. There is a clear need for further work to be done to better quantify the possible impacts of such substances.

4.3.1 Playground Fibre

Playground fibre is made from untreated ‘wood waste only’ without nails, staples, metal or glass etc. The product is an alternative to the ubiquitous pine bark that is typically used in children’s playgrounds. Individual wood waste chips must be large enough to reduce the likelihood of disintegration. Playground fibre is used by schools, parks and homeowners as ground cover under swings, slides and jungle gyms, and will not stain skin or clothing.

4.3.2 Animal Bedding

Animal bedding and pet litters (referred to collectively as litter) are absorbent and assist in the collection and removal of animal manure and urates from pens, stalls, and other bedding or holding areas. Wood waste used as litter includes sawdust, shavings, chips, and shredded wood. The resulting mixture of litter, manure, and urates must be disposed of or used in some manner, such as land application or composting. Animal litter cannot contain chemical contaminants, since animals have contact with and may ingest the litter. For example, poultry obtain up to 4 per cent of their diet from consuming litter.⁵¹ Chemicals in litter could potentially accumulate in the poultry in significant quantities that affect either the poultry or those who eat it.^{51, 52}

4.3.3 Compost, Amended Soil Product and Potting Mix

Wood waste used in composting may also come from a variety of sources. The needs of a composting facility vary widely with the types of feedstock, or “recipe”, it is using. Wood waste in compost serves as a bulking agent, provides carbon to micro-organisms, aids moisture retention, and gives the material a more solid structure. The type of material used as a bulking agent depends on the availability and cost to the facility, and often the cheapest material is used. Successful work has been done in the use of the composting process for the remediation of different toxic or environmentally harmful chemicals. This may be an avenue to follow for chemically treated wood waste.⁵³

The most common form of amended soil product is topsoil. Wood waste may be used to provide organic matter to topsoil, or to increase the overall quality of other, lower quality soils. Smaller wood particles are desirable, since they decompose or compost more quickly than larger particles.

Potting mix is generally of a higher quality than topsoils. Topsoils are usually bought by the tonne and have scope for certain levels of contamination, whereas potting mixes are often sold by the bag and have limited scope for contamination. They are generally used by the domestic market and are intended for the growth of garden plants.

⁵⁰ SBAEP (1998) The Research Report of The Small Business Assessment and Education Project, Blacktown City Council and the Western Sydney Waste Board, Sydney

⁵¹ Grimes, Smith and Williams (2002) Some alternative litter materials used for growing broilers and turkeys. World’s Poultry Science Journal, Vol. 58, pp. 515 – 526.

⁵² The Small Business Assessment and Education Project (1999) ‘Wood Waste Processing and Collection: A report on opportunities in wood waste processing and collection identified in the research report of the small business assessment and education project’, Blacktown City Council, Sydney.

⁵³ Recycled Organics Unit (2000) A Literature Review on the Composting of Composite Wood Products. 2nd Ed. Recycled Organics Unit, University of NSW. pp. 30.

4.3.4 Landscape Mulch

Landscape mulch is predominately made from wood, logs, bark, and leaves. Mulch is used as a ground cover material to control weeds, prevent moisture loss in the soil, and for aesthetic purposes. Wood waste used for mulch must produce an aesthetically pleasing product. As wood waste is generally an unattractive grey, several dyes are available to colour wood waste used for mulch. A benefit of mulch made from dyed wood waste is that it tends to last longer than bark mulches, due to increased resistance to degradation.

4.4 Energy Generation

Energy generation, in the form of heat or electricity, is a way of extracting the energy from wood waste for use as heat or electricity. However, there are specific issues relating to energy generation, for example, air pollution, which warrant its inclusion as a separate category. Energy generation is accomplished by a variety of means, such as combustion, combustion to produce steam or gasification to produce a combustible gas. Ethanol and methanol can also be produced from wood waste, but this is a complicated and difficult process, yet to reach commercial maturity. There are opportunities for wood waste to be used for energy generation in power stations, and emerging opportunities for engineered wood products to be used for both process heat in cement kilns and energy generation in power stations.

4.4.1 Electricity

Electricity from wood waste can be generated in numerous ways. Methods include using a:

- combustion boiler to produce steam and thereby drive a steam turbine
- combustion boiler to produce hot inert gas or heated air to drive a turbine
- gasification reactor to produce a gas to be combusted in a combustion boiler producing steam to drive a steam turbine
- gasification reactor to produce a gas to be combusted in a gas turbine
- gasification reactor to produce a gas to be combusted in an internal combustion (IC) engine
- pyrolysis process to produce syngas for combustion in a gas turbine.

4.4.2 Liquid Fuels

Other techniques can be used to generate liquid fuels from wood waste. Gasification followed by syngas reformation using a Fischer-Tropsch process is one route to synthetic diesel. Pyrolysis processing can provide ‘biocrude’ for processing into a diesel replacement. Technologies including enzymatic, thermal and acid hydrolysis are under active development for conversion of cellulosic materials to sugars and thence to ethanol; wood waste could form an important feedstock for any commercial manufacturing process.

4.4.3 Biochar

In addition to the production of gas and ‘biocrude’, pyrolysis processing also delivers a product referred to as biochar. This solid residue, or charcoal, is mainly composed of carbon and is what remains after processing woody biomass through pyrolysis. Biochar can be co-fired with coal in power stations as it has similar chemical composition and calorific value, and can also be upgraded for metallurgical applications. It is also emerging as a useful agricultural supplement with potential as a soil remediator that increases water retention, nutrient retention and stimulates soil microbial activity. A potential by-product of its use in agriculture is as a high volume carbon sequestration solution.

4.4.4 Cement Kilns

A cement kiln runs at approximately 1200 degrees Celsius and is usually fired with coal dust. However, the substitution of other materials is possible in this process. For example, in Melbourne,

old tyres are used as a feedstock material. The advantage of using alternative fuels such as this in cement kilns is the high temperature at which they operate, which in turn reduces the amount of emissions. The effectiveness of combustion is improved as particle size is reduced, thus making materials such as sawdust ideal.

4.4.5 Firewood

Firewood sales are extremely seasonal. However, there is undoubtedly a residential market for conveniently sized, consumer oriented boxes, bags or bundles of kindling or logs. These are often sold at petrol stations, hardware stores and even supermarkets, provided they meet quality controls.

4.4.6 Process Fuel

Commercial and domestic use of pellets and briquettes as process fuel (for heat or power) manufactured from wood wastes are commercially viable. Wood ‘pellets’ as a fuel source (Figure 2) are generally manufactured from sawdust and wood shavings from sawmills, although corn pellets are common in USA and pellets can also be made from a variety of other agricultural residues including nutshells. Pellet fuel is generally standardised and substantially more uniform in composition than traditional firewood.



Figure 2 - Wood pellets manufactured from wood waste and sawmill residues ⁵⁴

Pellets and briquettes are very low in moisture content, which means that they have a greater energy value than ‘green’ wood and generally use the naturally occurring resins in wood to hold the pellets together, which means no chemical additives need to be included.

⁵⁴ Image from J. Taylor (2007)

5 MATERIALS HANDLING OF WOOD WASTE

Materials handling arrangements can determine the success or failure of a wood recycling project. The following section provides guidance on issues related to the unloading, sorting, size reduction, screening and quality control required to transform waste wood residues into revenues.

