The Australian recycling sector

Department of Sustainability, Environment, Water, Population and Communities

January 2012

Report

Report preparation

Authors: Christophe Brulliard, Rebecca Cain, Daphne Do, Tim Dornom, Katherine Evans, Brendan Lim, Erica Olesson and Suzi Young

Net Balance

Project Manager: Rebecca Cain

Senior Associate

Net Balance

Project Director: Guy Edgar

Associate Director

Net Balance

Status: Final

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)

The Australian recycling sector

12 January 2012

NB Ref: MMPJ11DWH048

Table of Contents

Figures

Tables

Glossary

ACOR	Australian Council of Recycling
ANZIC	Australian and New Zealand Standard Industrial Classification
AuRPS	Australian Recovered Paper Specifications
AWT	Alternative Waste Treatment
C&D	Construction and demolition
C&I	Commercial and industrial
CDL	Container deposit legislation
COAG	Council of Australian Governments
CPI	Consumer Price Index
DECCEW	Department of Environment, Climate Change, Energy and Water
DERM	Department of Environment and Resource Management
DEWHA	Department of Environment, Water, Heritage and the Arts (now DSEWPaC)
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DSE	Department of Sustainability and Environment (Victoria)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DTEI	Department for Transport, Energy and Infrastructure
EPA	Environment Protection Authority (Tasmania, Victoria, NSW)
EPA	Environment Protection Agency (NT, SA)
EPD	Environmental product declaration
EPHC	Environment Protection and Heritage Council
ERA	Extended Regulated Area
FTE	Full time equivalent
GHG-e	Greenhouse gas emissions
HDPE	High density polyethylene
KABC	Keep Australia Beautiful Council

LARRs	Litter Abatement and Resource Recovery Strategy
LCA	Life cycle assessment
LDPE	Low density polyethylene
LGA	Local Government Associations
LLDPE	Linear low density polyethylene
MRF	Materials recovery facility
MSW	Municipal solid waste
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NRETAS	Department of Natural Resources, Environment, The Arts and Sport (NT)
NSW	New South Wales
OECD	Organisation for Economic Cooperation and Development
PETE	Polyethylene terephthalate
PETE	Polyethylene terephthalate
PNEB	Publishers National Environment Bureau
POPs	Persistent organic pollutants
PP	Polypropylene
PS	Polystyrene
QWRRS	Queensland Waste Reduction and Recycling Strategy
RAP	Reclaimed asphalt pavement
RRA	Regional Regulated Area
SA	South Australia
SASP	South Australian Strategic Plan
SAWS	South Australia's Waste Strategy
SEQ	South East Queensland
SMA	Sydney Metropolitan Area (SMA)

SV	Sustainability Victoria
TZW	Towards Zero Waste
UN	United Nations
V	Vinyls including polyvinyl chloride
VENM	Virgin excavated natural material
VRWG	Voluntary Regional Waste Groups
WARE	Waste Avoidance and Resource Efficiency
WARR Act	*Waste Avoidance and Resource Recovery Act*
WaSIP	Waste and Sustainability Improvement Payment
WMAA	Waste Management Association of Australia
WSWA	Waste Strategy for Western Australia
ZWSA	Zero Waste South Australia

1. Introduction

1.1 Background

The Australian recycling sector is an important aspect of Australia's economy and society. A strong and sustainable recycling sector is essential for Australia to utilise resources more efficiently and maximise the full value of materials. The recycling sector is critical to the achievement of the Australian Government's objectives outlined in the *National Waste Policy: Less waste, more resources* (Environment Protection and Heritage Council, 2009) and for state and territory governments to achieve the objectives they have identified in their waste and recycling strategies and policies.

At present there is limited up-to-date information on the recycling sector and the potential for this sector to contribute to environmental, economic and social outcomes. There are three key reasons underlying this lack of information:

- The recycling sector is often considered along with the waste sector and it is not always possible to isolate the data and information that relates to the recycling sector alone
- The recycling sector is often highly integrated with other sectors, particularly transport, waste and manufacturing, and it is not always possible to, or there has been no attempt to, isolate the data and information that relates to recycling activity
- Industry based research is often based on Australian and New Zealand Standard Industrial Classification (ANZSIC) codes and there is not a code for the recycling sector. Some recyclers and recycling activity is captured by other ANZSIC codes, such as that for the waste sector, however research relating to these codes is neither exclusive to nor exhaustive of the recycling sector.

1.2 Purpose

This study is intended to be a central reference tool that provides an up-to-date profile of the Australian recycling sector. Its objective is to describe the key characteristics of the sector and the environment in which it operates, outline the social, economic and environmental benefits and identify barriers and future opportunities for the sector.

In addition to achieving these objectives, this study will also contribute to the implementation of the *National Waste Policy: Less waste, more resources* by:

- Assisting with identification of impediments to the development and operation of effective markets for potential wastes (under strategy 5 of the National Waste Policy) by:
    - providing a stocktake of existing standards, specifications, principles and guidelines and identifying priorities in terms of the development of additional standards, specifications, principles and guidelines
    - identifying market barriers.

- Informing the development of a National Waste Data System (strategy 16) by identifying:
  - data recyclers collect and could reasonably easily collect
  - data recyclers disclose and could reasonably easily disclose (both disclose to the public or more limited disclosure to their supply chain or Government).

2. Approach

2.1 Project scope

There is a substantial amount of research that has been undertaken that relates to the recycling sector. In recognition of this, this study was primarily focused on drawing this research together into one consolidated document. The study was therefore largely a desktop research based exercise, with input sought from industry participants and government representatives to update or verify existing datasets and contribute to the assessment of issues.

Net Balance's role has been to draw together existing information about the sector, complement this information with limited input from industry and other stakeholders, conduct an assessment of the validity of existing information to determine what to include in this report and identify additional information that would be valuable in understanding the sector and its ability to contribute to economic, environmental and social outcomes.

The scope of this study is limited by existing data and research because it was largely desktop based. The study has not generated, and was not intended to generate, new datasets or new primary research.

Other factors relevant to the scope of this study include:

- Wastes are those generated by the municipal (i.e. municipal solid waste (MSW)), commercial and industrial (C&I) and construction and demolition (C&D) sectors.
- The major focus is on the reprocessing component of the recycling sector and only a minor focus is on collection and sorting.

2.2 Our approach

The approach adopted for the conduct of this study is presented in Figure 1 and discussed below.

Figure 1 Study approach

2.2.1 Desktop research

A thorough search was undertaken to identify data and information that would be relevant to this study. It involved internet research and requests for documents and/or data from selected stakeholders.

The material obtained from the search was reviewed and relevant information extracted.

Over 200 documents were compiled and reviewed in the preparation of this study and are referenced in Appendix A.

2.2.2 Stakeholder discussions

Discussions were undertaken with government representatives, industry associations and industry participants. These discussions were focused on gaining additional information that was not obtained through desktop research, such as information relating to end-markets for recycled products. During these discussions stakeholders had the opportunity to contribute to the assessment of a range of issues explored in this study, such as barriers impacting the sector and the future outlook for the sector.

A list of the organisations consulted in the preparation of this report is provided in Appendix B.

2.2.3 Information assessment

An important aspect of this study was an assessment of the accuracy and validity of existing data and information. The information obtained was analysed to ensure it was sufficiently robust and reliable to include in this report. This included an analysis of the methodology and source of data and information. Where relevant, comments relating to the assessment of available data have been provided.

2.2.4 Reporting

Following the preceding phases, this report was prepared to provide an up-to-date profile of the Australian recycling sector.

3. Points of reference

3.1 Definition of recycling

The *National Waste Report 2010* defines recycling as 'a resource recovery method involving the collection and processing of waste for use as a raw material in the manufacture of the same or similar non-waste product' (Environment Protection and Heritage Council, 2010b, p361).

An increasing variety of materials are recycled in Australia. The major material streams that are managed by the recycling sector, and those materials for which data and information is readily available, will be dealt with in detail in this report. These material streams include:

- metals
- organics
- paper & cardboard
- plastics
- glass
- masonry materials.

Other materials and products that are recycled are addressed throughout this report where relevant. These materials and products include hazardous wastes, oil, electronic waste and tyres.

Recycling includes:

- the collection and transportation of recyclable materials
- material sorting
- consolidation and transfer of materials
- material processing.

As previously mentioned, this project is largely focused on the material processing (also referred to as reprocessing) component of the recycling process. Collection and sorting are a minor focus of this study.

3.2 Reference data time period

This study aims to provide information and data from a consistent time period to enable meaningful comparisons. This time period is 2008–09 because, at the time of preparing the report it was the most recent time period for which a large number of datasets exist, and were available. These datasets include information produced in *Waste and Recycling in Australia 2011*, material-based annual recycling surveys such as the Plastics and Chemicals Industries Association (PACIA) national recycling survey and the Recycled Organics Unit's industry statistics.

The data presented in this report that relates to 2008–09 includes:

- Recycling quantities presented in section 4.5

- The value of resource recovery activity presented in section 6
- The environmental impacts and benefits associated with the quantity of material recycled presented in section 7.

If data for this period was not available, the data is the most recent available and the time period is stated.

3.3 Inclusion of recyclable materials exported

Significant quantities of recyclable materials are exported from Australia, both before and after reprocessing. Demand for recyclable materials from export markets is known to be strong for metals, paper and cardboard and plastic packaging. Where data and information relating to export markets is readily available, it has been incorporated into this report.

The quantities of materials collected within Australia and exported for reprocessing are captured within the data presented in section 4.5 (Australian recycling quantities) except for data relating to exported waste tyres, which was not available for 2008–09.The assessment of markets for recycled materials in section 5 also includes information relating to export markets.

4. Sector overview

- The recycling sector is defined as any company that is involved in the collection, transfer, sorting and processing of materials for use as a raw material in the manufacture of the same or similar non-waste product.
- Drawing a boundary around the recycling sector is complex. Recycling is an activity that is not restricted to 'recycling companies'; many companies that are significant contributors to the recycling sector also undertake other activities such as waste management and manufacturing.
- Collection, consolidation and transfer of recyclables occurs across Australia, however facilities are most commonly concentrated in major cities along with Australia's population and industry, particularly on Australia's east coast.
- 26,357,300 tonnes of material were recycled across Australia in 2008–09. This is 44% of all waste generated in Australia.
- The recycling sector is an integral link enabling the Australian economy to achieve a closed loop production system.

4.1 What is the recycling sector

The recycling sector is defined as any company that is involved in the collection, transfer, sorting and processing of materials for use as a raw material in the manufacture of the same or similar non-waste product (Environment Protection and Heritage Council, 2010b, p. 361).

Drawing a boundary around the recycling sector in terms of what it is and the outcomes it achieves is a very complex task.

Many industry sectors are defined in terms of an Australian and New Zealand Standard Industrial Classification (ANZSIC) that is relevant to the industry. There is no ANZSIC code for the recycling sector. There are ANZSIC codes for the waste sector that are likely to capture some recycling sector participants, however these codes cannot be used as a mechanism to define the recycling sector as they are neither exclusive to or exhaustive of the recycling sector.

Recycling is an activity that is not restricted to 'recycling companies'; many companies that are significant contributors to the recycling sector also undertake other activities such as waste management and manufacturing. Some companies that are part of the recycling sector according to the definition above would not define themselves as a recycling company. The following examples demonstrate the challenge in drawing a boundary around the recycling sector:

- Local governments across Australia are one of the major participant groups in waste management and recycling services which may include the provision of kerbside collection services and facilities for the recycling and disposal of materials. Recycling is just one of the many services that local governments deliver and is often provided alongside waste management and other infrastructure services such as street sweeping and landscaping. It can be difficult to isolate the activities and expenditure allocated to recycling.
- Companies such as Alcoa and Amcor recycle substantial quantities of material for use as a raw material in the manufacture of aluminium and paper/cardboard and packaging respectively. The manufacturing and recycling aspects of these businesses are highly integrated.
- There is a significant amount of overlap between the waste management and recycling sectors. Companies such as Veolia Environmental Services and Thiess are integrated waste management and recycling companies. It is common for waste management facilities to conduct both waste and recycling activities on the same site. Many government and industry data collection activities and reports present the waste and recycling sectors together, rather than looking at these sectors in isolation.
- Manufacturers are increasingly playing a role or becoming part of the recycling sector through end-of-life recycling schemes. Companies such as Dyson and Dell operate product take back schemes where they collect and reuse and/or reprocess materials from end-of-life

products. It is expected that the role of manufacturers in the recycling sector will build over time as product stewardship schemes proliferate.

- Retailers are increasingly using their extensive retail networks and reverse logistics potential[1] to contribute to collection schemes for end-of-life products such as used printer cartridges (through Cartridges for Planet Ark) and Christmas cards (through Cards for Planet Ark). While retailers would rarely identify themselves as recyclers, their retail and transportation networks are expanding the range of products and materials that it is financially viable to recycle.

The boundary of the recycling sector as adopted in this definition is presented in Figure 2. This figure is based on the industry structure of the waste management and resource recovery sector as represented in the *Blue Book* (WCS, 2008, p. 43). The recycling sector, bordered in grey, is depicted within the broader context of waste generation and end-of-life management of waste materials. This diagram is a simplified depiction of the recycling sector only and should not be interpreted as accurately representing the flow of materials. More detailed diagrams of the flow of different material streams are presented in section 5.

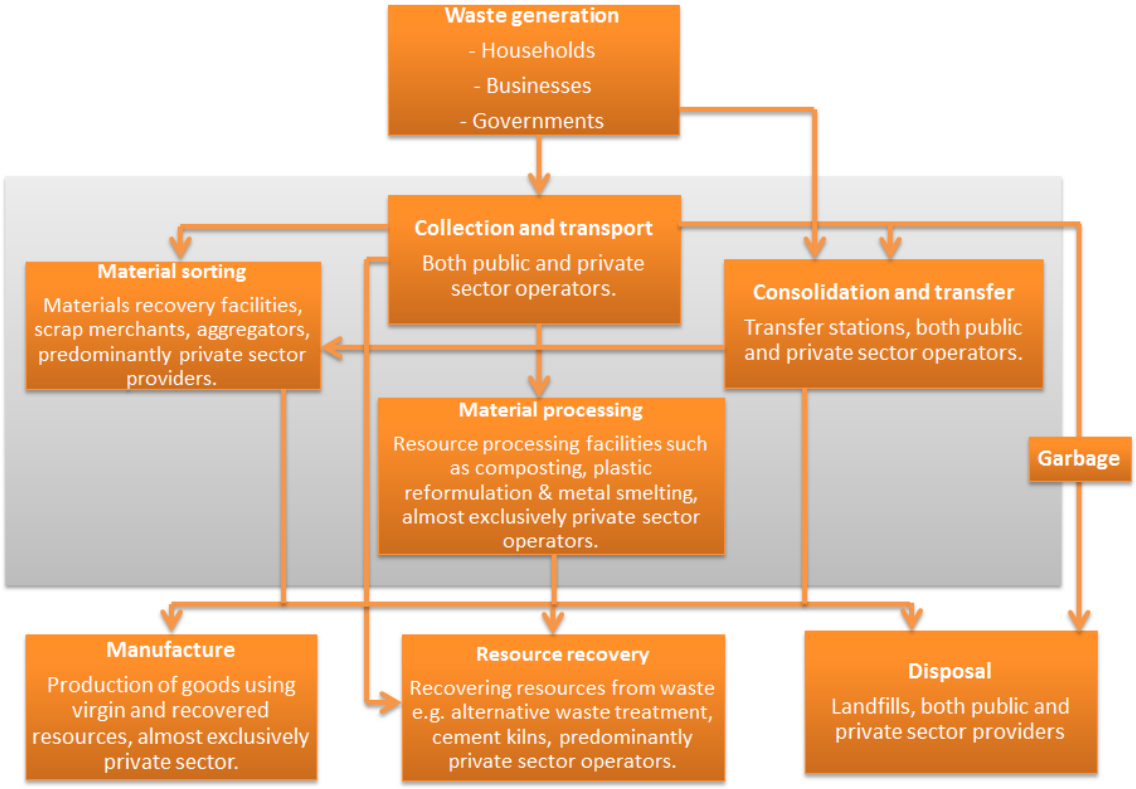


Figure 2 Simplified diagram of the recycling sector

[1] Reverse logistics is the process of moving goods from the point of sale back up the supply chain to the manufacturer in order to recapture value from the product or to ensure it is properly disposed.

This report is largely focused on the material reprocessing aspect of the recycling sector. Where possible, the other segments of the recycling sector have been addressed.

4.2 Sector participants

Both the public and the private sectors are active in the recycling sector. The roles of the sector participants are outlined below.

4.2.1 Australian Government

The Australian Government is responsible for legislation, strategies and policy frameworks for waste at the national level. The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), formerly known as the Department of Environment, Water, Heritage and the Arts (DEWHA), works collaboratively with state and territory governments on the National Waste Policy through the Environment Protection and Heritage Council (EPHC). In future these arrangements may change in response to the Council of Australian Governments (COAG) process of reforming ministerial councils.

The Australian Government coordinates Australia's responsibilities under international agreements to which Australia is a party such as the *Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal* (1989).

4.2.2 State and territory jurisdictions

State and territory governments are responsible for policy, regulation and compliance functions in relation to recycling. While the structure and organisations differ across jurisdictions, the functions are broadly similar. In most jurisdictions, only the more hazardous or potentially harmful materials or activities are regulated.

State and territory based regulators, such as Environment Protection Authorities/agencies in some jurisdictions or government departments in others administer regulatory instruments including policies, Works Approvals, Licenses, Environment Improvement Plans and enforcement tools.

Government departments, authorities or agencies provide the policy and planning frameworks for recycling, develop and implement programs and measure and report on progress.

Additional detail on the public sector participants in each Australian government jurisdiction is provided along with a discussion of the regulatory environment in section 9.

4.2.3 Local governments

Local governments play a pivotal role in providing recycling services within their municipalities. The functions of a local government are defined in state and territory based legislation, such as the *Local Government Act 1989 (Vic)* and the *Local Government Act 1995 (WA).* Local governments typically provide kerbside recycling collections for households and some commercial premises (or drop off points in more geographically dispersed or less populated areas), public place recycling

infrastructure and collection, recycling or resource recovery facilities where residents or businesses can deposit recyclables and hard rubbish collection services.

The trend in recent years has been for local governments to outsource the supply of both the infrastructure and the services to the private sector (WCS, 2008, p. 10). Public sector involvement in delivery of services or capital investment is more common where return on investment is lower than the private sector will tolerate, such as in regional and less populated areas.

Local government associations operate in most Australian jurisdictions in both a policy and a representative capacity on behalf of local governments.

4.2.4 Regional waste management groups

Regional waste management groups (also referred to as regional councils or Regional Organisation of Councils) operate in most Australian jurisdictions to coordinate and facilitate the delivery of waste management infrastructure and services across a geographic region, typically a number of local government areas in proximity to each other. Regional waste management groups may provide strategic frameworks for infrastructure and services, region wide procurement and contract management, and education services targeted at residents, businesses and community groups. In some jurisdictions, regional waste management groups may also supply infrastructure or services.

4.2.5 Industry associations

There are many industry associations that represent the interests of participants within the recycling sector and lead the industry in identifying opportunities and addressing barriers and issues.

The Australian Council of Recycling (ACOR) and the Waste Management Association of Australia (WMAA) are national bodies that represent recycling companies. There are also material specific industry associations, such as the Plastics and Chemicals Industries Association (PACIA), the Australian Tyre Recyclers Association and the Australian Metal Recycling Industry Association. Other associations exist to represent recyclers operating in particular geographic areas, such as Recyclers of South Australia (which currently represents 114 recycling centres). Broader industry groups such as the Australian Industry Group will also have recycling companies (or companies that contribute to the recycling sector) within their membership base.

4.2.6 Private companies

The majority of recycling services in Australia are provided by the private sector.

Private companies vary greatly in size and scope, from owner-operated bin hire or transport services, through to major multi-national companies. The five largest corporations that provide recycling services operating in Australia are Transpacific Industries, Veolia, Thiess, Visy and SITA (WCS, 2008, p. 9).

The private sector provides some infrastructure and services under contract on behalf of local governments, rather than local governments providing them directly. Other private companies provide recycling services on a fee for service basis to households and industry, and their business model typically relies on generating revenue through the provision of these services and the sale of reprocessed materials in excess of the costs associated with collection and processing of materials.

Private sector companies also vary from being narrowly defined to highly integrated companies that operate across multiple phases (e.g. collection, reprocessing) and across materials. There are a large number of small operators who may perform only one small element of the recycling process. For example, some small companies may collect and aggregate waste paper for sale to just one customer. At the other end of the spectrum, Visy Recycling is an example of a large, vertically integrated recycling company that operates across collection, sorting and reprocessing as well as being a major manufacturer of packaging. Visy also reprocesses various material streams (predominantly packaging) to manufacture new products.

4.2.7 Environment groups

Environment groups across Australia play a significant role in raising awareness of the environmental benefits of recycling and advocating for recycling. The types of environment groups contributing to the recycling sector range from national, multi-campaign, membership based organisations such as the Australian Conservation Foundation and the Total Environment Centre, issue specific groups such as Clean Up Australia, through to the many geographically focused, community based environmental groups that take and seek action on environmental issues.

4.2.8 Product stewardship schemes

A more recent development in the recycling space is the establishment of product stewardship schemes as a means for parties in the product chain to share responsibility for the products they produce, handle, purchase, use and discard. These schemes may be established by individual companies e.g. Fuji Xerox's end of life recycling scheme for printing devices and cartridges, or by an industry as a whole e.g. the Australian mobile phone industry's Mobile Muster program. These schemes can either be established voluntarily by companies or industries, or can be supported by government regulation.

The *Product Stewardship Act 2011,* introduced in August 2011, provides a framework to manage the environmental, health and safety impacts of products, and in particular those impacts associated with the disposal of products. The number of product stewardship schemes is likely to increase with the introduction of this legislation.

4.3 Quantifying recycling sector participants

As outlined in section 4.1 it is difficult to draw a boundary around the recycling sector, and therefore very difficult to quantify the number of participants within the recycling sector.

This report brings together existing data that has been published on the number of reprocessing sites across Australia. Reprocessors are companies that process a used material for use as a raw material in the manufacture of the same or similar non-waste product. The available data on the number of reprocessing sites is presented in Table 1. This data does not represent the recycling sector in its entirety but is reflective of the focus of this study on the reprocessing phase of recycling. Data is generally only available for industries and states for which annual recycling surveys are undertaken, therefore this data is not comprehensive. Material and state/territory based totals have been provided only when a total has been published elsewhere and where there is a single source, so as not to misrepresent data. Where there is no tally this reflects a lack of data and should not be interpreted as indicating that there are no reprocessing sites. Where there are no known sites, this is indicated as zero.

Table 1 Number of reprocessing sites in Australia

MATERIAL	ACT	NT	NSW	QLD	SA	TAS	VIC	WA	TOTAL SITES
Glass (packaging)		0	2		8		3		
Paper and cardboard		0	2		10		11		
Plastics	0	0	13	10	10	1	35	4	73
Metals		0	4		21		10		
Organics	N/A	3	59	43	32	3	25	27	186
Construction & demolition	2	0	48	4	17		30		
E-waste	0	0	5	4	3	1	5	2	20
Leather & textiles		0	2		3		2		
Tyres & other rubber		0	7		2		5		
TOTAL COMPANIES					54		126		

Sources:

Vic total: (Sustainability Victoria, 2010, p. 8). Vic breakdown provided by Sustainability Victoria.

SA total: (Hyder Consulting Pty Ltd, 2010, p. 4). Breakdown based on data provided by Zero Waste SA on the number of reprocessors per material classification as reported in the annual recycling survey. There is a high likelihood of double or under counting using the method adopted.

NSW data (aside from organics, plastics and e-waste): provided by the Office of Environment and Heritage based on reprocessors identified through industry surveys.

NT data: provided by Department of Natural Resources, Environment, The Arts and Sport.

Plastics: (Hyder Consulting Pty Ltd, 2011a, p. 27): tallies represent sites operating in 2009–10 financial year.

Organics: (Recycled Organics Unit, 2009). The survey did not include Tasmania, ACT and NT, so there may be additional facilities in these locations. Tasmania organics provided by Department of Primary Industries, Parks, Water and Environment.

C&D reprocessors for Qld and ACT: (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011). In the ACT, there are 2 reprocessors that dominate the market and a number of unquantified small operators.

Notes:

Totals on a material basis reflect the number of reprocessing sites, rather than the number of companies. Some companies may operate in multiple jurisdictions therefore the number of sites is likely to exceed the number of individual companies.

State/territory totals reflect the number of reprocessing companies, some of which reprocess multiple materials. Therefore the individual components for each state/territory may not sum to the total number of companies.

The following information is known about the recycling participants across Australia:

- There are often multiple activities occurring on the one site e.g. green waste processing occurring at a transfer station. A simple count of the number of recycling sites cannot be used as a proxy for the number of companies or the number of services provided.
- There are three companies – Visy, Amcor and Norkse Skog – which reprocess the bulk of paper and cardboard in Australia. There are a large number of small companies reprocessing paper and cardboard to manufacture products such as cat litter.
- The reprocessing sites in Tasmania are thought to be limited to glass and organics. Some glass is reprocessed in Tasmania however the number of reprocessing sites is unknown.
- The Tasmanian waste recovery and recycling directory (available at http://www.environment.tas.gov.au/index.aspx?base=151) provides a database of companies that collect, sort and reprocess materials, sorted by material and product type. It is not possible to identify the purpose of the organisation (i.e. collector, sorter, reprocessor) from the database listing so these companies have not been included in Table 1.
- The Business Recycling website (available at http://businessrecycling.com.au/) lists recycling service providers for over 90 materials. Recycling service providers must register their service with the website in order to be listed, therefore the listing cannot be considered suitable as a source of data on the number of industry participants. A full listing of the companies registered with the website is not publicly available, therefore these companies have not been included in Table 1.
- The Recycling Directory for WA (available at http://www.wmaa.com.au/hidden/Portal/W6CI/directory/index.html), developed for the Waste Management Association of Australia, provides a database of companies that collect, sort and reprocess materials, sorted by material and product type, with a focus on the Perth and Mandurah areas. It is not possible to identify the purpose of the organisation (i.e. collector, sorter, reprocessor) from the database listing so these companies have not been included in Table 1.
- Chapter 2 of the *National Waste Report 2010* (Environment Protection and Heritage Council, 2010b) identifies some recycling facilities in each state and territory. The information is acknowledged as a sample rather than a comprehensive view, therefore it is not considered suitable as a source of data on the number of industry participants.

4.4 Location of the recycling sector

Recycling facilities are most commonly concentrated in major cities along with Australia's population and industry, particularly on Australia's east coast. For reasons of efficiency, reprocessors tend to locate themselves near the source of materials or end markets, or both. This is particularly the case for heavier materials which are expensive to transport, such as construction

and demolition materials. This geographic concentration in NSW and Victoria and to a lesser extent SA is reflected in the number of reprocessing sites presented in Table 1.

The generation of recyclable materials occurs across Australia and for this reason the collection, consolidation and transfer of recyclable materials occurs across Australia. However, in some isolated or less populated areas, particularly in WA and NT, transport distances operate as barriers to the provision of recycling services.

There are examples of innovative approaches to overcoming the challenge of collecting material across vast distances. For example, some product stewardship schemes provide waste generators with the option to post some materials for recycling (posting of all materials may not be possible due to restrictions on posting hazardous materials).

4.5 Australian recycling quantities

The total quantity of material recycled in Australia in 2008–09 was 26,357,300 tonnes (Hyder Consulting Pty Ltd, 2011b). The quantity of material recycled by material category and Australian jurisdiction is presented in Table 2. In 2008–09, the greatest quantity of material was recycled in New South Wales (10,335,300) followed by Victoria (5,890,100). Combined this equates to over 60% of the recycling material. This data includes both materials that are reprocessed in Australia and materials that are exported for reprocessing (with the exception of data on waste tyres exported, for which data was not available for 2008–09).

The data was collected using a variety of approaches as outlined in detail in *Waste and Recycling in Australia 2011* (Hyder Consulting Pty Ltd, 2011a). In summary, the sources of data were reprocessors, state and territory agencies and industry associations. A major source of data was the annual recycling surveys undertaken in Victoria, SA, NSW and WA and the plastics and organics industries. Where annual recycling surveys were not available, data was extrapolated. Refer to *Waste and Recycling in Australia 2011* (Hyder Consulting Pty Ltd, 2011a) for a full discussion on the development and limitation of this data.

Table 2 Australian recycling quantities (tonnes), 2008–09

MATERIAL CATEGORY		NSW	VIC	QLD	SA	WA	TAS	ACT	NT	TOTAL
Masonry materials		4,344,100	2,329,000	1,133,400	1,220,000	723,500	0	280,400	0	10,030,400
Metals		1,985,000	1,099,000	700,900	311,700	375,200	1,200	38,800	800	4,512,700
Organics		1,076,000	563,000	1,069,000	355,800	435,200	25,400	228,400	0	3,752,700
Paper & cardboard		1,600,000	1,132,000	537,500	204,100	231,000	40,300	56,900	11,100	3,813,000
Plastics		73,500	144,000	32,100	13,800	19,400	2,800	1,100	900	287,600
Glass		500,700	185,000	192,800	61,600	26,700	7,100	16,000	4,000	993,900
Other	Leather & textiles	50,200	4,000	0	3,100	51,400	0	6,700	0	115,300
	Tyres & other rubber	0	35,000	0	10,100	2,000	0	4,000	0	51,200
Hazardous	Contaminated soil	0	0	176,400	0	0	6,000	0	0	182,400
	Industrial waste	0	0	221,500	0	0	0	0	0	221,500
Fly ash		705,800	399,200	929,600	223,000	139,200	0	0	0	2,396,700
TOTAL		**10,335,300**	**5,890,100**	**4,993,200**	**2,403,000**	**2,003,600**	**82,900**	**632,300**	**16,700**	**26,357,300**

Source:

(Hyder Consulting Pty Ltd, 2011b, p. 42).

Notes:

In *Waste and Recycling in Australia 2011 (p42)* Hyder Consulting Pty Ltd states that '…all figures have been rounded. Minor discrepancies may occur between the stated totals and the sums of the component items, as totals are calculated using the component item values prior to rounding'. It is noted by Net Balance that the total for NT is different to the sum of the parts and it is assumed that this is due to rounding.

The recycling rate for each material is presented in Table 3. These quantities are taken from the *Waste and Recycling in Australia 2011* report (Hyder Consulting Pty Ltd, 2011b). Metals has the greatest recycling rate with 90% of the material generated recycled, followed by glass with a recycling rate of 69%.

Table 3 Australian recycling rates by material, 2008–09

MATERIAL CATEGORY		WASTE GENERATION (TONNES)	RECYCLING (TONNES)	RECYCLING RATE
Masonry materials		16,148,800	10,030,400	62%
Metals		5,001,300	4,512,700	90%
Organics		11,616,700	3,752,700	33%
Paper & cardboard		6,173,300	3,813,000	62%
Plastics		1,789,400	287,600	16%
Glass		1,438,200	993,900	69%
Other	Leather & textiles	639,700	115,300	18%
	Tyres & other rubber	288,800	51,200	18%
Hazardous	Contaminated soil	1,817,300	182,400	10%
	Industrial waste	1,234,700	221,500	18%
Fly ash		14,026,500	2,396,700	17%
TOTAL		**60,802,900**	**26,357,300**	**44%**

Source:

(Hyder Consulting Pty Ltd, 2011b, p. 41).

The breakdown of recycling across the three source sectors commonly used in Australia – MSW, C&I and C&D – are presented in Figure 3. As illustrated, New South Wales recycles the greatest quantity of material, the majority of which is sourced from the C&D sector. These quantities are drawn from the *Waste and Recycling in Australia 2011* report (Hyder Consulting Pty Ltd, 2011b).