5.1 Collection and Transport

The logistics and hence costs associated with the collection and transport of waste wood present significant challenges, with factors such as scale, geography and system optimisation being key determinants. The distributed nature of wastes means that there are likely to be localised limits on the number of discrete material ‘types’ that can be collected at a commercially acceptable cost. There is also a requirement to deliver added-value, finished wood products to market after reprocessing that incurs additional transport cost. Most wood waste in commercial quantities tends to be localised around major metropolitan areas. Due diligence should be undertaken when locating wood waste stock and considering transport arrangements.

5.2 Aggregation and Stockpiling

It is very rare for recovered resources to fit nicely into a “just-in-time” system that removes the need for storage of pre-processing feedstocks or output products. Stockpiles are usually created until enough material has been processed to make up a load or batch for a customer. Embedded in this activity are costs associated with the storage site itself and also any requirements for buildings and equipment necessary to control dust, contamination, moisture or odour problems.

For example, concrete recycling requires a large area for stockpiling prior to processing. The aggregation space also needs peripheral buffer zones established and may also require enclosed buildings. Land costs for such operations may be low as resource recovery sites are often based at or adjacent to landfill sites, however some transfer stations are based in metropolitan regions and incur a high cost of site to aggregate materials.

5.3 Contamination

In a business sense, contamination can be reduced by engaging in actions such as differential pricing, education and supplier risk assessment. When these efforts fail, contamination must be removed from the wood waste material in order to ensure a quality output. The source of the contamination can be related to chemical treatments applied to timber products, prior use, handling or transport of the wood waste.

Typical contaminants and considerations in their separation from the waste stream include:

- **hard core materials**, i.e. soil, grit, stones, glass, and brick. These materials are heavy and abrasive by nature and have a high potential to damage plant and equipment, and compromise end product quality. These materials are likely to be found in C&D waste streams. Hard core materials can be removed by tromelling, screening or ballistic separation
- **ferrous metals**, i.e. iron and iron alloys. Ferrous metals are commonly found in C&D waste streams. Ferrous metals are usually magnetic (with a few exceptions such as stainless steel), and are therefore suitable for separation using magnetic separation processes
- **non-ferrous metals**, i.e. copper, aluminium, zinc, tin, and brass (an alloy of copper and zinc) are also likely to be found in C&D streams (for example in fasteners and fixtures). These materials are effectively removed using eddy current separators

- **lighter weight materials**, i.e. laminates, paper and film plastics can be removed using technologies which make use of their low weight, such as wind sifting.
- **preservative treated timber and painted/coated timber**, these are often removed either by hand or by visual sorting and removal of large sections by equipment operators.

A brief summary of the various individual technologies used for removal of contaminants follows.

5.3.1 Screening

Screening describes the process during which material is passed over a physical barrier that selectively allows a fraction of the waste stream to pass through or over this barrier on the basis of particle size. Screening technologies are commonly used to remove rock and grit, metals, and other foreign materials from waste streams, and subsequently to screen fibres into suitable size fractions for re-use.⁵⁵

Trommel or revolving drum screens are an established screening option for cleaning and classification of a wide variety of materials. Baffles encourage ‘unders’, such as soil, grit and stones, to drop out through the holes in the bottom screen as the trommel drum rotates. The screen size dictates the size of material being rejected, with typical screen sizes being 10mm, 25 mm and 35 mm for a mobile trommel.⁵⁶

Other types of screens exist and are used to separate waste stream contaminants. One example is a flat or inclined vibratory screen. Fine material which is required to meet tight sizing requirements can be sorted using such a screen. Vibratory screens are more relevant in material sizing applications and, for this reason, are discussed below in more detail when considering separation of fibres.

5.3.2 Magnetic Separation

The removal of ferrous metals including iron and steel is commonly performed using magnetic separation. The principle of operation is straightforward – the material infeed is brought into close proximity with a magnet. Magnetic contaminants are attracted to and attach to the magnet.

The depth of material to be screened dictates the efficiency of magnetic separation and it is important to maintain a relatively shallow depth of material throughput when using this technique – ferrous materials buried deep in the wood-based material are not likely to be drawn out by magnetic force.

5.3.3 Eddy Current Separation

Non-ferrous metals such as aluminium, copper and brass are removed from waste streams using eddy current separation. An eddy current is caused by a moving magnetic field intersecting a conductor or vice-versa. A circulating flow of electrons, or current, within the conductor is caused by the relative motion and the circulating eddies of current create electromagnets with magnetic fields. A secondary magnetic field around non-ferrous particles is also induced by the eddy currents. This field reacts with the magnetic field of the electromagnets, resulting in a combined driving and repelling force which ejects the conducting particle from the stream of mixed materials. The stronger the magnetic field or greater the electrical conductivity of the conductor, the greater the currents developed and the greater the opposing force.⁵⁷

⁵⁵ Warnken, M. (2001) Utilisation Options for Wood Waste: A Review of European Technologies and Practices. J.W. Gottstein Memorial Trust Fund. pp. 123.

⁵⁶ Brentwood Recycling Systems, 2007, ‘Beyer - Mobile Trommel, Star and Flat Screens’, accessed online at <http://www.brentwood.com.au/beyer.htm>, February 2007.

⁵⁷ aluMATTER 2007, ‘Eddy Current Separation’, accessed online at <http://aluminium.matter.org.uk/content/html/eng/default.asp?catid=172&pageid=2144416566>, February 2007

Ferrous metals interfere with effective separation of the non-ferrous metals. For this reason, eddy current separation is usually located after magnetic separation in a separation sequence.

5.3.4 Wind Sifting

Lighter weight materials such as laminates, film plastic and paper/cardboard are removed from a material flow by a technique called wind sifting. The mixed stream is fed or dropped into a column of upward moving air. This air carries the lightweight contaminants to the top of the column for removal. The lightweight materials are often forced or blown into a cyclone separator which removes them from the wood chip/fibre. The wood then drops down the column into a hopper.

Wind sifting is a cheap, simple and effective separation technology. The potential for light wood chip/fibre to be caught and removed in the updraft stream along with contaminants is one major limitation.

5.3.5 Air Density Separator

An air density separator operates on a similar principle to wind sifting. A high velocity vacuum pulls the light-weight wood materials away from the heavier rock and metals, with the heavy materials falling into a reject conveyor. Air density separators are typically preceded in the process by pre-screening equipment, such as a trommel screen, that removes over-sized wood and contaminants, in addition to 'unders'.⁵⁸ These separators are typically inserted at a transfer point, for example between two conveyors or between a screen and its collector conveyor. The air density separator is placed in the mid-air section between two conveyor belts of two separate machines.

5.3.6 Ballistic Sorting

Ballistic sorting utilises the fact that the trajectories of materials 'launched' from reaction plates (paddle boards) differ depending on their density, shape and hardness. Materials with soft shapes, such as film-type plastics, and hard shapes, such as solid plastics, can be sorted in this way, as can stone/wood and plastic/paper in construction wastes. Plastic/paper is transported in the forward direction by the eccentric rotating action of the paddle boards, while stone/wood is thrown up by the paddle boards and then transported in a downward diagonal reverse direction. Small-diameter items fall through the holes in the paddle boards and are sorted under the boards. Ballistic sorting is particularly useful for sorting highly heterogeneous feed streams, such as municipal waste. It is unlikely to have direct application for dry separation of wood fibre unless significant contamination by large contaminants, e.g. large pieces of rock or stone, is present in the stream.