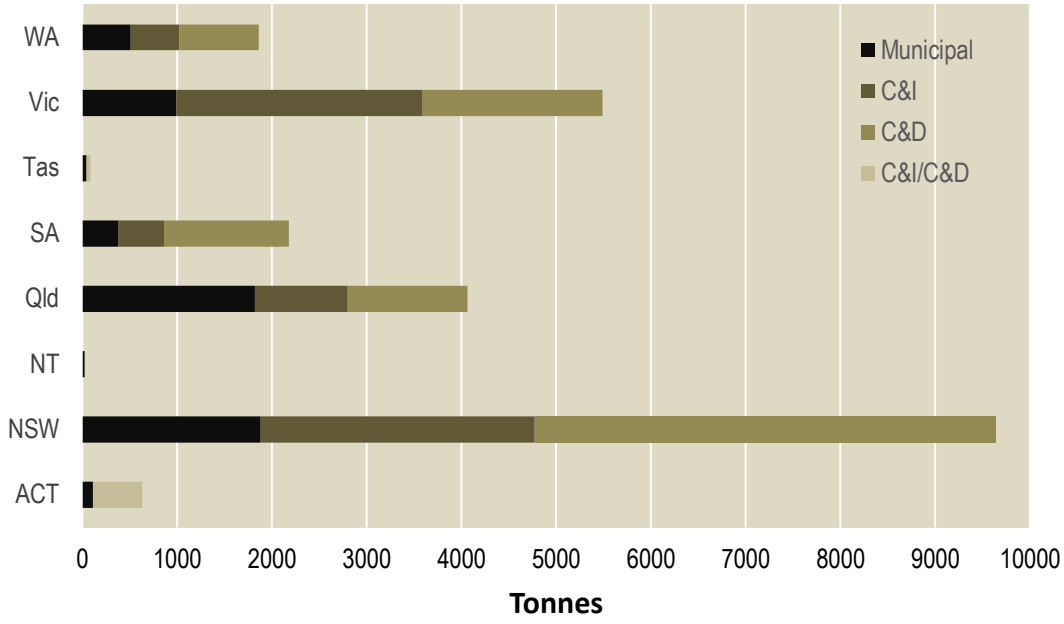


Figure 3 Quantity of material recycled in Australia by source sector, 2008–09 (Hyder Consulting Pty Ltd, 2011b)

4.6 What's unique about the recycling sector

Across Australia households and businesses contribute to the recycling sector by generating materials that companies collect, and add value to, before on-supplying to the manufacturing sector or consumers. The quantity and quality of recycled material is significantly influenced by the behaviour of householders and businesses.

Recycling is not a new concept. It came to prominence as a very visible and tangible component of the environmental political movement in Australia in the 1970s and 1980s. Recycling was an activity that every household could do to benefit the environment. Once it was introduced, the community came to expect it as an essential service. Growth in disposable income fuelled rising consumerism and waste generation, increasing the perceived importance of recycling. In most product markets, consumer demand drives the development of products, and industries meet the demand by supplying them. In the case of recycling, consumers are not necessarily demanding products to be manufactured from recycled material. These dynamics can be described as "supply-push".

For some materials, the drive for recycling is economic and would exist regardless of society's expectation for recycling. In the case of paper and cardboard, waste paper is a much more cost effective raw material input than manufacturing using virgin materials e.g. wood chips. A paper mill that uses recycled pulp is also less capital intensive than a mill that uses only virgin materials to manufacture products.

Another aspect of the recycling sector that differentiates it from other industrial sectors is that it

does not start with primary industries. Aside from the resources required to reprocess materials, such as energy and water, the recycling sector does not deplete natural resources such as precious metals in order to produce its outputs. In fact, one of the key outcomes of the existence of the recycling sector is that it provides resources or inputs to a range of industries without depleting natural resources.

A further unique and complex aspect of the recycling sector is its integration with other sectors of the economy. The recycling sector is simultaneously:

- Providing a collection service to waste generators
- Producing and marketing recovered products that are on-sold as inputs into manufacturing processes.

The recycling sector is an integral link enabling the Australian economy to achieve a closed loop production system.

5. Processes & markets

The following chapter provides a review of the recycling process from input materials to reprocessing and through to products and end markets across the following material streams:

- Plastics
- Metals
- Glass
- Paper & cardboard
- Organics
- Masonry materials

Market drivers are outlined for the primary recycled-content products within each material category. In addition, a high level assessment of the degree of market competition for the recycling sector is provided for each stream.

This section provides an overview of the processes for recycling materials and the uses and markets for the sale of recycled materials. The materials discussed in this section include plastics, metals, glass, paper and cardboard, organics and masonry materials.

A number of steps are undertaken to recycle materials so that they can be used as a raw material in the production of goods. The typical process for recycling, from the generation of materials through to their sale, is provided in Figure 4.

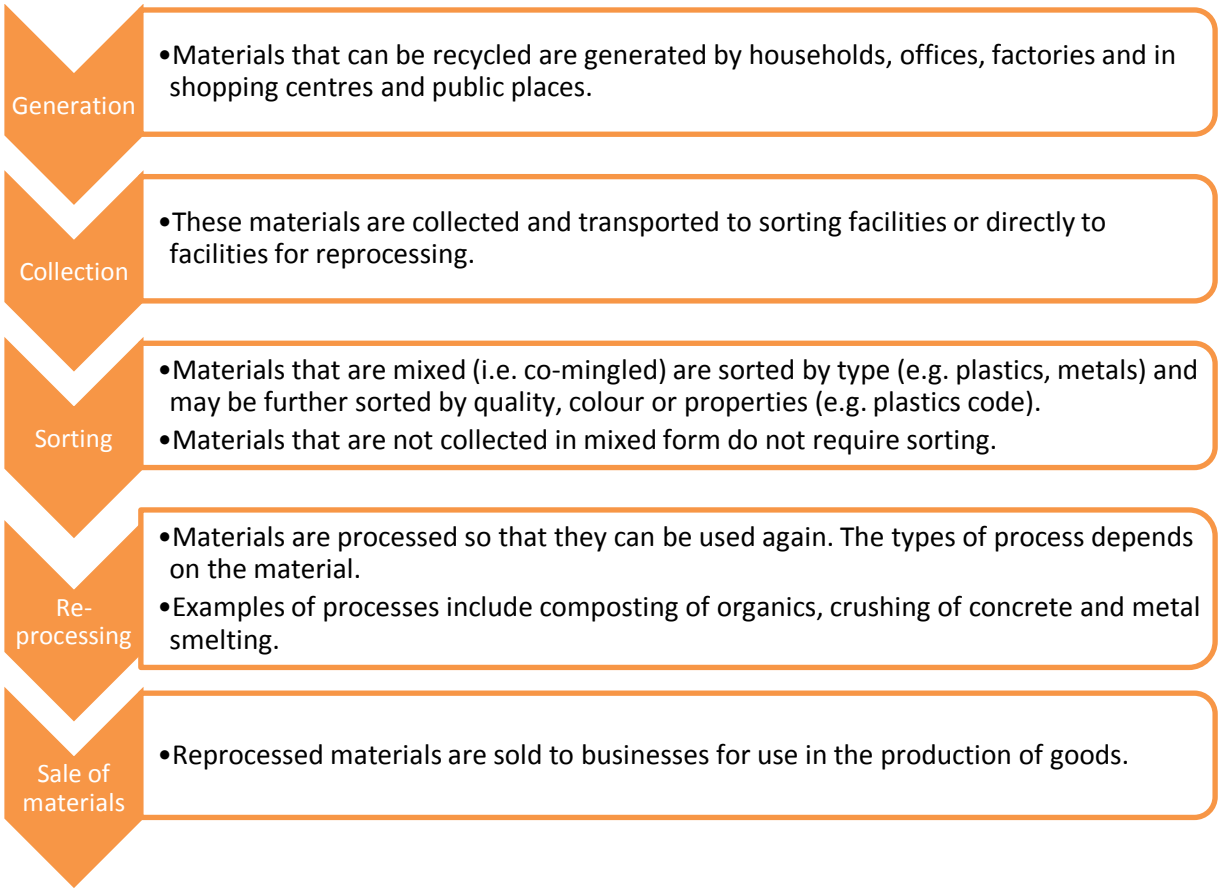


Figure 4 Process for the recycling and sale of reprocessed materials

Due to differences in the method of collection, type of material, reprocessing requirements and end uses, the process for recycling differs for each material. The process for the recycling and sale of plastics, metals, glass, paper and cardboard, organics and masonry materials is discussed in detail in this section.

Detailed data and information on the sale of reprocessed materials is often not publicly available due to the commercial and competitive nature of sales and market development. Information relating to customers for reprocessed materials and the degree of competition amongst suppliers of reprocessed materials has been obtained through discussions with industry participants.

5.1 Plastics

Plastics and polymer products are significant contributors to overall Australian waste generation, as they are incorporated into a wide variety of materials across all industries. Plastics are classified into seven different categories based on material composition, accompanied by a number commonly seen within product symbols, as shown in Figure 5.

Figure 5 Plastics Identification Code (Plastics and Chemicals Industries Association)

Each category of plastics has different properties which makes it suitable for different applications. The typical applications for each of the categories are:

- PETE (Polyethylene Terephthalate) - uses include beverage, food, liquid containers.
- HDPE (High Density Polyethylene) - uses include piping, electrical, liquid containers.
- V (Vinyls including Polyvinyl Chloride) -uses include clothing, piping, electrical, signs, joining.
- LDPE (Low Density Polyethylene) - uses include containers, tubing, plastic bags, and computer components.
- PP (Polypropylene) - uses include packaging, textiles, stationary, containers and auto components.
- PS (Polystyrene) -uses include insulation, cutlery, models, packaging, CD and DVD cases.
- Other - includes rubberised plastics, acrylonitrile, polyurethane and nylon. The category also includes composite materials which are a blend of multiple types of plastic and therefore cannot be separated or reprocessed into pure products.

An overview of the flow of plastics from generation through to the manufacture of products using recycled material is provided in Figure 6 and further discussed below.

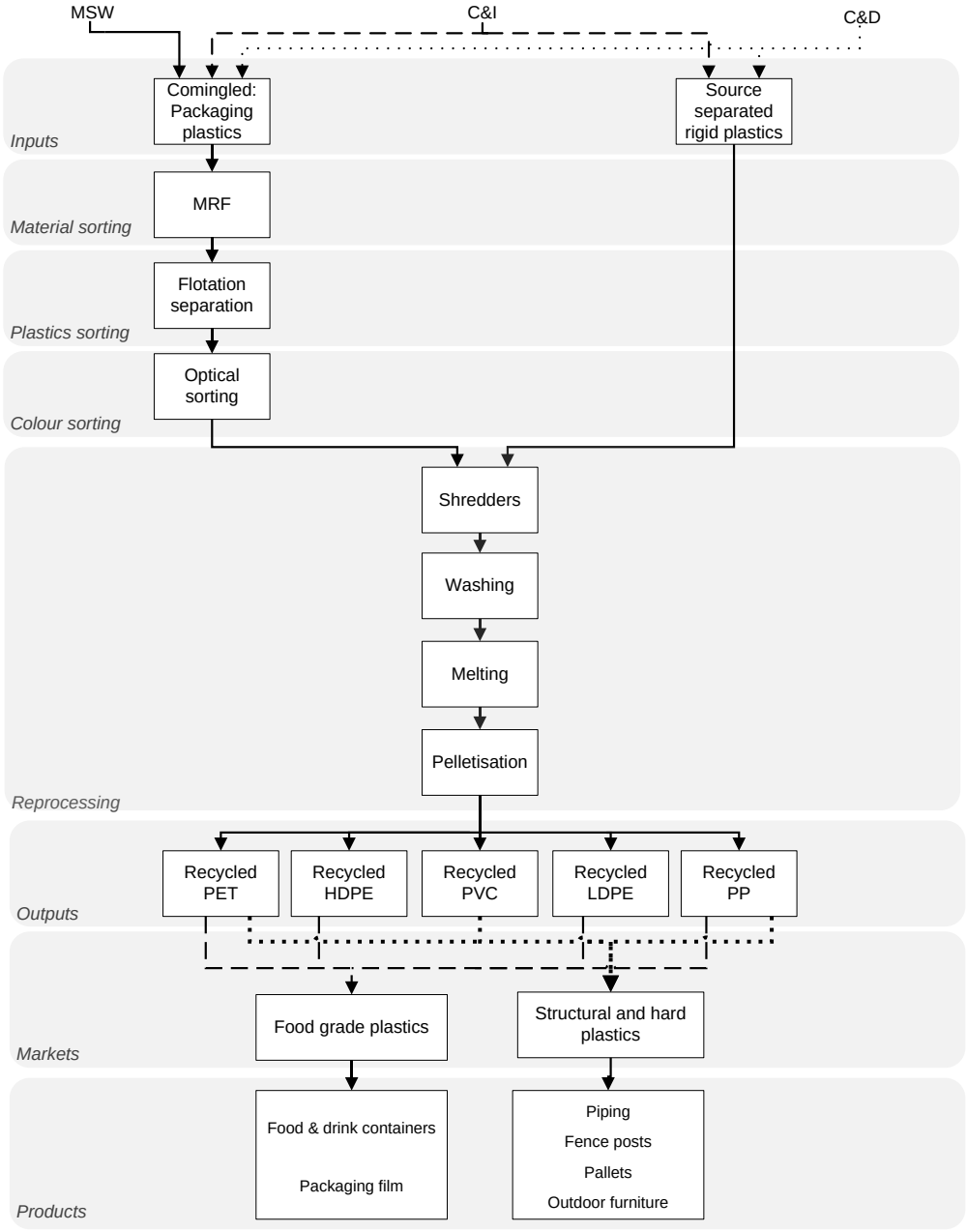


Figure 6 Flow of plastics through the recycling chain

5.1.1 Inputs

Packaging and the building industry generate the greatest proportion of plastic waste with a combined total greater than 60% as shown in Figure 7. Generation of plastic waste is relatively evenly divided amongst domestic and industrial sources.

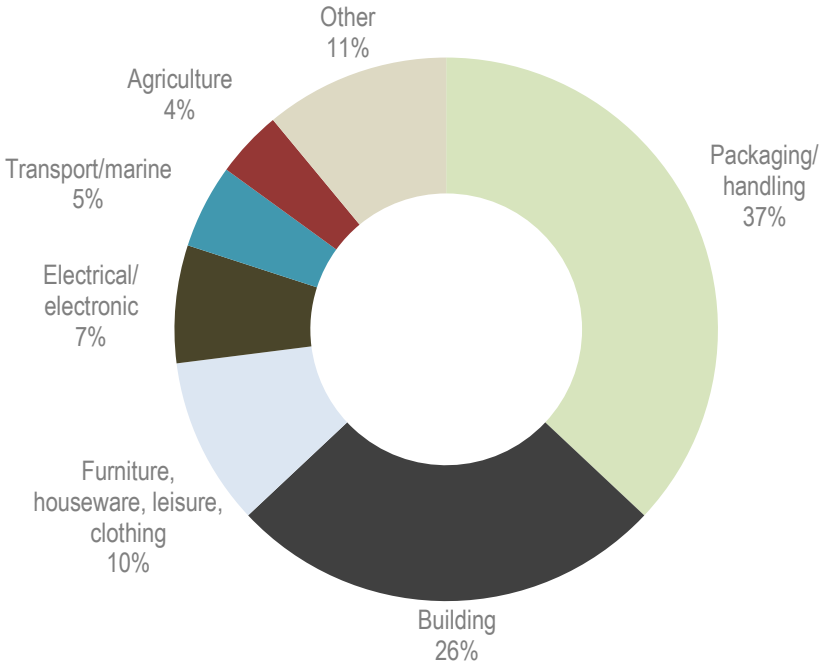


Figure 7 Sources of plastic waste in Australia, 2009–10[2] (Hyder Consulting Pty Ltd, 2011a)

Amongst these sources of waste, the most commonly recycled plastics in Australia are PET, HDPE, LDPE and PP. Other plastics produced in lesser quantities, although recycled at significant recovery rates include PS and certain types of "other" plastic (Hyder Consulting Pty Ltd, 2011a).

Some plastic types are more difficult to reprocess owing to the chemical properties of the plastic, leading to increased proportions being sent to landfill. This is evident in the lower overall proportion of these plastic streams recycled, shown in Figure 8. In addition, less common plastics may lack large reprocessing infrastructure, and products which comprise multiple types of blended plastic are more difficult to reprocess (Kutz, 2011).

[2]The National Plastics Recycling Survey changed from calendar to financial year after 2008, therefore 2008–09 data was not available.

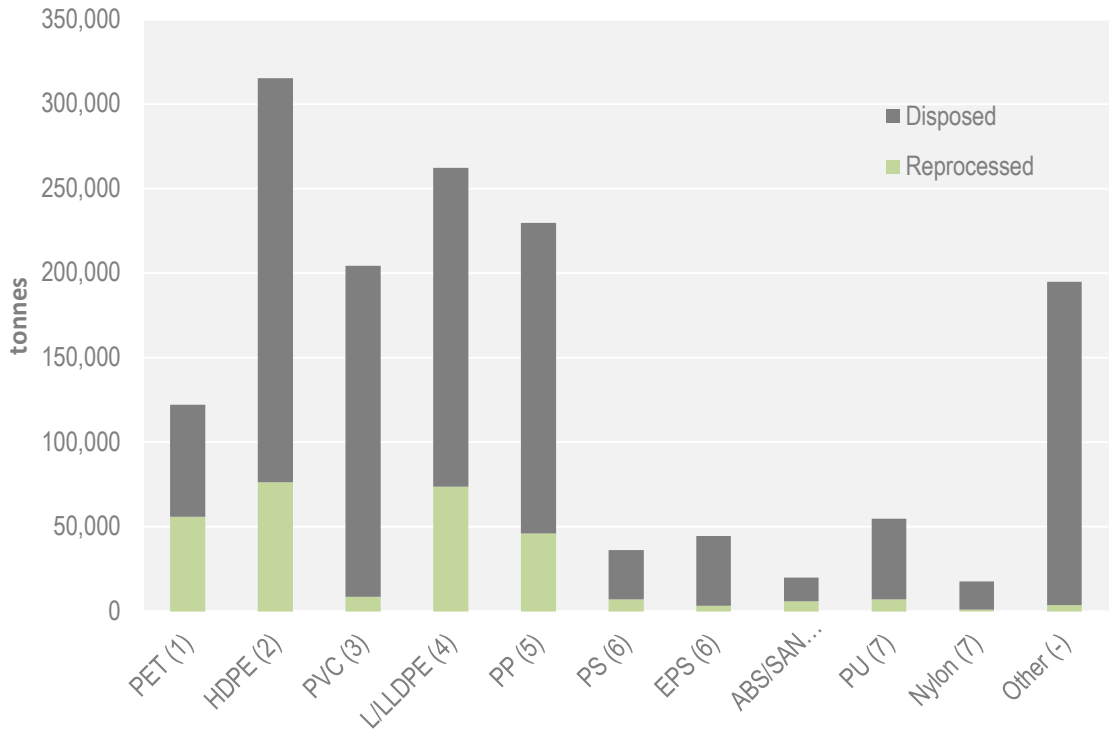


Figure 8 Individual plastics consumption and destination in Australia, 2009–10 (Hyder Consulting Pty Ltd, 2011a)

Notes on figure:

PET	Polyethylene Terephthalate
HDPE	High Density Polyethylene
PVC	Polyvinyl Chloride
L/LLDPE	Low/Linear Low Density Polyethylene
PP	Polypropylene
PS	Polystyrene
ABS/SAN	Acrylonitrile Butadiene Styrene/Styrene Acrylonitrile
PU	Polyurethane

PET, HDPE, LDPE and PP comprise over 85% of all reprocessed Australian plastics (Hyder Consulting Pty Ltd, 2011a). Accordingly, the majority of information presented in this section focuses on the recycling of these plastics.

5.1.2 Reprocessing

Kerbside collections deliver co-mingled waste to a Materials Recovery Facility (MRF) for automated sorting of plastics from metals, paper and glass. Larger scale C&I and C&D sites sometimes segregate plastics and other recyclables on-site at the point of collection. This may occur at sites where large quantities of a single type of plastic are used, making segregation easier than in households with highly variable output streams. In this case, sorting at an MRF may be reduced or not required.

When MRFs are utilised, after mixed plastics are separated from other bulk materials they must be sorted into individual plastic streams (such as PET, HDPE, LDPE and PP). This is commonly achieved with the use of density-based separation technologies, flotation and optical colour-sorting devices (Pascoe, 2000). The sorted plastics are grouped together (such as large bales of crushed, compacted PET bottles) and may be distributed to specialised recyclers of particular plastics.

Separated plastics undergo thorough cleaning to remove contaminants (labels, glue residue and other mixed materials) and then size reduction via shredding and grinding. Following size reduction, further cleaning and separation occurs to obtain a pure stream of only a single plastic type, which can then be reprocessed into new plastic materials. Cleaned, sorted plastic is typically in the form of granulated flakes (Kutz, 2011).

Currently, the most common method for the reprocessing of plastics is via mechanical recovery (Hyder Consulting Pty Ltd, 2011a). In this process, the pure flakes are melted and reformed via a process known as melt-extrusion, which produces uniformly-sized pellets of recycled plastic. These pellets are able to be used as a raw material to be re-moulded into plastic goods (Kutz, 2011).

Alternative reprocessing methods exist to chemically convert the collected plastics back into original feedstock chemical compounds (precursors to plastic polymers). Currently these methods are more complex and require high reprocessing throughput to allow commercial viability. For these reasons, chemical recycling is not undertaken on any significant scale in Australia (Hyder Consulting Pty Ltd, 2011a). Similarly, biological reprocessing utilises natural enzymes to convert collected plastic into compostable organic material, and is also not currently undertaken on any large scale (Hyder Consulting Pty Ltd, 2011a).

5.1.3 Quantity of materials recycled

In 2008–09 the total quantity of plastic waste generated in Australia was 1,789,400 tonnes, of which 287,600 tonnes was reprocessed into recycled materials, a recycling rate of 16% (Hyder Consulting Pty Ltd, 2011r, p. 41). Over the past decade, both the overall quantity and the percentage recycling rate have consistently increased (Hyder Consulting Pty Ltd, 2011a).

While domestic reprocessing has grown slowly or remained consistent, the bulk of increased reprocessing has been achieved by greater quantities of plastics being exported, particularly to China where demand for both virgin and recycled plastics is high (Plunkett Research, 2008).

5.1.4 Outputs and products

The direct output of plastic reprocessing is generally fine pellets or flakes which are then able to be re-moulded into finished products.

The products obtained from reprocessing will be of the same classification as the input plastic, but may not always be suitable for the original purpose of the collected material. Over time and also during reprocessing, the polymer components of plastic materials degrade leading to impurities or changes to physical properties which can no longer meet the requirements of the original material (Harper, 2002). The quality of the recycled plastic is governed by both the quality of the collected material, and the extent of reprocessing undertaken.

As an example, PET bottles used for beverages require high quality “food grade” PET plastic, manufactured to a standard suitable to contain liquids without risk of contamination. After use and disposal, collected PET bottles can be thoroughly reprocessed in order to meet these requirements once more (Harper, 2002). An alternative is to recycle the collected “food grade” material into lower grade products which do not require such high purity, and therefore only require reprocessing to a lesser extent. For this reason, recycled PET plastic is often used to produce “fibre grade" goods such as materials for synthetic textiles (Kutz, 2011).

Non-food plastics are more easily reprocessed into identical materials (Harper, 2002).

5.1.5 End markets

Plastics types are classified by physical composition (PET, HDPE, PVC, PP etc.) however for the purpose of providing a high-level assessment of market conditions it is more practical to group recycled products by broad end use. In practice, recycled plastics of a variety of classifications may serve the same end-use.

The predominant markets for recycled plastic materials are discussed below. The information is sourced from a range of publications including the Plastics and Chemicals Industries Association National Plastics Recycling Survey, news publications relating to the plastics industry and industry consultation.

5.1.5.1 High quality 'food grade' plastics

Products	Food and beverage containers (PET, HDPE, PP) Packaging film (HDPE, LDPE)
Competing products	Virgin food packaging and film
Clients	Bottle and beverage manufacturers; packaging companies; intermediaries who trade in plastic, particularly supply to overseas markets. Food-grade recycled plastic is dominated by Visy, which owns the only food-grade PET bottle recycling facility in Australia.
Contractual bases	Manufacturers want certainty around quality, price and availability of materials, so will enter into long term contracts to secure this wherever possible.
Market assessment	Food-grade recycled plastic is produced in Australia, although currently manufacturers incorporate only partial recycled content in a limited range of beverage and container products. This is largely due to the slight discoloration caused by the degradation of recycled polymers, also leading to an increased risk that the product will leach impurities into edible goods. A significant amount of plastic is exported for reprocessing – in 2008 approximately 40% from Victoria (Sustainability Victoria, 2010), 35% from WA (Hyder Consulting Pty Ltd, n.d) and 23% from SA (Hyder Consulting Pty Ltd, 2010), was exported. Markets are strong due to economics compared with virgin processes, therefore demand likely to exceed supply. Demand and price are linked to international commodities markets.
Degree of competition	Specialised equipment for plastics reprocessing is not capital intensive. Relationships with suppliers of feedstock and end-markets are critical.
Market drivers	Cost of recycled materials relative to virgin materials. Perception/risk of minor contamination affecting the taste or quality of food and beverages. In many cases, companies producing or purchasing recycled bottles and containers will set limits on the amount of recycled content which is incorporated by the reprocessor. Fluctuation in the cost differential between virgin and recycled plastics may influence the proportion of recycled content included in products. Fluctuations in the quantity and quality of collected and reprocessed plastic available also influences the proportion which is incorporated into food-grade products.

5.1.5.2 *Structural and hard plastics*

Products	Piping (PVC), fence posts (PET, HDPE, PP) pallets (PET, HDPE), outdoor furniture (PP, other)
Competing products	Virgin plastics Timber and metals
Clients	Construction and landscaping businesses; intermediaries who trade in plastic, particularly supply to overseas markets.
Contractual bases	Manufacturers want certainty around quality, price and availability of materials, so will enter into long term contracts to secure this wherever possible.
Market assessment	Piping, landscaping, packaging and furniture products are increasingly having recycled content incorporated by many manufacturers. Minor impurities in recycled plastic are unimportant as long as the material remains structurally sound. A significant amount of plastic is exported for reprocessing – in 2008 approximately 40% from Victoria (Sustainability Victoria, 2010), 35% from WA (Hyder Consulting Pty Ltd, n.d) and 23% from SA (Hyder Consulting Pty Ltd, 2010), was exported. Markets are strong due to economics compared with virgin processes, therefore demand likely to exceed supply. Demand and price are linked to international commodities markets.
Degree of competition	Specialised equipment for plastics reprocessing is not capital intensive. Relationships with suppliers of feedstock and end-markets are critical.
Market drivers	Cost of recycled materials relative to virgin materials. Consumer acceptance of recycled products.

5.2 Metals

Scrap metals are a traded commodity on the international market and are predominantly comprised of steel, with lesser proportions of non-ferrous materials including aluminium, copper and lead.

An overview of the flow of metals from waste generation through to the manufacture of products using recycled metal is provided in Figure 9 and further discussed below.

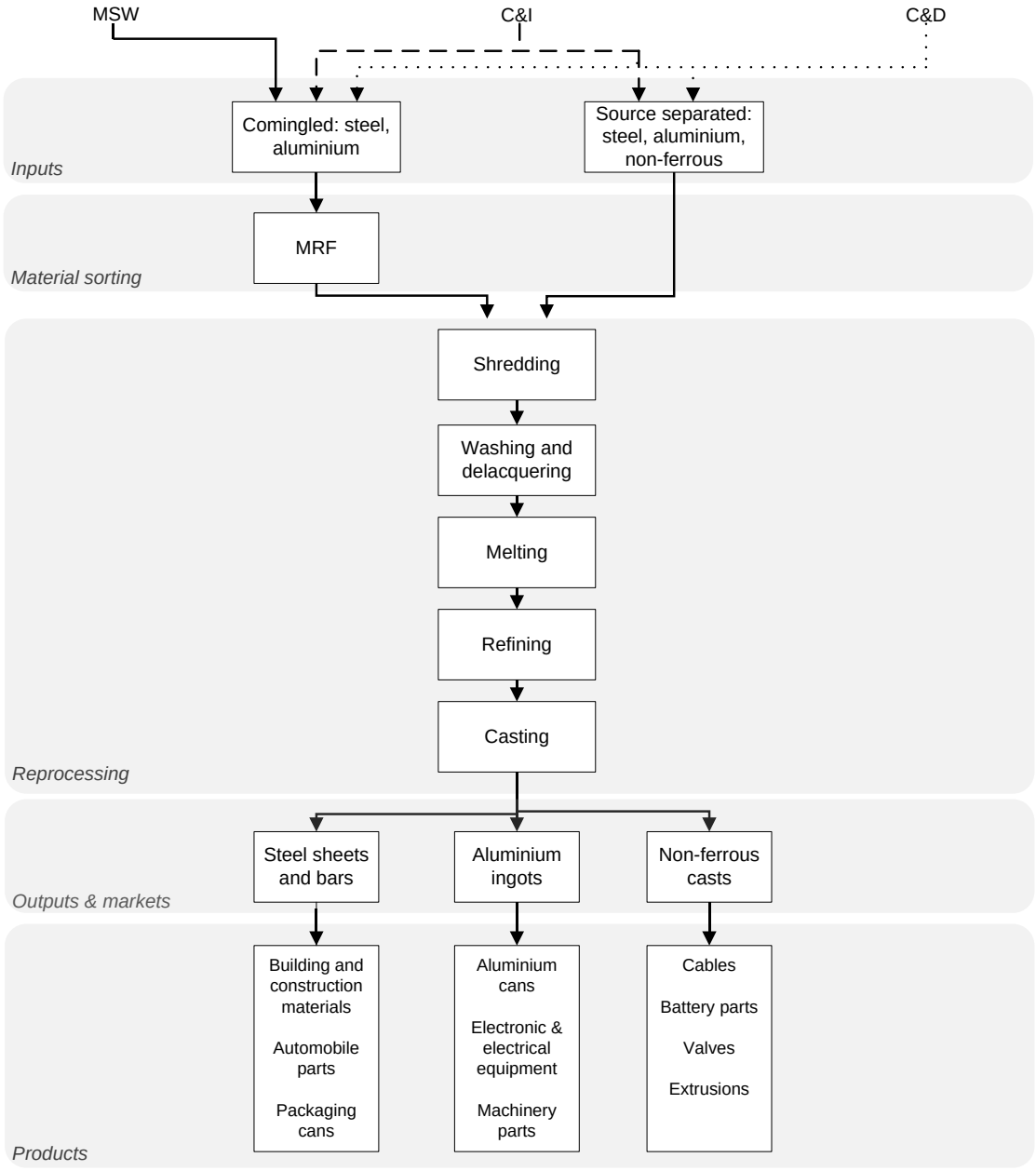


Figure 9 Flow of metals through the recycling chain

5.2.1 Inputs

The primary inputs for metals reprocessing fall into three material streams: steel, aluminium and other non-ferrous materials.

Metal waste is predominantly sourced through C&I activities, with contributions from municipal and C&D waste streams varying slightly by state/territory.

Steel scrap is 100% recyclable, having a potentially continuous lifecycle with the exception of some applications which render the steel unrecyclable (Bluescope Steel). Recyclable scrap steel comes from a wide range of sources including packaging cans from municipal waste sources, automobile parts, large equipment and machinery, manufacturing off-cuts and building and construction materials.

Aluminium is also 100% recyclable, with infinite reprocessing resulting in no loss of properties (Australian Aluminium Council Ltd). Common municipal aluminium waste comes from aluminium beverage cans. Inputs from C&I and C&D sources include automobile parts, machinery, electrical and electronic equipment, cables and foil.

5.2.2 Reprocessing

Aluminium and steel cans are collected through kerbside collections of comingled waste, and separated through Materials Recovery Facilities (MRFs) (Department of Environment, Climate Change and Water (NSW), 2010c).

Scrap metal from the C&I and C&D sectors are typically source separated and collected by scrap metal merchants for direct on-sale to reprocessing sites (Department of Environment, Climate Change and Water (NSW), 2010c).

While the process of recycling each metal differs slightly depending on the collected source of the scrap metal, the key steps for each primary metal type are similar.

Aluminium waste is shredded at steel shredding facilities and reprocessed through remelting of the scrap streams (European Commission, n.d). Any coated aluminium is stripped of its coating prior to remelting. Once the aluminium metal is in a molten state, its alloy levels are tested and adjusted before casting into aluminium ingots for further processing.

Copper waste is remelted, either with or without refining processes, for use as a substitute for virgin copper (Department of Environment, Climate Change and Water (NSW), 2010c). Refining processes reduce undesirable impurities and contaminants, which is particularly important to electrical-grade copper.

Steel undergoes size reduction processes and is then separated from other materials through magnetic separation (Department of Environment, Climate Change and Water (NSW), 2010c). Reprocessing is undertaken using one of two technologies: a Blast Furnace-Basic Oxygen Furnace or an Electric Arc Furnace.

5.2.3 Quantity of materials recycled

In 2008–09 the total quantity of metal waste generated in Australia was 5,001,300 tonnes, of which 4,512,700 tonnes was reprocessed into recycled materials (Hyder Consulting Pty Ltd, 2011b, p. 41). This represents a 90% recycling rate, the highest recovery of any material type addressed in this study.

The high recovery rate achieved for metals is partially driven by the higher cost of metals compared to other recyclables (Department of Environment, Climate Change and Water (NSW), 2010c), and subsequent financial benefits in limiting disposal to landfill. Particularly for C&I and C&D metal waste, collected scrap metal achieves a resale value which makes recycling financially beneficial to the waste generator if undertaken on a reasonable scale.

The physical properties of metals are also well-suited to effective recycling, as products made from steel, aluminium and copper are often highly pure single materials and are able to be recovered with little contamination. In contrast, plastics and paper are comprised of multiple different components and are also more likely to be interspersed with other materials.