5.4 Screening for Sizing of Fibres

Once contaminants have been removed using a variety of the aforementioned techniques, separation of the 'clean' fibre is often undertaken to isolate the desired size fractions for different recovery applications. Technologies which are available for this purpose include trommel screens, vibrating screens, fractionators and disk screens. These techniques are discussed below.

5.4.1 Vibrating Screens

Vibratory screens (or sieves) are flat or inclined surfaces with a mesh grid with a certain passing size. Materials are placed on top of the screens. These screens are then mechanically vibrated. Smaller

⁵⁸ Clean Washington Centre, 1997, 'Best Practices in Wood Waste Recycling: Air Density Separators', accessed online at http://www.cwc.org/wd_bp/wbp2-0408.htm, February 2007.

sized particles fall through under gravitational force. Material can be passed over screens of increasing mesh size to allow for classification of material into a range of size fractions. Vibratory screens are especially effective with fine material to meet tight sizing requirements, and are more commonly used for this purpose than for contaminant separation.

5.4.2 Fractionators

Vibrating screens can be used in a vertical stack, with each screen removing a distinct range of chip/fibre sizes. For example, the top deck may remove over 30 mm, allowing all particles under 30 mm to pass through. The next deck may remove the plus 20 mm particles, effectively sizing for 20-30 mm. This principle can be applied to virtually any sized fraction. Screens operating in this manner are referred to as fractionators. There are some issues with managing fibres, in terms of clogging of screens. In these cases the use of disk screens is preferred.

5.4.3 Disc Screens

Disc scalping screens have been used extensively in many sectors, including wood processing, for separating out different size fractions. These screens are especially useful when separating small particles.⁵⁹

Disc scalping screens are typically designed to align with a chain or belt conveyor of the same width. The material is fed from the conveyor onto the disk screens which consist of a series of parallel shafts perpendicular to the material flow, with a series of offset interspacial discs mounted in overlapping rows on the shafts. The spacing between the discs is set to the desired size fraction to be recovered in the under stream. Successive shafts, or groups of shafts, are generally run at higher speeds to provide a "pulling" or separation in the direction of material flow.

5.4.4 Disc Screens

The table below (Table 7) summarises the various separation and screening technologies presented, along with their strengths and weaknesses.

Table 7 – Summary of Separation and Screening Technologies		
Technology	Application	Strengths/Weakness
Trommel screens	Removal of rock, dirt, grit etc	Robust, effective, can separate out different size fractions. Unable to separate out very fine fibres.
Magnetic separators	Removal of ferrous metals	Simple, but cannot remove materials buried deep in the waste. Wood attached to metal may be removed
Eddy current separators	Removal of non-ferrous metals	Needs to be used in conjunction with magnetic separation of ferrous metals to be effective
Wind sifting	Removal of light materials	Simple and effective.

⁵⁹ Clean Washington Centre, 1997, 'Best Practices in Wood Waste Recycling:: Disk Scalping Screens, accessed online at http://www.cwc.org/wd_bp/wd_bp_pdf/2-04-01.pdf, February 2007.

	from heavier ones.	Potential for use both before and after the panel dissolution stage.
Air density separation	Removal of lighter materials from heavier ones such as rock from wood waste	May not be effective for small particle sizes
Ballistic separation	Separation of materials on the basis of weight, density etc	Main use is for highly heterogeneous feedstocks.
Vibrating screens and fractionators	Separation on basis of particle size	Simple and effective
Disc Scalping Screens	Separation on basis of particle size	Good for separation in very fine size fractions

5.5 Loading, Receiving, Conveying and Storage

Storage of wood waste product occurs in a bunker, silo, hardstand, shed, or stockpiled on the ground. Loading of wood waste product is via a front-end loader, excavator with modified bucket or an automated conveyor system. Road (and potentially rail) systems are used to transport wood waste to market.

It is difficult to achieve high rates of product throughput when processing wood waste. This relates to the low density of wood waste and the variability in wood waste material size and shape. Processed wood waste does not flow and is hard to convey. There are also several occupational health and safety problems inherent in wood waste materials handling arising from dust generation and the operation of size reduction equipment. Large stockpiles of unprocessed wood waste also present a potential fire hazard.

5.6 Quality Assurance and Product Testing

Product testing is usually performed on processed wood waste before it is sent to market. Tests on recovered product include determination of moisture content, percentage of particle fines (particles under 5 mm) and percentage of particle overs (particles over the product specification maximum size), in addition to testing for chemical contamination if required (for instance if being used as a fuel).

5.7 Management of Wood Dust

Exposure to wood dust should be prevented and controlled through the adoption and maintenance of effective extraction and filtration systems (engineering controls) and supplemented by the use of Personal Protective Equipment (PPE), such as masks and respirators, as necessary. Care should also be taken to ensure that a build up of wood dust on or inside equipment, that could impair operation or present a fire hazard, does not occur.

5.7.1 Engineering controls

Wood dust is emitted at high velocity from equipment such as saws and sanders that run at high RPM. The primary method of control is with local exhaust ventilation (LEV) systems. LEV removes dust at or near the dust source and systems can often be integrated with machine guards to improve safety and operation. Exhaust hoods of a LEV should be located as close as possible to the dust emission source, i.e. on the woodworking machinery itself or nearby, and must incorporate an efficient air and filter cleaning device.

A LEV needs to be properly maintained in order to ensure maximum protection. This maintenance includes:

- checking and cleaning of ducts and dust collectors at specified regular intervals
- inspection of ducts to ensure that they are not loose, broken or damaged
- belt-driven exhaust fans should be checked for slippage or breakage.

Sanders, shapers and routers generally produce the greatest amount of dust. LEVs are generally not very effective for exhausting these machines. Where the waste contains a significant proportion of particles whose largest dimension is less than 20 microns (e.g. sander dust), the use of a fabric or cartridge filter is necessary to obtain satisfactory collection efficiency. This is preferable to using a high efficiency cyclone because it will collect fine wood dust.

Wood dust collected using these control measures is commonly stored on site in facilities such as silos, or simply in piles, and eventually disposed of to landfill or employed as a fuel source (i.e. as briquettes or pellets).

5.7.2 Personal Protective Equipment

PPE includes eye protection (safety glasses/goggles), protective clothing and gloves, and respiratory equipment. Long sleeved shirts, long pants, barrier cream and skin cleansing cream should be used in the case of skin irritation occurring.

5.8 Management of Preservative Treated Timber

The presence of treated timber in mixed wood waste presents a particularly difficult problem for accurate, cost efficient sorting. Although there may be some opportunities to use small quantities of treated timber for specific recycling or reuse options, there are limited commercial products for which a minimum level of chemical contamination can be tolerated.

There are numerous preservatives approved for use in Australia. The most commonly found preservative in timber waste is copper chromium arsenic (CCA). The most commonly used method of removing preservative treated timber is manual sorting, which tends to be expensive and has health and safety implications for staff. Large pieces of treated timber are removed by equipment operators when moving and loading the waste. Accuracy is also questionable, as the timber preservatives are difficult to identify in aged and dirty timber.

There are a number of chemical indicators which can be sprayed onto the timber to identify preservatives. The most common of those is chrome azurol, which indicates only for copper and can identify timber containing CCA, copper azole and copper naphthanate. Other timber preservatives necessitate the use of other indicators formulated specifically to identify the presence of the particular chemical constituents of each timber preservative.

Automatic on-line sorting technologies have been tested overseas, but have yet to be commercialised. Identification of preservatives can also be done with laser induced breakdown spectroscopy (LIBS), X-ray fluorescence (XRF), ion mobility spectroscopy (IMS), 'electronic nose' (EN), and near infrared (NIR) technologies.⁶⁰

⁶⁰ Rochester, I. (2004) "Rapid identification and sorting of preservative treated wood". The Waste and Resources Action Programme (WRAP), UK.

6 REGULATION AND WOOD WASTE RECOVERY

Regulation is one of the factors affecting the operational parameters of a wood recycling project. The current trend involves government placing moral responsibility on wood waste generators. Extended Producer Responsibility (also known as Product Stewardship) is one example. These issues are reviewed in the following, together with other current regulatory considerations pertinent to wood recovery.

6.1 Legislative frameworks

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, Water, Heritage and the Arts, 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. As a result, some states have started to investigate extended producer responsibility schemes which place the burden of action on manufacturers for the end-of-life management of their products. This could mean that manufacturers using wood in their products 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.

The timber industry has recently voluntarily formed a *National Timber Product Stewardship Group (NTPSG)* to address the environmental impacts from the disposal of timber products. The NTPSG is comprised of timber companies and associations from all parts of the timber supply chain. The group has recently finalised baseline research and has prepared a National Timber Product Stewardship Strategy for post-consumer wood products to double their recovery for re-use, recycling and energy recovery by 2017.

6.1.1 New South Wales

In 2003, The *NSW Waste Avoidance and Resource Recovery Strategy* was released.⁶¹ This strategy was superseded in 2007 by the *NSW Waste Avoidance and Resource Recovery Strategy 2007*.⁶² 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 and priority areas 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 the *Extended Producer Responsibility Priority Statement 2004*, of which treated timber is one of the 16 wastes of concern.⁶³ The *Extended Producer Responsibility Priority Statement 2004*

⁶¹ Resource NSW (2003) *NSW Waste Avoidance and Resource Recovery Strategy*. Sydney. Accessed at: http://www.environment.nsw.gov.au/resources/warr/warr2003_fullreport.pdf, August 2008.

⁶² Dept. of Environment and Climate Change NSW (2007) *NSW Waste Avoidance and Resource Recovery Strategy 2007*. Sydney. Accessed at: http://www.environment.nsw.gov.au/resources/warr/07226_WARRreport07.pdf, August 2008.

⁶³ <http://www.environment.nsw.gov.au/warr/EPRPriority2004.htm>, Accessed August 2008.

was superseded by the *Extended Producer Responsibility Priority Statement 2005 – 2006*, which has recently been superseded by the *Extended Producer Responsibility Priority Statement 2007*.⁶⁴

The NSW DEC has established an Expert Reference Group (ERG), comprised of representatives from the NSW DEC, a local government authority, the recycling industry, an environmental group and a 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-like 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 product's 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. 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:

- Improved resource recovery.
- 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.³²

6.1.2 Victoria

Waste management in Victoria is dominated by policies established by both the EPA and Sustainability Victoria (previously EcoRecycle Victoria). In Victoria, product stewardship is

⁶⁴ Dept. of Environment and Climate Change NSW (2007) *NSW Extended producer Responsibility Priority Statement 2007*. Sydney. Accessed at: <http://www.environment.nsw.gov.au/resources/warr/2007592prioritystatement.pdf>, August 2008.

embedded in the *Environment Protection Act 1970*⁶⁵ and the *Towards Zero Waste Strategy*⁶⁶, which sets out priority products for this approach.

The aim is to improve the efficiency of raw material use, increase resource recovery rates, extend product life and manage toxic wastes. Wood waste, as timber products and furniture manufacturing, is specifically mentioned under Priority Industry Sectors, and timber is listed under municipal, C&I and C&D waste sectors as a priority material or product. As such, waste wood has been targeted for increased resource recovery in coming years through the strategy.

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.

Further strategies for waste recovery and avoidance for treated timber in particular are not expected to come into effect immediately as it falls under the Product Stewardship scheme in the *Towards Zero Waste Strategy*. Victoria currently has no 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.

6.1.3 Queensland

The *Environmental Protection Act 1994*⁶⁷ 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*⁶⁸ further elucidated illegal activities under the *Environmental Protection Act 1994* and incorporates various acts and regulations into the one document. This document is further supported by the *Environment Protection (Waste Management) Policy 2000*⁶⁹ that defines acceptable waste management.

As recently at 2007, Queensland released a waste strategy, the *Let's Not Waste Our Future: Queensland Waste Strategy*⁷⁰ mentions used timber as a product in which development of a product stewardship partnership may be considered.

⁶⁵ http://www.austlii.edu.au/au/legis/vic/consol_act/epa1970284/, accessed August 2008.

⁶⁶ Sustainability Victoria (2005) *Toward Zero Waste Strategy*. Accessed at: [http://www.sustainability.vic.gov.au/resources/documents/Towards_Zero_Waste_Strategy_\(Sep_05\)2.pdf](http://www.sustainability.vic.gov.au/resources/documents/Towards_Zero_Waste_Strategy_(Sep_05)2.pdf), August 2008

⁶⁷ Accessed at: <http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtA94.pdf>, August 2008.

⁶⁸ Accessed at: <http://www.legislation.qld.gov.au/Search/isyquery/00a19d03-cd24-4f8c-a8ea-c6bc591b5187/2/doc/EnvProtWaMR00.pdf#xml=http://www.legislation.qld.gov.au/Search/isyquery/00a19d03-cd24-4f8c-a8ea-c6bc591b5187/2/hilite/>, August 2008.

⁶⁹ Accessed at: <http://www.legislation.qld.gov.au/Search/isyquery/00a19d03-cd24-4f8c-a8ea-c6bc591b5187/1/doc/EnvProtWaMP00.pdf#xml=http://www.legislation.qld.gov.au/Search/isyquery/00a19d03-cd24-4f8c-a8ea-c6bc591b5187/1/hilite/>, August 2008

⁷⁰ EPA Qld (2007) *Let's Not Waste Our Future: Queensland Waste Strategy*. Accessed at: http://www.epa.qld.gov.au/publications/p02217aa.pdf/Lets_not_waste_our_future_Queensland_waste_strategy_Discussion_paper_for_public_comment.pdf, August 2008.

6.1.4 Western Australia

The regulatory authority for waste management in Western Australia is set out in the *Environmental Protection Act 1986*.⁷¹ The *Environmental Protection Regulations 1987*⁷² followed the *Environmental Protection Act* but more recent regulations such as *The Environmental Protection (Controlled Waste) Regulations 2004*⁷³ (related to the transport of waste) and the *Environmental Protection (Landfill Levy) Act 1998*⁷⁴ (established the levy on disposal of waste to landfill) have recently added more strength to the regulation of waste management.