5.2.4 Outputs and products

Outputs from reprocessed metals are typically sold into the manufacturing industry for remanufacturing into other products (Sustainability Victoria, 2010). Given that the properties of metals are not diminished through the recycling process, recycled products fulfil the same purposes as those produced via virgin methods.

For steel, this includes building and construction materials, automobile parts, and packaging cans, while aluminium products include cans, metal frames, electrical equipment, and machinery parts (Department of Environment, Climate Change and Water (NSW), 2010c). Copper products include cables and battery parts.

5.2.5 End markets

The markets for different metal streams including steel, aluminium and other non-ferrous metals are discussed below. In the case of metals, scrap metal is generally traded rather than the reprocessed product, therefore the markets analysed are those for scrap metal.

The information below was drawn from various publications, particularly the annual reprocessing surveys conducted by the Victorian, South Australian and Western Australian governments. It was not possible to speak to an industry participant in the preparation of this report, therefore a discussion of competition and the contractual bases for the supply of scrap metal has not been provided.

5.2.5.1 Steel

Applications (Hyder Consulting Pty Ltd, 2010, p. 17)	Many, including car parts, general rod and sheet, mining equipment.
Competing products	Virgin steel
Market assessment	Steel represents the bulk of metals recycled (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). Material is 100% recyclable and markets are strong due to economics compared with virgin processes, therefore demand likely to exceed supply. Demand and price are linked to international commodities markets. Export market represents a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). The supply of scrap metal can be limited when prices are low as suppliers, such as demolition companies, stockpile metals if they can and wait for improved commodity prices (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 41) (Sustainability Victoria, 2010, p. 18).
Market drivers	Demand from export markets which represent a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). Export demand subsequently driven by manufacturing and construction. Exports of all metals decreased significantly during 2008-09 due to a reduction in manufacturing and construction during the global financial crisis (Hyder Consulting Pty Ltd, 2010, p. 19).

5.2.5.2 Aluminium

Applications (Hyder Consulting Pty Ltd, 2010, p. 17)	Valves and extrusions, automotive parts, building industry and aluminium cans.
Competing products	Virgin aluminium

Market assessment	Material is 100% recyclable and markets are strong due to economics compared with virgin processes, therefore demand likely to exceed supply. Demand and price are linked to international commodities markets. Export markets represent a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). The supply of scrap metal can be limited when prices are low as suppliers, such as demolition companies, stockpile metals if they can and wait for improved commodity prices (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 41), (Sustainability Victoria, 2010, p. 18).
Market drivers	Demand from export markets which represent a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). Export demand subsequently driven by manufacturing and construction. Exports of all metals decreased significantly during 2008–09 due to a reduction in manufacturing and construction during the global financial crisis (Hyder Consulting Pty Ltd, 2010, p. 19).

5.2.5.3 Other non-ferrous metals (excluding aluminium)

Applications (Hyder Consulting Pty Ltd, 2010, p. 17)	Many, including batteries, cables, valves and extrusions.
Competing products	Virgin materials
Market assessment	Material is 100% recyclable and markets are strong due to economics compared with virgin processes, therefore demand likely to exceed supply. Demand and price are linked to international commodities markets. Export markets represent a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). The supply of scrap metal can be limited when prices are low as suppliers, such as demolition companies, stockpile metals if they can and wait for improved commodity prices (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 41), (Sustainability Victoria, 2010, p. 18).

Market drivers	Demand from export markets which represent a large proportion of the market, particularly outside of NSW and Vic (i.e. 68% for SA, 95% for WA, 40% for Vic) (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d), (Sustainability Victoria, 2010). Export demand subsequently driven by manufacturing and construction. Exports of all metals decreased significantly during 2008–09 due to a reduction in manufacturing and construction during the global financial crisis (Hyder Consulting Pty Ltd, 2010, p. 19).

5.3 Glass

Glass is a material that can be reprocessed indefinitely (APC Environmental Management, 2006, p. 22), and results in a reduction in the energy and raw materials used to manufacture products in comparison to virgin materials.

An overview of the flow of glass from waste generation through to the manufacture of products using recycled glass is provided in Figure 10 further discussed below.

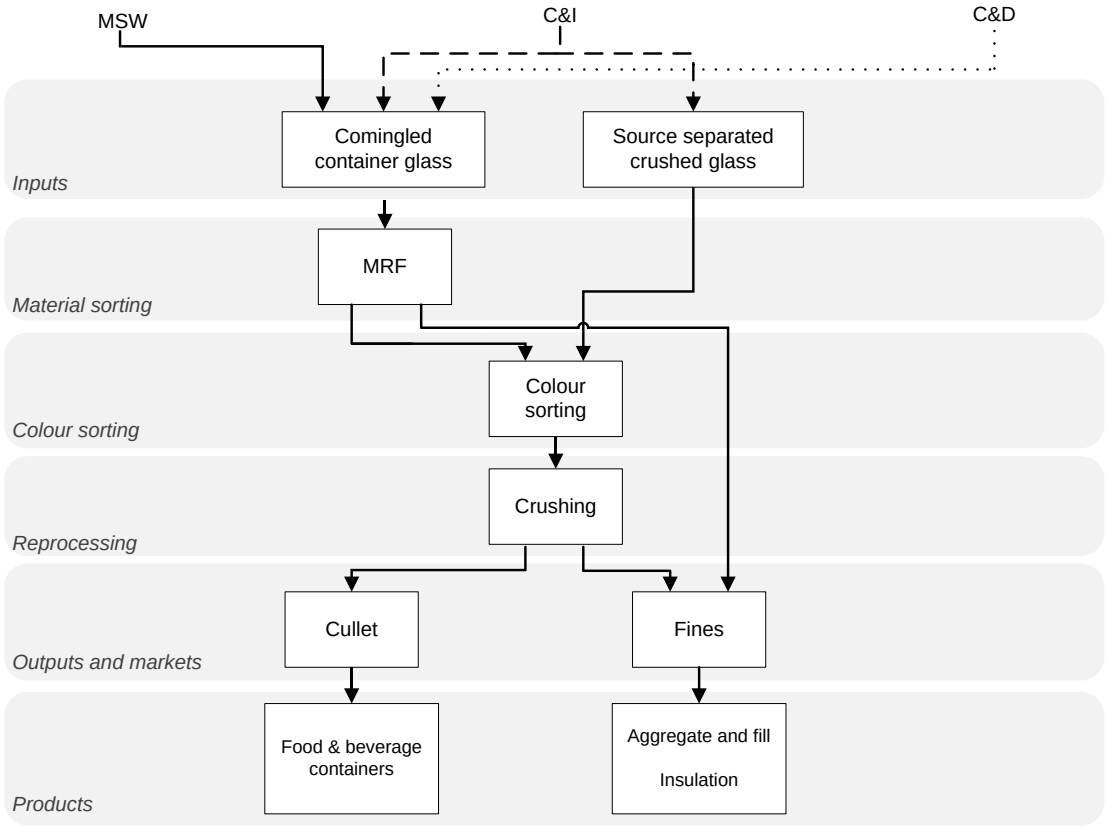


Figure 10 Flow of glass through the recycling chain

5.3.1 Inputs

Glass collected for recycling in Australia primarily comes from food or drink containers, and includes clear, green and amber glass. Cookware glass, light globes, drinking glasses and window glass are examples of common glass types that will contaminate the recycling process for glass containers due to different melting points compared to that of recyclable glass (Clean Up Australia Ltd, 2009).

Plate glass, or window glass, may be reprocessed in Australia into insulation, however this is not widespread and a large quantity goes to landfill. Plate glass can also be used as aggregate and for blast cleaning.

5.3.2 Reprocessing

Glass is typically sorted from mixed recycled waste at MRFs and then further refined ("beneficiated") to achieve properties required for reprocessing. BottleCycler Glass Management technology is used by some businesses in the hospitality sector for onsite bottle crushing, which allows for reduced transportation volumes, improved occupational health and safety standards and higher recycling yields due to a reduction in glass breakage (Australian Food & Grocery Council, 2009).

Glass bottles and jars are separated by colour either by hand or using automated sorting equipment which applies coloured optical filters to detect the different colours of glass (APC Environmental Management, 2006). Fragments less than 60 mm in size are often too small to be mechanically sorted and are mixed together to produce *glass fines* as a secondary product for use in aggregate and abrasives. Contamination is removed before the glass is sent to a beneficiation plant.

The colour-sorted glass is transferred to a beneficiation plant where contaminants are removed. Here, the raw material is loaded into a vibratory feed hopper and the material is broken down and fed into shearer units which crush the glass (APC Environmental Management, 2006). This crushed glass is referred to as *cullet*.

The cullet is sorted by size, and undergoes a visual inspection to remove obvious contamination.

5.3.3 Quantity of materials recycled

In 2008–09 the total quantity of glass waste generated in Australia was 1,438,200 tonnes, of which 993,900 tonnes or 69% was reprocessed into recycled materials (Hyder Consulting Pty Ltd, 2011b, p. 41).

South Australia is currently the only state/territory in Australia to have a container deposit scheme, with the Northern Territory implementing one in 2012 (EPA SA, 2010). Container deposit schemes provide financial incentives for consumers to recycle drink containers by returning them to collection centres. The value of container deposits in South Australia increased from five to ten

cents in 2008, which has been cited as resulting in increased glass collection in the 2008–09 financial year (Hyder Consulting Pty Ltd, 2010).

5.3.4 Outputs and products

The two main outputs of glass reprocessing are glass fines and cullet. Glass fines are a lower grade product which is used in aggregate for road base, backfill, general construction fill and utility trenches (APC Environmental Management, 2006, p. 65). In addition, much work has been conducted regarding the incorporation of glass fines into asphalt.

Cullet is a higher grade product which is mixed in manufacturing furnaces with virgin glass-making material, such as sand, limestone and soda ash to produce new glass (Shire of Augusta Margeret River, 2010). While the primary application of cullet is for glass bottle production, it can also be used in place of glass fines in aggregate mixes.

5.3.5 End markets

The majority of the glass that is reprocessed and recycled is food and beverage containers. Glass collected for recycling is generally classified as either crushed glass which has been sorted by colour, known as cullet, or glass fines which are fragments that are often too small to be mechanically sorted and are mixed together.

Other types of glass such as cookware, light globes and window glass can be reprocessed however these streams represent a small percentage of the quantity that is recycled. Given this and the limited amount of information available on the markets for these types of recycled glass, the assessment of end markets is limited to cullet and fines.

An analysis of the end markets for cullet and fines is presented below. The information is predominantly drawn from the used glass sourcing study for Queensland EPA (APC Environmental Management, 2006), the Review of Waste Strategy and Policy in New South Wales (Steering Committee for the Review of the NSW Waste Strategy and Policy, 2010) and (EcoRecycle Victoria, 2005).

5.3.5.1 Cullet

Applications	Food and beverage containers
Competing products	Virgin materials (sand)
Clients and contractual bases	Clients are local manufacturers of container glass such as Owens Illinois and Amcor. Manufacturers want to ensure their continued access to high quality feedstock so it is likely that medium to long term contracts are in place, with price per tonne possibly fluctuating based on an external market price.
Market assessment	The vast majority of beneficiated glass is supplied to local (Australian) markets (Sustainability Victoria, 2010), (Hyder Consulting Pty Ltd, 2010), (Hyder Consulting Pty Ltd, n.d). The recycled glass market is typically very strong, but also subject to price. When prices are low, it is common for stockpiling to take place (Hyder Consulting Pty Ltd, 2010, p. 42). Markets are largely limited to Owens Illinois and Amcor, the two manufacturers of container glass located in Australia. Markets are concentrated in NSW, SA and Vic. With consumers of glass packaging accepting a larger proportion of recycled glass in packaging materials, the strength of the reprocessed glass market is growing. For example, wineries will now typically accept 25% recycled glass in wine bottles (Hyder Consulting Pty Ltd, n.d, p. 44).
Degree of competition	Visy is the dominant supplier of beneficiated glass and could be viewed as a natural monopoly. High barriers to entry include access to feedstock and technology (e.g. optical sorting equipment).
Market drivers	Two critical factors interact to determine demand: ▪ Cost of recycled materials relative to virgin materials ▪ Availability of virgin materials within same geographic distance to end markets (e.g. sand quarries).

5.3.5.2 Fines

Applications	Sand/abrasive grit blasting, asphalt (glassphalt), construction and road aggregates, concrete aggregate, sports turf/drainage, brickmaking, water filtration, insulation batts and an alternate day cover for landfills (APC Environmental Management, 2006, p. 11).
Competing products	Virgin materials (sand and aggregates)
Clients and contractual bases	Clients include construction companies, landscaping companies, local government, water authorities, blasting and painting facilities, manufacturers of insulation and abrasives. Some of these markets are still emerging therefore supply contracts tend to be one-off or shorter term. Where use of fines is more established, such as in the manufacture of insulation and manufacturers want to ensure continued access to raw materials, medium term contracts are likely to be in place.
Market assessment	The vast majority of beneficiated glass is supplied to local (Australian) markets. A significant amount of international and national research into alternate market applications for used glass and glass fines has been conducted (APC Environmental Management, 2006, p. 11). Given the emerging nature of some end markets, demand is not considered to be strong or certain. Due to the nature of the applications, markets can be located across Australia.
Degree of competition	There are a large number of companies beneficiating glass fines. Barriers to entry are low because there is ample feedstock and equipment is not necessarily capital intensive.
Market drivers	Two critical factors interact to determine demand: ▪ Cost of recycled materials relative to virgin materials. ▪ Availability of virgin materials within same geographic distance to end markets (e.g. sand quarries) Existence of specifications that allow for the use of recycled materials in construction.

5.4 Paper and cardboard

There are a wide range of products which can be prepared using post-consumer paper and cardboard, from recycled printing and writing paper, to lower-grade or mixed paper inputs for packaging, cat litter, insulation and wallboard.

An overview of the flow of paper and cardboard from waste generation to product manufacture using recycled paper and cardboard is provided in Figure 11 and further discussed below.

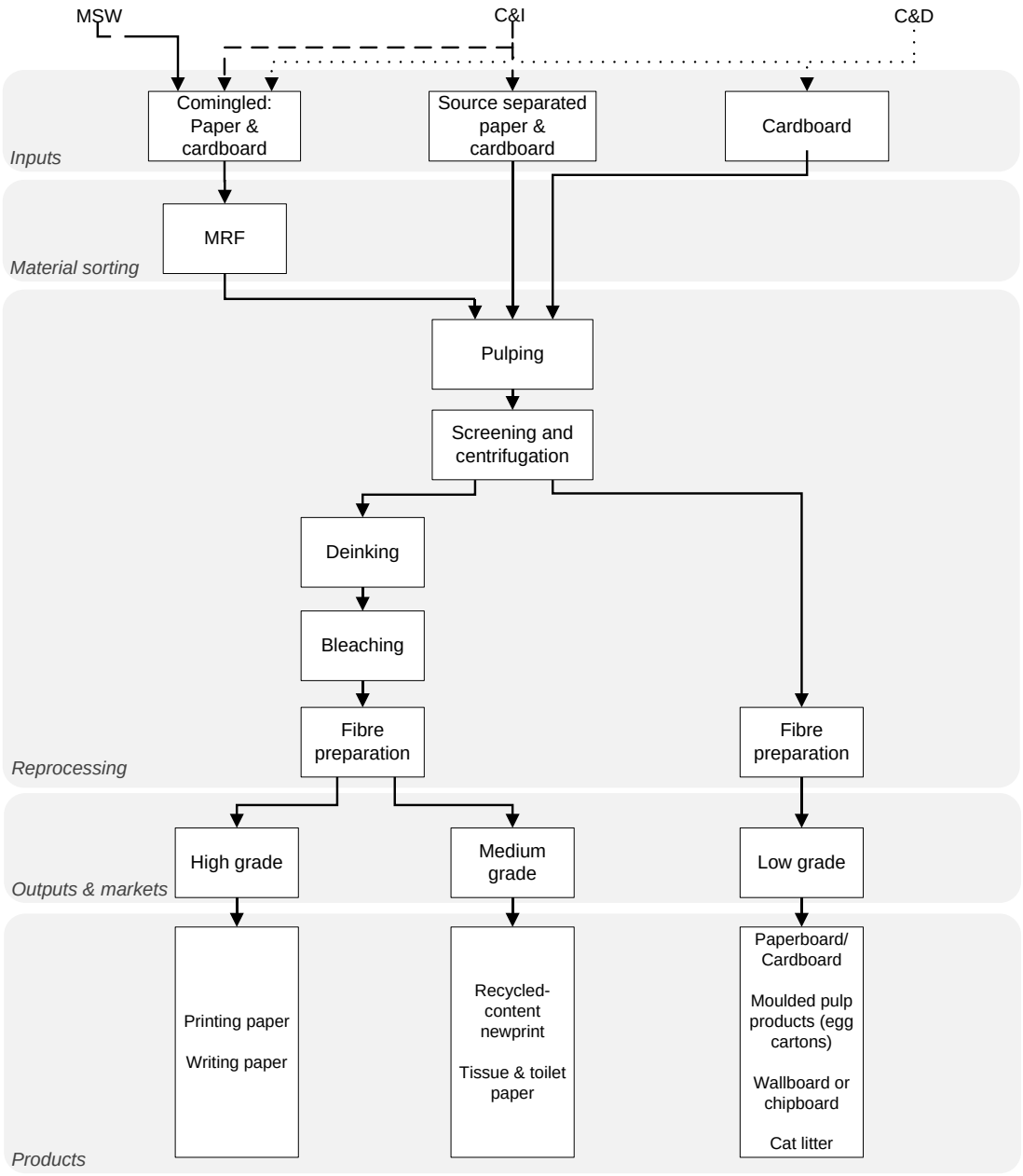


Figure 11 Flow of paper and cardboard through the recycling chain

5.4.1 Inputs

The four general categories of paper and cardboard accepted for recycling in Australia are packaging (typically cardboard, waxed cardboard, liquid paperboard and packaging paper), newsprint and magazines, printing and writing paper, and telephone books. The proportion paper recycled by each category has been estimated and presented in Figure 12.