The recent passing of two particular bills, the *Waste Avoidance and Resource Recovery Act 2007*⁷⁵ and the *Waste Avoidance and Resource Recovery Levy Act 2007*⁷⁶, established an independent authority to strategically plan and manage waste resources in WA. The strategic authority established, Waste Smart WA, replaced the WA Waste Management Board in May 2008. Waste Smart WA will focus on continuous improvement of waste avoidance and resource recovery.

6.1.5 South Australia

*South Australia's Environment Protection Act 1993*⁷⁷ established waste facilities and waste levies. It supports increased resource recovery by supplying capital grants and waste minimisation programmes.

6.1.6 Tasmania

The *Environmental Management and Pollution Control Act 1994*⁷⁸ 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. Both of these policies have been superseded by the *Towards a Tasmanian Waste Management Strategy 2000*. Different EPR models and the potential impact of a national EPR system on Tasmania is being investigated.

⁷¹ Accessed at: http://www.austlii.edu.au/au/legis/wa/consol_act/epa1986295/, August 2008.

⁷² Accessed at:

[http://www.slp.wa.gov.au/statutes/regs.nsf/3b7e5f26432801b348256ec3002c128c/5a021ea94cf24052482566f90007c0bc/\\$FILE/Environmental%20Protection%20Regulations%201987.PDF](http://www.slp.wa.gov.au/statutes/regs.nsf/3b7e5f26432801b348256ec3002c128c/5a021ea94cf24052482566f90007c0bc/$FILE/Environmental%20Protection%20Regulations%201987.PDF), August 2008.

⁷³ Accessed at:

[http://www.slp.wa.gov.au/statutes/regs.nsf/3b7e5f26432801b348256ec3002c128c/db996fe4ba481de148256ec8003099d7/\\$FILE/Environmental%20Protection%20\(Controlled%20Waste\)%20Regulations%202004.PDF](http://www.slp.wa.gov.au/statutes/regs.nsf/3b7e5f26432801b348256ec3002c128c/db996fe4ba481de148256ec8003099d7/$FILE/Environmental%20Protection%20(Controlled%20Waste)%20Regulations%202004.PDF), August 2008.

⁷⁴ Accessed at: http://www.austlii.edu.au/au/legis/wa/consol_act/epla1998417/, August 2008.

⁷⁵ Accessed at: http://www.zerowastewa.com.au/documents/WARR_act07.pdf, August 2008.

⁷⁶ Accessed at: http://www.zerowastewa.com.au/documents/WARRlevy_act07.pdf, August 2008.

⁷⁷ Accessed at:

<http://www.legislation.sa.gov.au/LZ/C/A/ENVIRONMENT%20PROTECTION%20ACT%201993/CURRENT/1993.76.UN.PDF>, August 2008.

⁷⁸ Accessed at:

http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=ALL;doc_id=44%2B%2B1994%2BAT%40EN%2B20080807200000;histon=;prompt=;rec=;term=environmental%20management%20and%20pollution, August 2008.

7 SUSTAINABILITY AND WOOD RESOURCE RECOVERY

Recovering waste wood residues for recycling is not enough to automatically establish the activity as 'environmentally friendly'. Communities are increasingly vigilant and sophisticated when assessing whether to grant a community 'licence to operate' and issues regarding sustainability are key to project success.

The most frequently quoted definition of sustainability comes from Our Common Future, otherwise known as the Brundtland Report. This definition suggests that sustainability is about meeting 'the needs of the present without compromising the ability of future generations to meet their own needs'.⁷⁹ Sustainability thus focuses on improving the quality of life for earth's inhabitants, without increasing the use of natural resources beyond the capacity of the environment to supply them indefinitely.

Any increase in greenhouse gas emissions, for example through the emission to atmosphere of landfill gas from wood waste landfilling, or even through the lost opportunity greenhouse cost from renewable energy that is not generated, increases the environmental burden that future generations will face. The sustainability challenge as it relates to wood waste is in maximising the recovery of value from waste wood resources as there is no future for landfilling wood waste in a sustainable future.

Issues related to sustainability, industrial ecology, cleaner production and highest value resource recovery are profiled and discussed in the following.

7.1 Sustainability – Increasing Value – Decreasing Impact

Society has a genuine need and demand for waste disposal services. However, this does not directly translate to a demand for landfill. It is true that landfill provides a disposal service, but this disposal service is the limit of any 'value' returned to society, rather it is associated with a number of negative impacts. Table 8 identifies the benefits diverting waste from landfill.

Table 8 – Summary of benefits of diverting waste from landfill⁸⁰

<i>Benefit</i>	<i>Description</i>
Prevention of methane emissions	The anaerobic decomposition of wood waste in landfills produces methane (amongst other gases). Methane is a greenhouse gas with a global warming potential 25 times that of carbon dioxide. Even the best landfill gas collection systems in the world will not recover all of the methane. Furthermore, fugitive methane emissions will continue to be released long after the landfill is closed, and any attempts to 're-mine' old landfill sites will incur a significant carbon loading when any trapped methane is released.

⁷⁹ World Commission on Environment and Development, 1987, 'Our common future', Oxford, Oxford University Press.

⁸⁰ Adapted from ACOR, 2006, 'Productivity Commission Inquiry into Waste and Resource Efficiency Submission by Australian Council of Recyclers February 2006', Productivity Commission, Canberra, accessed at http://www.pc.gov.au/__data/assets/pdf_file/0005/22001/sub040.pdf, December 2007.

Table 8 – Summary of benefits of diverting waste from landfill⁸⁰

<i>Benefit</i>	<i>Description</i>
Prevention of land pollution	There are no benefits arising from disposal of wood waste in landfill as disposal returns no value from embodied material and energy investments within the ‘waste’. The indiscriminate disposal of wood waste creates a variety of legacy problems. Closed landfill sites are not ‘geologically’ sound and may continue to subside over time, reducing future land use options. There is a need to rehabilitate extractive voids, however this should be done with materials that have civil applications as their highest resource value and are fit-for-purpose, that is compactable, inert and unlikely to leach.
Prevention of leachate generation	Leachate refers to water that has percolated through waste in landfills and become contaminated. Leachate contains soluble substances including chemicals and heavy metals, in addition to particles and micro-organisms, and can potentially contaminate water bodies if not properly captured and treated.
Mitigation of human health impacts	The operation of disposal facilities presents a number of human health impacts related to air, land and water pollution, in addition to the creation of dust, air-blown litter, breeding grounds for vermin and toxic fumes (in the case of landfill fires).
Preservation of social amenity	The combined impacts of disposal facilities results in a loss of social amenity. No community wants to host a waste dump. Conversely, there is widespread community support for resource recovery outcomes.

The recovery of value from wood waste thus serves as the ability to simultaneously reduce the impacts of wood waste ‘disposal’ while adding value to society in the form of additional material and energy flows, and increased economic activity.

7.2 Industrial Ecosystem Thinking

Historically, landfill has been the main end-of-life management option for wood waste. This has resulted in a linear ‘one-way’ flow of resources from harvesting through to waste in landfill. Based on the premise that natural systems are essentially cyclical in nature and that natural systems present the optimal model for sustainability, efforts have been made to create cyclical patterns of resource recovery.

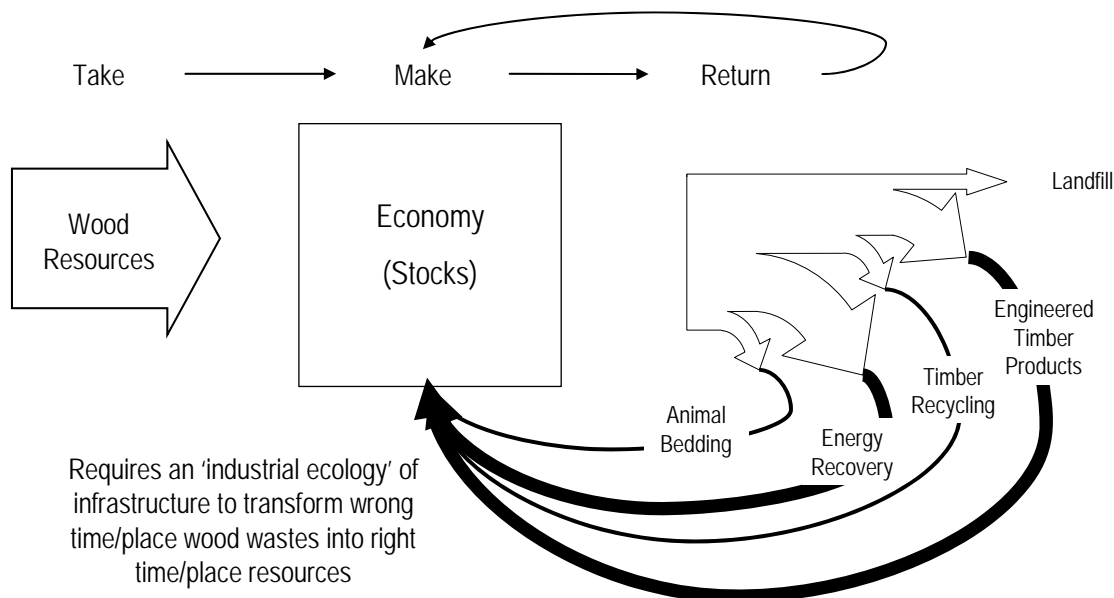


Figure 3 – Cyclical sustainable resource flows for wood waste⁸¹

The analogy is the creation of an ‘industrial ecology’ that is able to ‘digest’ the wood waste and return resources for use back into the economy (see Figure 3 above). Such an industrial ecosystem for wood waste would involve a network of collection capacity and infrastructure with the ability to transform wrong time/place wastes into right time/place resources. For example, the ability to return boutique recycled materials, provide a feedstock for an engineered timber product, supply animal bedding and recover energy could be part of a region-wide approach to wood waste value-adding. This prompts the question regarding involvement of the original manufacturers of the timber products in such an Industrial Ecosystem – or what is their ‘Extended Producer Responsibility’?

7.3 Extended Producer Responsibility (EPR) and Product Stewardship

Extended producer responsibility schemes are created in order to integrate the lifecycle impact and associated costs (often referred to as ‘externalities’ in classical economics) into the market price of a product. They work by shifting the responsibility for the end-of-life product back onto the manufacturer, who then takes responsibility for the recycling or disposal of the product. The costs associated with this whole-of-lifecycle approach are usually shifted onto the consumer through the integration of the predicted costs of recycling or disposal into the market price of the product.

Extended producer responsibility schemes differ throughout the world and are often voluntary. Some of the most recognised EPR schemes, such as EPR for Packaging and Packaging Waste, exist in the

⁸¹ Adapted from Warnken ISE, 2004, Market Based Instruments and Sustainable Resource Recovery, Total Environment Centre, Sydney, accessed at http://www.greencapital.org.au/index.php?option=com_docman&task=doc_download&gid=18, December 2007.

European Union (EU) and Australia. Their success is due largely through regulation, although Australia's EPR for Packaging and Packaging Waste is a voluntary scheme.

Australia does not currently have any regulatory EPR schemes. There do exist, however, several voluntary EPR schemes, covering products such as:

- Packaging.
- Waste oil.
- Tyres.
- Pesticide containers.
- Mobile phones.
- Pharmaceuticals.
- Plastic shopping bags.

The timber industry has recently voluntarily formed a *National Timber Product Stewardship Group (NTPSG)* to address the environmental impacts arising from the disposal of timber products.⁸² The NTPSG comprises timber companies and national associations from all parts of the timber supply chain, including: Australian Plantation Products and Paper Industry Council (A3P); National Association of Forest Industries (NAFI); Engineered Wood Products Association of Australasia (EWPA); Timber Preservers Association of Australia (TPAA); Forests NSW; Osmose Australia; Arch Wood Protection; Timber Queensland; importers, wholesalers and retailers of timber and wood products. The Timber Development Association NSW provides secretariat services to the NTPSG. Late in 2007 the NTPSG announced a target of doubling the amount of post consumer timber recovered in Australia.⁸³ The group has prepared a National Product Stewardship Strategy for post-consumer timber and wood products. A number of research papers were produced to inform the development of the final strategy including reports of packaging timber, timber from demolition of structure, preservative treated timber.⁸⁴

7.4 Highest Resource Value Recovery

One issue that arises in developing opportunities for sustainable resource recovery of wood waste is that there are many recovery options for a given material, which begs the question as to which option will maximize the highest resource value of the material? This is similar to asking what is the best use of a recovered resource.

An example is recycled solid hardwood floorboards. It could be argued that it would be a better use to turn those floorboards into a dining room table rather than to chip up the timber for fuel or landscape mulch. What is not so clear is how to balance the issues with regard to composting and energy recovery for woody waste materials on a large scale.

Ideally, the highest resource value would be used to decide between the resource recovery options of re-use, direct recycling, indirect recycling or energy recovery. The main difficulty lies in distinguishing which option is best when they each have advantages and disadvantages with regard to

⁸² <http://www.timberstewardship.org.au/>

⁸³ A3P, 2007, 'Media release - National Timber Recovery Target - A Wood-be Success', Australian Plantation Products and Paper Industry Council, Canberra, accessed at <http://www.a3p.asn.au/admin/assets/pdf/Media%20releases/2007/A3P%20and%20TDA%20Media%20Release%20-%20Timber%20Recovery%20Target.pdf>, February 2008.

⁸⁴ Pers. Comm. Stephen Mitchell, TDA NSW, August 2008.

economic, environmental and social impacts.

Net present highest resource value (NPHRV) is used to qualitatively assess the range of resource recovery options available to any given material stream by asking:⁸⁵

- What are the recovery options for the material in question? – understanding what is possible in terms of recovering value.
- How many of these are commercial at the present time? – recovery options need to be commercially viable.
- What kind of recovery opportunity is it? – for example, re-use, direct recycling, indirect recycling, and energy recovery.
- What is the planned and accessible end of life use for the recovered material? – for example, is the recycling of the wood waste creating a product that has no further recovery options at the end of its life?
- What is the economic case for the commercial recovery options? – is there a business case?
- What is the environmental case for the commercial recovery options? – will the recovery option reduce or increase environmental impact?
- What is the social case for the commercial recovery options? – is there community support for the project?
- What are the prevailing local conditions? – for example, urban encroachment, need for energy, access to markets and transport.