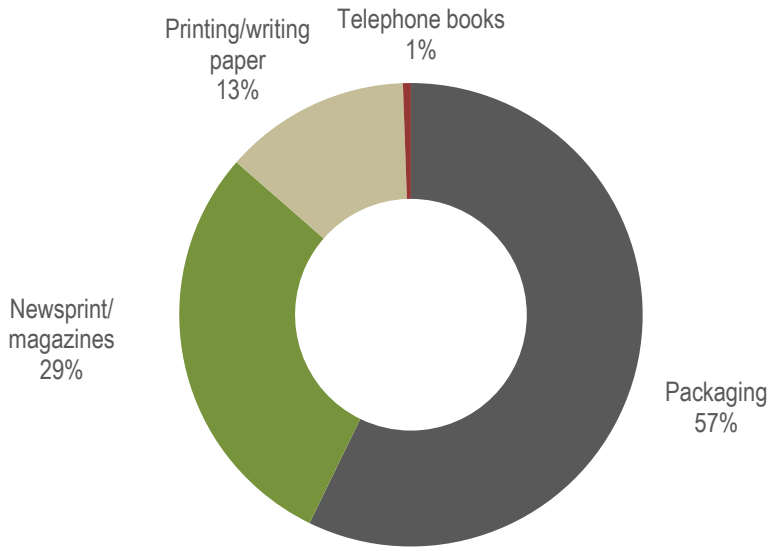


Figure 12 Main types of paper collected for reprocessing[3] (Hyder Consulting Pty Ltd, 2011b), (Department of Environment, Climate Change and Water (NSW), 2009).

Typically, C&I paper and cardboard streams outweigh the amount retrieved through MSW. C&D activities contribute little to overall recycling figures.

5.4.2 Reprocessing

The majority of paper and cardboard reprocessing takes place along the east coast of Australia in NSW, Queensland and Victoria. Paper collected from Tasmania, SA and WA is sent to these states or exported overseas (Hyder Consulting Pty Ltd, n.d), (Hyder Consulting Pty Ltd, 2010).

Recycled paper products are generally produced via re-pulping of post-consumer paper and cardboard; the pulp of the collected materials can then undergo traditional virgin paper processes (Queensland Government Chief Procurement Office).

Pulp is created by shredding paper and cardboard and mixing it with water and chemicals to create slurry. Contaminants such as staples or glue are removed through centrifugation and/or screening processes (Department of the Environment, 1996). The pulp may be deinked and bleached to create whiter-coloured products, and then beaten to make the fibres swell to a state suitable for papermaking. From this point, the process mimics the virgin papermaking process.

Paper and cardboard can only be recycled a finite number of times as the recycling process degrades the fibres. For this reason, virgin fibres cannot be completely avoided.

[3] This data has been estimated from breakdowns in (Hyder Consulting Pty Ltd, 2011b) and (Department of Environment, Climate Change and Water (NSW), 2009). Data manipulation includes combining cardboard & waxed cardboard and liquid paperboard categories with packaging figures, and averaging the printing & writing paper and telephone books ratio to estimate NSW figures.

5.4.3 Quantity of materials recycled

In 2008–09 the total quantity of paper and cardboard waste generated in Australia was 6,173,300 tonnes, of which 3,813,000 tonnes was reprocessed into recycled materials (Hyder Consulting Pty Ltd, 2011b, p. 41). This represents a 62% recycling rate.

Recycling of paper and cardboard has fewer end uses for the material (it is used almost exclusively in rolls and sheets for packaging and in written/printed materials). There is more uniformity in paper products than in materials such as plastics, which may vary in appearance, composition and recyclability even within the same plastic classification.

5.4.4 Outputs and products

There is great diversity across the range of products utilising recycled pulp from post-consumer paper and cardboard (Productivity Commission, 1990).

High quality inputs, typically printing and writing paper with little contamination are used to recreate printing and writing products including paper and envelopes.

Middle grade inputs, including magazines and newsprint, may be recycled into newsprint, tissue or toilet paper amongst other products.

Lower grade inputs, which may include packaging board, telephone books and mixed paper from unsorted municipal and C&I collection, tend to be converted into products which do not require the high quality of smoothness and texture as higher grade products. These include sheet products such as cardboard and paperboard, as well as moulded pulp products such as egg cartons, building wallboards, chipboard and cat litter.

5.4.5 End markets

The markets for waste paper and cardboard can be divided into high, medium and low grade inputs. In the case of paper and cardboard, it is aggregated waste paper and cardboard that is generally traded, rather than the reprocessed product, as reprocessing is often highly integrated with the manufacturing process. Therefore the markets analysed are those for waste paper and cardboard.

An analysis of the end markets for high, medium and low grade inputs is presented below.

5.4.6 *High grade inputs*

Products	Printing paper; writing paper
Competing products	Virgin pulp
Client and contractual bases	Major local clients of bulk quantities of waste paper are manufacturers Visy and Amcor. There are generally contracts in place for many sellers of waste paper. Large manufacturers want to have security of supply and certainty about price. Contracts might be for 5 or 7 years.
Market assessment	The bulk of waste paper and cardboard is sold to paper mills. Export markets are substantial for collected material (37% by quantity for Victoria, 90% for WA and 50% from SA). (Hyder Consulting Pty Ltd, n.d), (Hyder Consulting Pty Ltd, 2010), (Sustainability Victoria, 2010). The majority of paper and cardboard reprocessing in Australia occurs along the east coast, with SA and WA having no significant local markets for waste paper (Hyder Consulting Pty Ltd, 2010). North and South-East Asia are areas which are fibre-deficient, fuelling demand in these regions for wood, pulp and recovered fibre (Pulp & Paper Industry Strategy Group, 2010). Demand and price are linked to international commodity markets. During 2008–09 the export market for recovered paper (packaging, writing paper and newsprint) reduced in volume and value. This occurred as a result of global economic challenges, resulting in less demand and consequently a falling supply of goods, particularly packaging (Department of Environment, Climate Change and Water (NSW), 2009). The demand for higher grade input materials is generally always strong (Hyder Consulting Pty Ltd, 2008).
Degree of competition	Large-scale collection of waste paper has high barriers to entry in terms of vehicles and a wide geographic collection network. There are a large number of small companies collecting small quantities often from single generation sources. They compete on price, quality of product, service and reliability (being able to guarantee supply). There are low barriers to entry.
Market drivers	Demand and price are linked to international commodity markets (Department of Environment, Climate Change and Water (NSW), 2009). Greater consumer awareness and demand for recycled products. Collection, contaminant screening and deinking of high grade printing and writing paper is costly, making its virgin alternative cost competitive (Hyder Consulting Pty Ltd, 2010).

5.4.7 *Medium grade inputs*

Products	Newsprint; tissue and toilet paper; packaging
Competing products	Virgin pulp
Client and contractual bases	Major local clients of bulk quantities of waste paper are manufacturers Visy and Amcor. There are generally contracts in place for many sellers of waste paper. Large manufacturers want to have security of supply and certainty about price. Contracts might be for 5 or 7 years. The major client for newsprint in Australia is Norske Skog who manufactures newsprint. There are generally long term contracts in place for the supply of old newsprint.
Market assessment	The bulk of waste paper and cardboard is sold to paper mills. Export markets are substantial for collected material (37% by quantity for Victoria, 90% for WA and 50% from SA) (Hyder Consulting Pty Ltd, n.d), (Hyder Consulting Pty Ltd, 2010), (Sustainability Victoria, 2010). The majority of paper and cardboard reprocessing in Australia occurs along the east coast, with SA and WA having no significant local markets for waste paper (Hyder Consulting Pty Ltd, 2010). North and South-East Asia are areas which are fibre-deficient, fuelling demand in these regions for wood, pulp and recovered fibre (Pulp & Paper Industry Strategy Group, 2010). Demand and price are linked to international commodity markets. During 2008–09 the export market for recovered paper (packaging, writing paper and newsprint) reduced in volume and value. This occurred as a result of global economic challenges, resulting in less demand and consequently falling supply of goods, particularly packaging (Department of Environment, Climate Change and Water (NSW), 2009). The demand for higher grade input materials is generally always strong (Hyder Consulting Pty Ltd, 2008).
Degree of competition	Large-scale collection of waste paper has high barriers to entry in terms of vehicles and a wide geographic collection network. There are a large number of small companies collecting small quantities often from single generation sources. They compete on price, quality of product, service and reliability (being able to guarantee supply). There are low barriers to entry.
Market drivers	Demand and price are linked to international commodity markets (Department of Environment, Climate Change and Water (NSW), 2009).

5.4.8 Low grade inputs

Products	Cardboard; paperboard; moulded pulp products (e.g. egg cartons); wallboard or chipboard; cat litter; packaging
Competing products	Virgin pulp
Client and contractual bases	Major local clients of bulk quantities of waste paper are manufacturers Visy and Amcor. There are generally contracts in place for many sellers of waste paper. Large manufacturers want to have security of supply and certainty about price. Contracts might be for 5 or 7 years. There are a large number of smaller companies utilising relatively small quantities of waste paper and cardboard.
Market assessment	The bulk of waste paper and cardboard is sold to paper mills. Export markets are substantial for collected material (37% by quantity for Victoria, 90% for WA and 50% from SA), (Hyder Consulting Pty Ltd, n.d), (Hyder Consulting Pty Ltd, 2010), (Sustainability Victoria, 2010). The majority of paper and cardboard reprocessing in Australia occurs along the east coast, with SA and WA having no significant local markets for waste paper (Hyder Consulting Pty Ltd, 2010). North and South-East Asia are areas which are fibre-deficient, fuelling demand in these regions for wood, pulp and recovered fibre (Pulp & Paper Industry Strategy Group, 2010). Demand and price are linked to international commodity markets. During 2008–09 the export market for recovered paper (packaging, writing paper and newsprint) reduced in volume and value. This occurred as a result of global economic challenges, resulting in less demand and consequently a falling supply of goods, particularly packaging (Department of Environment, Climate Change and Water (NSW), 2009). The demand for higher grade input materials is generally always strong (Hyder Consulting Pty Ltd, 2008).
Degree of competition	Large-scale collection of waste paper has high barriers to entry in terms of vehicles and a wide geographic collection network. There are a large number of small companies collecting small quantities often from single generation sources. They compete on price, quality of product, service and reliability (being able to guarantee supply). There are low barriers to entry.
Market drivers	Demand and price are linked to international commodity markets (Department of Environment, Climate Change and Water (NSW), 2009).

5.5 Organics

When disposed to landfill, organic waste decomposes, leading to the production of methane (CH_4) gas, which has a higher global warming potential (i.e. contribution to the greenhouse effect) compared with carbon dioxide (CO_2). Organics recycling not only offers the benefit of avoiding these emissions, but also provides valuable outputs for land application due to its nutrient content, ability to hold soil moisture and carbon absorption benefits.

An overview of the flow of organics from waste generation through to manufacture of products using recycled organic material is provided in Figure 13 and further discussed below.

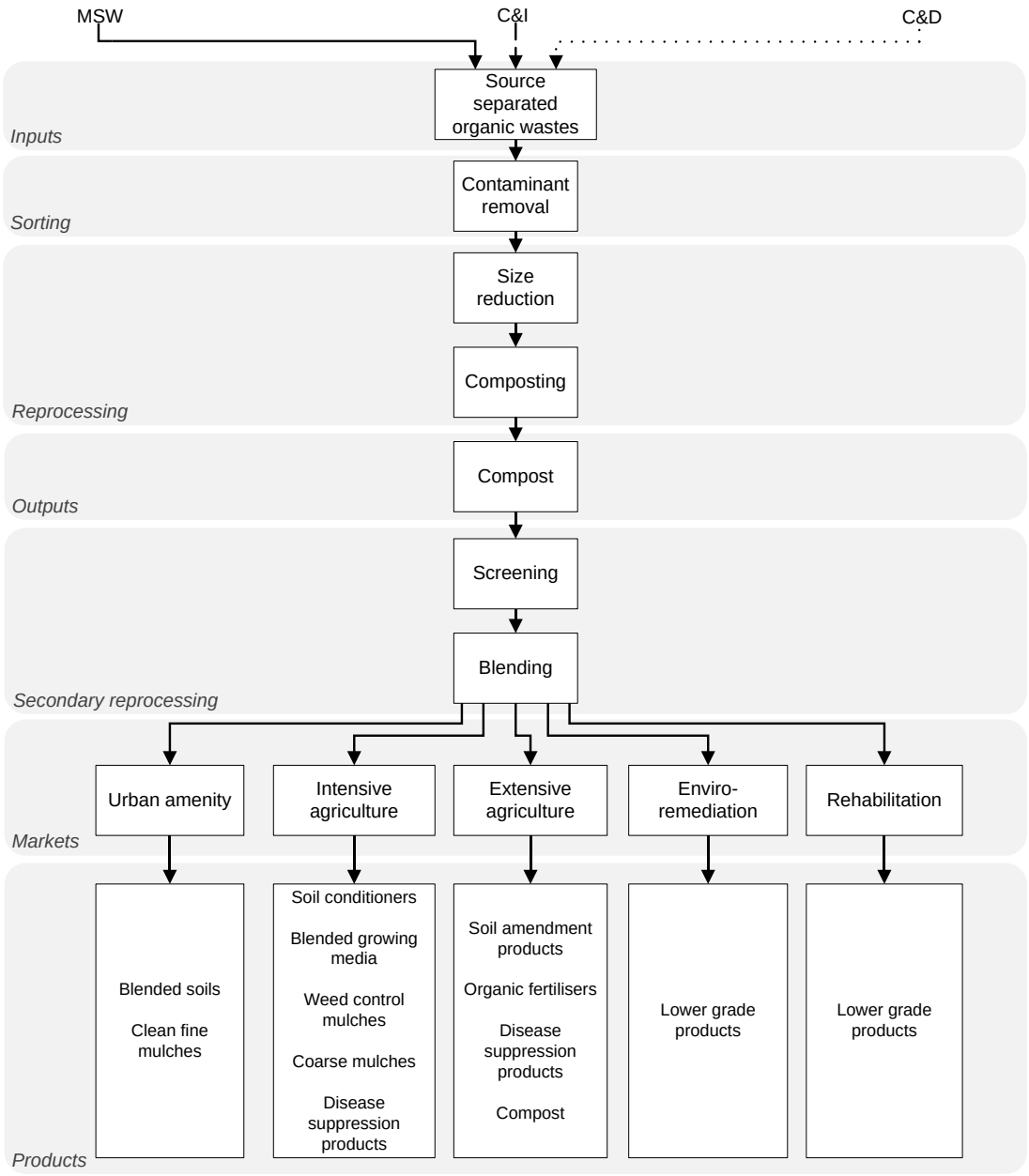


Figure 13 Flow of organics through the recycling chain

5.5.1 Inputs

Organics encompass a wide range of diverse waste types including food waste, green waste, residuals from forestry processes and biosolids from sewage treatment (Recycled Organics Unit, 2009). Sources for organic wastes range across the three primary waste streams: MSW, C&I and C&D. A profile of the input organic wastes reprocessed in 2008–09 is provided in Figure 14.

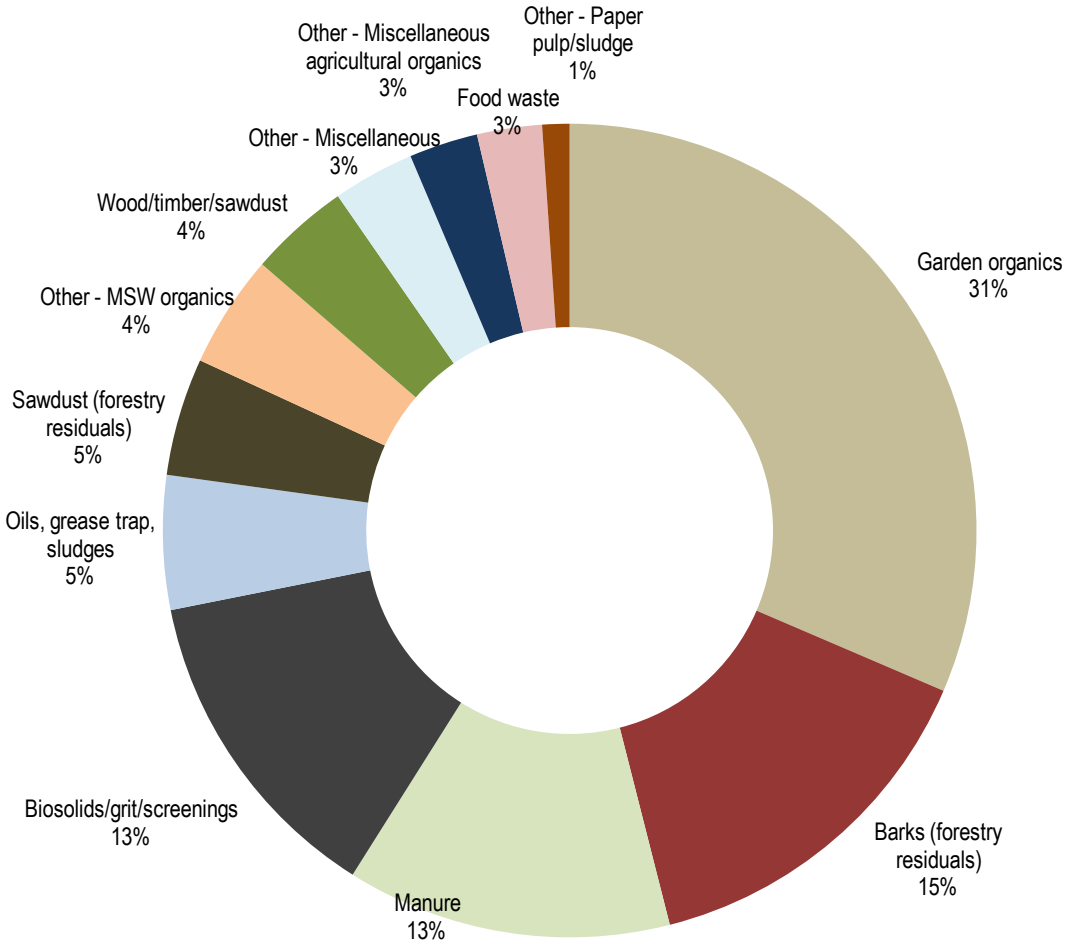


Figure 14 Contribution of each organics source in 2008–09 (Recycled Organics Unit, 2009)[4].

The most significant sources of organic wastes received for processing in the 2008–09 financial year were garden organics, bark from forestry residuals, manure and biosolids (Recycled Organics Unit, 2009).

5.5.2 Reprocessing

For organics reprocessing, the organic material is typically source separated. Kerbside collection of green waste from residential areas is relatively common across major cities in Australia (GHD Pty Ltd, 2009). Municipal food waste kerbside collection has been trialled by a number of councils including food waste only and combined with green organic waste.

[4] All organics source streams contributing less than 1% to the overall quantity of raw organic material processed as provided by the source have been aggregated into the 'Other – Miscellaneous' category.

C&I organics from industry-specific, source-separated organics streams, such as forestry residuals, commercial food waste, biosolids and manure, provide high quality feedstock for reprocessing with low contamination.

The process involves four primary stages beyond collection: sorting and shredding, composting, screening and blending. Further product enhancement processes can be used to meet market specifications or demand (Recycled Organics Unit, The University of New South Wales, 2006).

Sorting is the first step in the recycling process following collection, and is used to remove contaminants from the input material which can reduce the value of the final product as well as damage machinery and equipment.

Shredding, chipping and grinding are size reduction techniques used to reduce organic waste inputs into an acceptable size to increase the rate of decomposition. Following this, the material is typically mixed with high-nitrogen and high-moisture materials, such as food and grass clippings, to provide a balanced nutrient mix for the aerobic bacteria for composting (Recycled Organics Unit, The University of New South Wales, 2006).

While composting may be achieved via several different arrangements, the aims of all composting systems are to manage an aerobic process through temperature, oxygen and moisture controls.

Aerobic windrow composting, or hot composting, is the dominant method for reprocessing of organic material across Australia, particularly for garden organics (Recycled Organics Unit, The University of New South Wales, 2006). Windrows are long piles of organic materials, periodically watered and turned to mix materials and provide bacteria with oxygen. Aeration of the material is critical in minimising odours. This method is simple, non-intensive, has a relatively low capital cost, and is commonly used around the world; however, it may be constrained by land availability.

Alternative composting methods include aerated static piling, aerated turned trough and in-vessel composting, where the compost material is aerated via mechanical fans. A benefit of these methods is that odorous air drawn through the pile can be captured and treated, however power consumption is typically higher (Waste Management Association of Australia: National Technical Committee for Organics Recycling, 2004).

Following composting of the organic materials via any of the methods discussed above, screening occurs to different extents depending on the product end use. For example, soil conditioners typically are screened to less than 10mm, while coarse mulches screened to greater than 15mm (Department of Environment, Climate Change and Water (NSW), 2008). Compost is then blended as per the requirements of the final product.

5.5.3 Quantity of materials recycled

In 2008–09 the total quantity of organic waste generated in Australia was 11,616,700 tonnes, of which 3,752,700 tonnes was reprocessed into recycled materials (Hyder Consulting Pty Ltd, 2011b, p. 41). This represents a recycling rate of 32%, relatively low compared to many other materials

addressed in this study. The recovery of organic waste is subject to greater limitations than many materials for a number of reasons, including:

- Municipal services do not collect organics via kerbside services to the same extent as comingled recyclables
- If putrescible organic materials at commercial properties are to be reprocessed off-site, they may not be able to be stored for long periods of time at the point of generation (due to degradation and health risks)
- C&I sites such as office buildings often do not have capacity to collect compostable material, and so disposal occurs via more regularly-serviced landfill bins.

Mixed C&I waste-to-landfill typically contains a large proportion of organic materials that could otherwise be recycled. During a two month field survey in 2007 at six landfills and transfer stations in Sydney, it was found that 60% of the mixed C&I waste stream was organic, the majority of which was food waste (Department of Environment, Climate Change and Water, 2010a).

5.5.4 Outputs and products

Compost is the primary output of reprocessing, and can be further blended and screened to produce recycled organic products tailored to different applications. Typical products include potting mixes, mulches, soil conditioners and composted manure for land application (Nolan-ITU Pty Ltd, 1999).

Recycled organic products can provide alternatives to traditional chemical fertilisers, assisting in the improvement of soil structure and microbial activity for long-term soil health benefits (Grains Research and Development Corporation, 2010). While benefits are site- and purpose-specific, potential benefits of recycled organic products for land application include:

- improved soil structure and, as a result, increased yields in crop production
- increased water retention
- improved microbial biomass and activity
- increased crop production.

5.5.5 End markets

The predominant end markets for recycled organics products are:

- urban amenity
- intensive agriculture
- extensive agriculture
- enviro-remediation
- rehabilitation.

In addition to these end markets for recycled organic products, it must be acknowledged that a significant and growing outlet for resource recovery of organic waste is bioenergy – using solid fuels including organics to generate electricity and heat. Bioenergy has not been included in the scope of this study, because it is considered a recovery process rather than part of the recycling sector. However, bioenergy represents one of the most sizeable opportunities to divert vast quantities of organic wastes from landfill, which could significantly increase Australia's overall rate of waste diversion from landfill.

An analysis of the key end markets for recycled organic products is presented below. The information is drawn from a range of sources including the Organics Recycling in Australia Industry Statistics, Compost Australia publications and the annual recycling surveys undertaken by the Victorian, South Australian and Western Australian governments. Input was also obtained through consultation with industry stakeholders.

5.5.5.1 Urban amenity

Description (Compost Australia, n.d.)	Includes the beautification of environments such as parks, gardens, playing fields and roadsides, and sport, leisure and recreation areas such as golf, bowling and racing clubs.
Primary products (Blue Environment, 2009)	Blended soils; clean fine mulches
Clients (Research Solutions Pty Ltd, 2007, p. 1) **and contractual bases**	Landscaping; local government; nurseries (retail); major development projects; State/territory governments; sport, recreation and leisure. Contracts can be project-specific producing peaks and troughs. However market is mature and demand is well understood.
Market assessment	Domestic markets only. Largest existing organic market segment and in some areas, particularly NSW and SA, it is fully developed or oversupplied (Compost Australia, n.d., p. 8). In WA there appears to be significant market potential - one third of the organisations surveyed in the urban amenity market did not use recycled organic products due to cost, both to buy and transport compared to chemical fertilisers, access to appropriate products and concerns about contamination and quality (Research Solutions Pty Ltd, 2007, p. 1). Low quality and/or contaminated products, reduced confidence in the market (Recycled Organics Unit, 2009).
Degree of competition	Healthy degree of competition due to size and maturity of market. Medium barriers to entry due to limited good quality feedstock required for these products.

Market drivers	Increasing water prices or water use restrictions Level of construction activity and landscaping of large developments (GHD Pty Ltd, 2004). Price relative to competing products such as chemical fertilisers and raw animal manures, materials which are readily available and relatively cheap (Research Solutions Pty Ltd, 2007).

5.5.5.2 Intensive agriculture

Description (Compost Australia, n.d.)	Activities include nurseries – production, nurseries – wholesale, fruit and orchid growing, market gardening, mushroom farming, turf grass growing and viticulture.
Primary products (Blue Environment, 2009)	Soil conditioners; blended growing media; weed control mulches; coarse mulches; disease suppression products
Clients (Research Solutions Pty Ltd, 2007, p. 1) **and contractual bases**	Nurseries (production and wholesale); fruit and orchids; market gardening; cut flower; mushroom farming; turf grass growing; viticulture. Markets and supply arrangements are often structured and medium-long term.
Market assessment	Domestic markets only. Potential entry into viticulture, fruit and orchid and olive growing (high-value crops, require long-term soil health). Quantities of product sold remain relatively insignificant (Recycled Organics Unit, 2009). These markets are considered emerging, with significant potential for growth (Research Solutions Pty Ltd, 2007, pp. 1–2). In NSW, the intensive agriculture market is strong, but future growth is considered to be limited due to changing climate and gardening practices (GHD Pty Ltd, 2004, p. 5). Low quality and/or contaminated products have reduced confidence in the market (Recycled Organics Unit, 2009).
Degree of competition	There are a number of established market participants who compete largely on product quality. Strong demand reduces the need for companies to compete for markets. There are high barriers to entry due to limited high quality feedstock.
Market drivers	Desire to avoid soil degradation associated with the use of chemical fertilisers. Price relative to competing products such as chemical fertilisers and raw animal manures, materials which are readily available and relatively cheap (Research Solutions Pty Ltd, 2007).

5.5.5.3 Extensive agriculture

Description (Compost Australia, n.d.)	Activities include forestry, farming of sheep, cattle and other livestock and broad acre farming of grain, oilseed and other crops.
Primary products (Blue Environment, 2009)	Soil amendment products; organic fertiliser products; disease suppression; composts
Clients (Research Solutions Pty Ltd, 2007, p. 1) **and contractual bases**	Pasture; broad acre; forestry. Long term supply contracts are unlikely due to emerging nature of market.
Market assessment	Domestic markets only. Very small in WA. Quantities of product sold remain relatively insignificant (Recycled Organics Unit, 2009). These markets are considered emerging, with significant potential for growth (Research Solutions Pty Ltd, 2007, pp. 1–2). Low quality and/or contaminated products have reduced confidence in the market (Recycled Organics Unit, 2009). Issues preventing growth of market include the cost of purchasing and transporting recycled organic materials, concerns about product quality, not the appropriate machinery to spread products and long-term relationships with stock agents which support the use of chemical fertiliser use. (Research Solutions Pty Ltd, 2007, pp. 1-2). Non-commercial (local government resource recovery centres) organics processing operations are reported to be distorting markets by shredding and distributing a low quality raw mulch product (Recycled Organics Unit, 2009).
Degree of competition	High barriers to entry due to market commitment to existing practices, technologies and suppliers.
Market drivers	Increasing awareness of current unsustainable farming practices (Research Solutions Pty Ltd, 2007). Price relative to competing products such as chemical fertilisers and raw animal manures, materials which are readily available and relatively cheap (Research Solutions Pty Ltd, 2007).

5.5.5.4 Enviro-remediation

Description (Compost Australia, n.d.)	Includes contaminated sites and soils, water purification and biofiltration where recycled organic products act as a medium for hosting microorganisms that bioremediate soils, water and air.

Primary products (Blue Environment, 2009)	Lower grade and lower value materials that are often excess products
Clients (Research Solutions Pty Ltd, 2007, p. 1) **and contractual bases**	Contaminated sites. Long term supply contracts are unlikely due to emerging nature of market.
Market assessment	Domestic markets only. Very small in WA. Low quality and/or contaminated products have reduced confidence in the market (Recycled Organics Unit, 2009). Limited understanding of bio-remediation and preference for mechanical means to remediate sites and the use of onsite recycled organic material (Research Solutions Pty Ltd, 2007, p. 2). Often uses excess products rather than being a viable market itself; an outlet for lower grade and lower value materials (Blue Environment, 2009, p. 43).
Degree of competition	Due to excess supply of lower grade and lower value materials, there is a high degree of competition for outlets for the use of these materials.
Market drivers	Price relative to competing products such as chemical fertilisers and raw animal manures, materials which are readily available and relatively cheap (Research Solutions Pty Ltd, 2007).

5.5.5.5 Rehabilitation

Description (Compost Australia, n.d.)	Activities include revegetation projects, landfill cover, erosion control, acid soil amelioration and mine reclamation.
Primary products (Blue Environment, 2009)	Lower grade and lower value materials that are often excess products
Clients (Research Solutions Pty Ltd, 2007, p. 1) **and contractual bases**	Landfills; catchment management authorities; mines; parks authorities, local governments, voluntary groups e.g. Landcare. Long term supply contracts are unlikely due to emerging nature of market.

Market assessment	Domestic markets only. Very small in WA. Demand likely to be sporadic. NSW: potential for growth in catchment rehabilitation works. Large potential application however there is little evidence of large scale activity in this area as onsite recycled organic material is often used (GHD Pty Ltd, 2004, p. 24). Often uses excess products rather than being a viable market itself; an outlet for lower grade and lower value materials (Blue Environment, 2009, p. 43).
Degree of competition	Due to excess supply of lower grade and lower value materials, there is a high degree of competition for outlets for the use of these materials.
Market drivers	Price relative to competing products such as chemical fertilisers and raw animal manures, materials which are readily available and relatively cheap (Research Solutions Pty Ltd, 2007).

5.6 Masonry materials

Masonry materials are generated by building, construction and demolition activity. The largest proportion of masonry materials are generated by the construction and demolition (C&D) industry, with the residential and commercial sectors generating only small amounts.

An overview of the flow of masonry materials from generation through to the manufacture of products using recycled masonry materials is provided in Figure 15 and further discussed below.