⁸⁵ Warnken ISE, 2004, Market Based Instruments and Sustainable Resource Recovery, Total Environment Centre, Sydney, accessed at http://www.greencapital.org.au/index.php?option=com_docman&task=doc_download&gid=18, December 2007.

8 ACCESSING THE CARBON MARKET

The recovery and recycling of wood residues can give rise to a range of ‘green property rights’ or additional environmental benefits that may have commercial value. The main example is the diversion of wood waste from landfill and its use as a renewable fuel in order to create carbon offsets or renewable energy certificates.

One of the main contributors to global warming is the extraction and combustion of fossil carbon resources, such as oil, gas and coal. The release of stored carbon, mostly in the form of carbon dioxide (CO₂) after combustion, increases the concentration of carbon dioxide emissions over and above the absorbing capacity of the natural carbon cycle – hence the systematic increase in atmospheric CO₂ concentration.

Fossilised carbon needs to be contrasted against ‘biogenic’ carbon, or the carbon in current stocks of biomass, like food, garden organics, paper, wood and some textiles. The combustion of wood waste is sometimes considered ‘carbon neutral’ because of the ‘biogenic’ nature of the carbon. As trees grow they sequester carbon in into their wood structure, through the action of photosynthesis and exchange of carbon dioxide for oxygen with the atmosphere.

When trees die and decompose, the carbon is released to the atmosphere and soil through decomposition, maintaining a net neutral carbon balance in terms of the contribution to greenhouse gas concentrations in the atmosphere. Furthermore, where forest resources are managed and harvested in a sustainable manner, new trees will be grown to replace harvested trees – in effect recycling the carbon that would be emitted through natural decomposition. When wood is used as a fuel the stored carbon is returned to the atmosphere, largely through carbon dioxide and other gases, and the same natural carbon cycle is maintained.⁸⁶ This ‘carbon neutrality’ gives rise to the potential to create carbon credits and also underpins the renewable status of wood as a fuel.

The carbon value of wood recovery and recycling is presented in Figure 4 below.

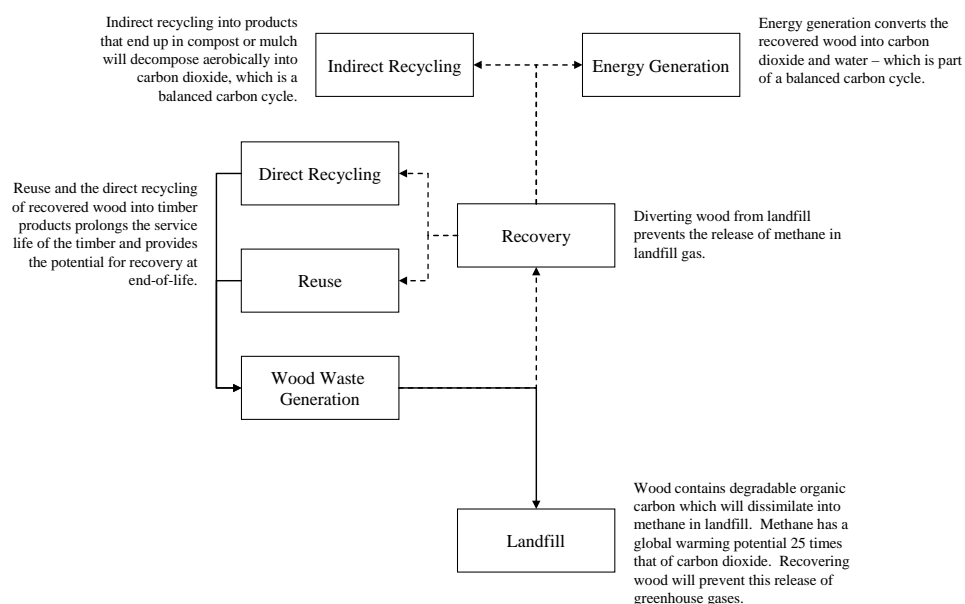


Figure 4 – Carbon value of recovering wood resources

⁸⁶ Seacoast NRG, 2007, Is burning wood really carbon neutral?, accessed at <http://www.seacoastnrg.org/2007/01/30/is-burning-wood-really-carbon-neutral/>, December 2007.

The recovery of wood waste prevents its decomposition under anaerobic conditions into a methane containing landfill gas, which represents a source of greenhouse gas emissions (unless it is captured and used as an energy source).

There has been some research recently in Australia which suggests a much slower rate of decomposition of timber products in landfill than previously thought.⁸⁷ A comprehensive review on the variability of data pertaining to the decomposition of cellulose and hemicellulose (the major components of timber-based products) and their subsequent conversion to methane, has recently been published by Morton Barlaz.⁸⁸ This journal paper includes the recent investigations by Gardner and Ximenes. The Department of Climate Change have indicated that individual facilities may utilise this methodology to calculate their emissions from wood buried in their landfill.⁸⁹

Methane has a hundred year global warming potential (GWP), estimated as 21, 23 or 25 times that of carbon dioxide based on Intergovernmental Panel on Climate Change (IPCC) estimates from its Second (21), Third (23) and Fourth (25) Assessment Reports. This means that every tonne of methane released into the atmosphere is equivalent to the release of 25 tonnes of carbon dioxide (1 t CH₄ = 25 t CO₂e).⁹⁰ However, the GWP value of 21 t CO₂e has been used here to be consistent with current Australian Government methodology.

Using National Greenhouse Accounts (NGA) Factors suggests that the maximum available credit for the avoided landfilling of degradable organic carbon in wood waste is 2.7 tonnes of CO₂e for 1 tonne of avoided wood landfill.⁹¹

Any resource recovery activity that diverts wood from landfill, whether it be for compost, landscape mulch or energy generation, thus prevents the generation of greenhouse gases that would have been generated should the wood have been landfilled.

When a wood derived fuel is used in place of fossil fuels, the avoided emissions from fossil fuel use can also be claimed as a credit. An example is the use of wood derived fuel in cement kilns to

⁸⁷ Ximenes FA, Gardner WD, Cowie AL. (2008) The decomposition of wood products in landfills in Sydney, Australia. *Waste Manag.* 2006;26(4):321-33. Epub 2006 Jan 6.

⁸⁸ Barlaz (2006) Forest products decomposition in municipal solid waste landfills. *Waste Management*, 26, pp. 321 – 333.

⁸⁹ Australian Government Department of Climate Change (2007) Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Waste, National Greenhouse Gas Inventory Committee, Canberra, accessed at:

<http://www.climatechange.gov.au/inventory/methodology/pubs/methodology-waste2006.pdf>

⁹⁰ IPCC 2001, 'IPCC Third Assessment Report – Technical Summary of the Working Group I Report', Intergovernmental Panel on Climate Change, Geneva, accessed at http://www.grida.no/climate/ipcc_tar/vol4/english/pdf/wg1ts.pdf, December 2007. Note that the Intergovernmental Panel on Climate Change (IPCC) in their third assessment report revised the Global Warming Potential (GWP) of methane to 23 times that of carbon dioxide, which was revised again in their fourth assessment report to 25 times that of carbon dioxide (IPCC 2007, 'IPCC Fourth Assessment Report – Technical Summary of the Working Group I Report', Intergovernmental Panel on Climate Change, Geneva, accessed at <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>, July 2007.) However the 2004 Australian National Greenhouse Inventory prepared by the Australian Greenhouse Office (AGO, 2006, 'Australian National Greenhouse Inventory 2004', Australian Greenhouse Office, Canberra, accessed at <http://www.greenhouse.gov.au/inventory/2004/index.html>, December 2007) uses the IPCC's previous estimate (Second Assessment Report) of 21 times the 100 year GWP of carbon dioxide in national accounts for the first Kyoto commitment period of 2008-2012. The GWP value of 21 has been adopted here to be consistent with Australian Government methodology.

⁹¹ DoCC 2008, 'National Greenhouse Accounts (NGA) Factors', Department of Climate Change, Canberra, accessed at www.climatechange.gov.au, April 2008.

displace natural gas or coal.⁹² Here, the amount of carbon abatement relates to the energy content of the fuel and the greenhouse gas emissions related to the fossil fuel.

Black coal used domestically in NSW has a calorific value of 22.5 gigajoules per tonne.⁹³ A wood derived fuel at 15 gigajoules per tonne would replace two thirds of a tonne of coal. Using NGA Factors again, the combustion of one tonne of black coal will release 2.2 tonnes of CO₂e. Thus, the use of the wood derived fuel would abate approximately 1.5 tonnes of CO₂e.

Conversely, if the fuel is used to generate electricity, the renewable nature of the wood fuel might be used to create a Renewable Energy Certificate (REC) as opposed to a carbon credit (note that both credits cannot be created simultaneously from the use of the same tonne of fuel).

Innovative options for carbon abatement also exist, including the manufacture of biochar through pyrolysis processing of wood waste. The biochar is essentially a more stable form of carbon than was originally in the biomass, minus much of the volatile content. One tonne of biochar will 'biosequester' over three tonnes of CO₂e.⁹⁴

It should be noted that the full opportunity for resource recovery of wood waste to create 'carbon credits' will be better understood once the details of the Australian Emissions Trading Scheme (AETS) are released.

The following features are known about the design of the Carbon Pollution Scheme:⁹⁵

- the scheme will set a cap for greenhouse gas emissions; those liable parties are able to abate greenhouse gas emissions at less cost than the prices of a permit to release one tonne of carbon dioxide equivalent will reduce their obligations (and costs) to acquire permits
- the cap will establish a trajectory in line with the policy objective of reducing emissions by 60 per cent of year 2000 levels by 2050
- transitional measures will be put in place to protect energy intensive and trade exposed industries
- input into the design of the scheme will be provided by the Garnaut review, with a final report by 30 September 2008
- information on the design of the scheme will be released by the end of 2008 in a White Paper on the Carbon Pollution Reduction Scheme
- full emissions trading is planned to start by 1 July 2010

⁹² Note that in many circumstances a full life cycle assessment is required to quantify the potential emission benefit.

⁹³ DCC (2008) 'Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at the Facility-Level - Overview and Discussion Papers', Department of Climate Change, Canberra, accessed at <http://www.climatechange.gov.au/reporting/publications/pubs/nger-techguidelines-overview.pdf>, July 2008.

⁹⁴ This assumes that the majority of the biochar is carbon that will not decay over a 100 year period.

⁹⁵ DoCC Undated, 'About the ETS', Department of Climate Change, Canberra, accessed at <http://www.greenhouse.gov.au/emissionstrading/about.html>, May 2008.

9 CONCLUSIONS & RECOMMENDATIONS

Wood waste disposal to landfill represents a wasted resource. It is estimated that 12.5 per cent by volume and 5.5 per cent by mass of all urban waste landfilled in Australia comprises wasted wood resources.

Untreated timber and engineered timber products from Commercial and Industrial (C&I) and Construction and Demolition (C&D) sources can be better used in a raft of potential applications. Examples include re-use (original form and function such as building materials, pallets and other wooden packaging), direct recycling into other timber products (for example demolition timber into particleboard), indirect recycling into non-timber products (such as landscape mulch, animal bedding and playground fibre) and energy generation (process heat in cement kilns and electricity generation in stand alone biomass power stations or co-fired with coal). There are also new technologies developing with the potential to convert wood waste into liquid fuels and also biochar, which has agricultural applications.

In order to convert wood waste into a wood resource there are a number of materials handling challenges that must be overcome. Wood is a bulky material which makes collection, transportation, aggregation and stockpiling difficult. The varied sources of wood waste are such that there are often additional non-wood materials and contaminants that need removing. Some of these materials, such as metal from nails and fastenings, can be readily removed with electro-magnets. Hard-core materials, such as glass, bricks and stone, need to be removed through a variety of screens. Screens and hand picking can also remove plastics; however, some additional wind sifting may also be required. Non-ferrous materials can be removed through eddy current separation. Other forms of sorting, such as ballistics and water baths, can also be used to create a homogenous stream of wood resource from 'waste' inputs. A range of size reduction equipment is also available to prepare wood materials to an end user's specifications.

Treated timber is one area where additional work is required to manage its removal more effectively from mixed wood waste streams in order to increase the potential applications of the wood waste resource into a broader and innovative range of products. However, good 'front of house' screening, training of operators in timber product identification and education of waste 'suppliers' can minimise the amount of treated timber received into a wood recovery operation and ensure quality of the supplied materials to meet manufacturers expectations of low chemical contaminant in the resource.

Many jurisdictions from around Australia have signalled their intention to move towards zero waste, making the recovery of waste wood resources all the more important. Recovering wood resources and diverting them from landfill will prevent methane emissions contained in landfill gas, prevent land pollution, prevent leachate generation, reduce ancillary human health impacts of landfill and preserve social amenity through the avoided need for landfill facilities. The sustainability challenge as it relates to wood waste is in maximising the recovery of waste wood resources at their highest resource value. Extended Producer Responsibility and Product Stewardship for wood products could play a role in establishing an industrial ecosystem for wood waste recovery.

Importantly, the recovery of wood waste prevents its decomposition under anaerobic conditions into a methane containing landfill gas which represents a source of greenhouse gas emissions. Wood derived fuels are also considered renewable fuel.

It is hoped that this wood recovery and recycling source book will play a role in accelerating information dissemination and the development of new markets throughout the emerging wood recovery industry in Australia.

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Acknowledgements

Funding for the project provided by The Department of the Environment, Water, Heritage and the Arts; Forest and Wood Products Australia (FWPA); CSIRO Forest Biosciences. Assistance with writing and gathering information contained herein provided in part by: J. Ramamurthy (CSIRO), M. Henderson (CSIRO), and M. Bojadzic (CSIRO). External review provided by David de Jongh from the National Association of Forest Industries (NAFI), Peter Juniper from A3P, and Stephen Mitchell from the Timber Development Association NSW (TDA).

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