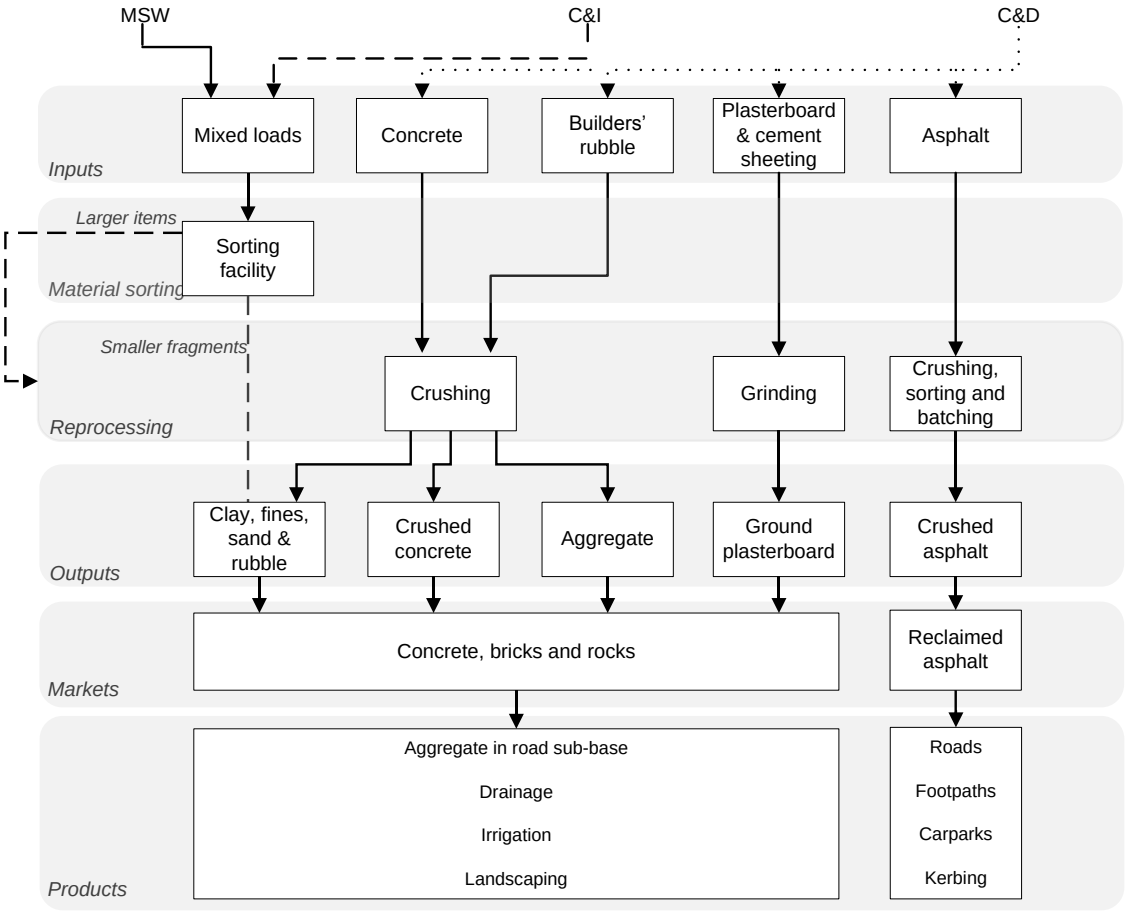


Figure 15 Flow of masonry materials through the recycling chain

5.6.1 Inputs

Masonry materials include asphalt, bricks, concrete, clay, fines, sand and rubble and plasterboard and cement sheeting (excluding asbestos) (Nolan-ITU Pty Ltd, 1999, p. 12). The breakdown of masonry materials recycled in Australia is presented in Figure 16.

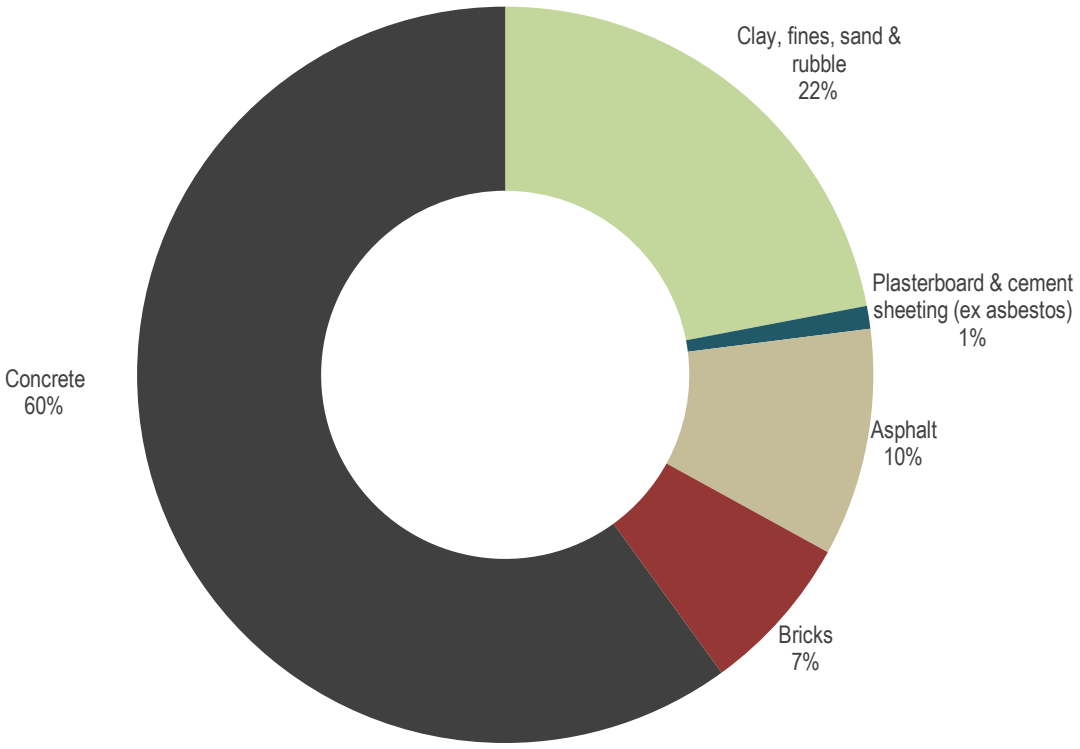


Figure 16 Breakdown of masonry materials recycled (Hyder Consulting Pty Ltd, 2011b).[5]

5.6.2 Sorting and reprocessing

There is a strong preference within the reprocessing market for materials to be source separated. This enables much simpler, cheaper and more effective processing (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 35). This is reflected in pricing mechanisms such as gate fees, which are lower for source separated loads. The C&D sector is more likely to produce source-separated streams because of the quantities being generated (gate fees being a larger proportion of expenses) and availability of space on site to sort materials.

Where loads are mixed, the most common approach is for operators to segregate materials using a high degree of manual labour, coupled with mechanical equipment such as excavators and front end loaders (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 35).There are limited examples of fixed equipment and automated sorting systems being employed to separate mixed C&D waste by material stream (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 35).

[5] Compositional breakdown is based on data that is available for Victoria, South Australia and Western Australia. Compositional data is not available for the other states.

Reprocessing techniques for masonry materials are generally relatively uncomplicated. Concrete, bricks and asphalt are crushed, either as mixed loads or in source separated streams. Once crushed, asphalt is generally taken to an asphalt plant for sorting and batching, to test the physical properties of the mix (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 33). Plasterboard is most frequently ground down (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 45).

5.6.3 Quantity of materials recycled

In 2008–09 the total quantity of masonry waste generated in Australia was 16,148,800 tonnes, of which 10,030,400 tonnes was reprocessed into recycled materials (Hyder Consulting Pty Ltd, 2011b, p. 41). This represents a recycling rate of 62%. The two critical factors driving recovery are the price of landfill disposal and the demand for and price of recovered materials.

Recovery levels are much higher for source separated streams than mixed loads which require sorting and may be contaminated by other materials such as asbestos, plasterboard and soil. Mixed materials currently represent the majority of C&D waste that is disposed to landfill (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 35).There is a high recovery rate for source separated C&D waste in all jurisdictions, except Tasmania and the NT due to landfill costs being cheaper than the costs involved in recovering materials (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 55).

Heavier and higher value materials are most frequently recovered due to the desire to maximise profits and reduce landfill costs for residual materials. Recovery of soil and sands is very limited, as collecting and transporting such cheap and fine material is more difficult, and any treatment requirements are greater due to the higher surface area of finer particles.

In regional locations, unless there is a local market and the ability to process materials in close proximity to where they are generated, masonry materials are more likely to be landfilled. In general, materials tend to be transported to the closest site, whether this is a landfill or reprocessor due to the expense of material cartage and the relatively low value per tonne of recovered product (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011, p. 39).

5.6.4 Outputs and products

Masonry materials are highly recyclable due to their inert nature and predominantly physical reprocessing requirements, with lesser need for chemical processes compared to other materials.

In 2008–09 concrete was the greatest proportion of masonry material recycled in Australia (refer to Figure 16). Concrete is crushed and then reused as an aggregate with fresh cement. Aggregate products are screened to divide crushed materials into different sizes for different applications. Clay, fines and rubble can be suitable for reuse in aggregate applications including road bases, paths, backfill and drainage applications.

Aggregate products such as these may be reprocessed from single collected material sources, or blended together to produce more consistent products, to meet certain composition requirements. The final application of recycled masonry aggregate may depend on:

- the size of the crushed, screened masonry
- the composition of recycled materials (brick, rock, sand, crushed asphalt) and the resulting physical strength of the blended product.

Bricks may be reused completely intact in housing and construction, or in less structural applications if the collected bricks are excessively damaged, although technically these uses for intact bricks may constitute “reusing” rather than “recycling”.

5.6.5 End markets

The predominant end markets for reprocessed masonry materials can be divided into:

- concrete, bricks and rocks
- reclaimed asphalt

There may be markets for ground plasterboard, soil and sand as substitutes for virgin gypsum, virgin soil and sand respectively, however these markets are small and complex. The nature of mechanised demolition means that plasterboard is generally broken or crushed and is therefore not readily separated from mixed loads. Some plasterboard manufacturers may support the recovery of clean product from the construction sites/companies who purchase their materials. The market size for soil and sand is theoretically very significant, however supply is limited because the costs associated with sampling requirements established by environmental regulators for the use of Virgin Excavated Natural Material (VENM) are considered excessive and raise the price of materials. Demand is also limited because of concerns about product quality and contamination (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011).

The markets for concrete, bricks and rocks and reclaimed asphalt are discussed below. This information is drawn from the *Construction and demolition waste status report* prepared by Hyder Consulting in 2011 and commissioned by DSEWPaC which is considered to be the most comprehensive and up to date review of C&D waste and recycling. It was not possible to speak to an industry participant in the preparation of this report, therefore a discussion of competition has not been provided.

5.6.5.1 Concrete, bricks and rocks

Applications	Aggregate in road sub-base, drainage, irrigation and landscaping
Competing products	Quarry products such as virgin crushed rock.
Clients and contractual bases	Civil engineering and construction sectors, such as water authorities, construction contractors. Supply contracts are generally project-specific resulting in no certainty of demand and many peaks and troughs.
Market assessment	Domestic markets only. Because of weight of product and associated transport costs, markets need to be in close proximity to source of generation. Concrete is highly recyclable and the use of concrete is substantial. The markets for recycled concrete are generally mature and strong, particularly in metropolitan areas. The C&D recovery sector is dominated by private companies where basic economic principles apply, that is, when there is sufficient market demand and the product is the right price, the supply side of the equation will to a large extent look after itself. Geographic experiences include: In Sydney, potential market demand is at least 40% higher than potential supply of locally sourced material. Civil works in the ACT seem to absorb as much reprocessed concrete and brick products as companies can produce. Tasmania has relatively few major civil works developments, which can both generate considerable amounts of C&D waste as well as absorb large quantities of recycled product. There is limited capacity to recycle bricks and concrete in regional areas in WA even in areas with increased construction activity around mine sites.
Market drivers	Two critical factors interact to determine demand: ▪ Cost of recycled materials relative to virgin materials. ▪ Availability of virgin materials within same geographic distance to end markets. Other drivers include: Guidance on and specifications for the use of recycled materials such as the Austroads' *Guide to Pavement Technology Part 4E: Recycled Materials* and jurisdictional specifications. Programs such as the Green Star rating program which recognise the use of recycled material in building star ratings. Amount of construction activity in the economy. Market acceptance of the recycled product. The desire to "do the right thing".

5.6.5.2 Reclaimed asphalt

Applications	Roads, footpaths, car parks, kerbing
Competing products	New asphalt.
Clients and contractual bases	Road authorities, local governments. Supply contracts are generally project-specific resulting in no certainty of demand and many peaks and troughs.
Market assessment	Domestic markets only. Because of weight of product and associated transport costs, markets need to be in close proximity to source of generation. Asphalt is potentially 100% recyclable and the use of asphalt is substantial, however this level of recycling and use of recycled content in pavements has not been fully realised in Australia due to product specifications or consumer bias. The C&D recovery sector is dominated by private companies where basic economic principles apply, that is, when there is sufficient market demand and the product is the right price, the supply side of the equation will to a large extent look after itself. Geographic experiences include: There is limited capacity to recycle asphalt in regional areas in WA even in areas with increased construction activity around mine sites. There is no lack of end users in ACT, with 100% of asphalt sold.
Market drivers	Cost of recycled materials relative to virgin materials. Availability of virgin materials within same geographic distance to end markets. Guidance on the use of recycled materials such as the Austroads' *Guide to Pavement Technology Part 4E: Recycled Materials* and jurisdictional specifications. Amount of construction activity in the economy. Market acceptance of the recycled product. The desire to "do the right thing".

6. Economic evaluation

- The data available on economic indicators across the recycling industry is limited. It is difficult to separate out the economic contribution of recycling in the manufacturing sector because of integrated processes including virgin material inputs. Data on waste management services similarly combines both waste to landfill and recycling processes. As a result, estimating sector turnover and capital investment has proven particularly difficult.
- Over 50% of the industry's revenue is attributed to the sale of recovered materials, however this value is dependent on the highly volatile commodity markets.
- The cost structure for landfill disposal influences recycling rates. In many states, government landfill levies have been introduced to address market failure in disposal costs and to minimise disposal of waste to landfill (where it could otherwise be recycled).
- Compared with landfill services, the recycling industry generates more jobs per tonne of waste recycled than per tonne of waste sent to landfill.

6.1 Introduction

This section addresses the key economic indicators typically used to characterise an industrial sector, compare it to other sectors of the economy and give some estimate of its contribution to the overall economy. This section provides:

- a theoretical analysis of the dynamics of recycling, in order to provide a framework for the identification and analysis of issues particular to the sector
- an analysis of available data
- an analysis of the drivers of the recycling sector and its potential for growth, as well as the barriers and difficulties facing the sector, now and in the near future.

The data relating to employment and capital investment relates to the Australian market only and does not include the impact on employment and capital investment in overseas countries that arises from the reprocessing of materials that are generated in Australia and exported to these countries. The data relating to turnover does include the value of materials that are exported from Australia for reprocessing, however the breakdown of the value that is retained in Australia versus overseas is not known.

There are a number of key economic and financial metrics that are critical to understanding the economics of any sector. These metrics have been adopted by organisations such as the Australian Bureau of Statistics (ABS), to provide a comprehensive and standardised structure for assessing the state of a sector. The metrics include:

- turnover
- value-add
- profitability (i.e. income and expenses)
- capital investment
- wages and salaries
- employment.

There is limited robust and suitably disaggregated data relating to these metrics available on the Australian recycling sector. ABS industry research is based on ANZSIC industry codes, however there is no ANZSIC code for the recycling sector. Economic activity in the recycling sector is expected to be primarily captured within the waste management and broader manufacturing sectors (both represented in the ANZSIC system).

Further, the dominance of private companies and tightly held financials are particularly challenging to the assessment of industry profitability and capital investment, hence it has not been possible to address profitability within this study.

Notwithstanding these difficulties, compared with a 2008–09 Australian GDP of about $1,250

billion, the recycling sector is likely to represent no more than 1% of the economy. In terms of employment, the sector potentially provides 0.15% to 0.3% of Australia's jobs (Australian Bureau of Statistics, 2011).

Beyond the metrics, the recycling sector is economically important and unique as it provides resources or inputs to a range of industries in a similar way to the mining industry but without depleting natural resources[6]. This preservation of natural capital for future generations represents economic value that cannot be adequately captured by classic economic indicators. This constitutes a significant distinction between recycling activities and landfill activities. Important drivers for the sector economic dynamism are explored, including:

- the role of the landfill levy, which puts a price on landfill externalities, as well as the impact of other targets and policies
- the fact that landfill and recycling activities are often bought as a 'package' by waste generators and undertaken by the same waste management groups, hence their financial viability is intimately enmeshed
- the impact of the commodity prices on the financial viability of recycling activities
- investment required to meet set recycling targets, where a diverse situation can be observed on a state/territory basis.

6.2 Dynamics of the economy of recycling

The market for recycling services is characterised by a chain of dynamic processes and market forces that influence the passage of waste to recycled product. In particular, the level of economic activity within the recycling sector is influenced by:

- externalities associated with landfill disposal options and government intervention to correct market failure[7]
- impact of commodities markets on recovered material prices
- complex conditions that create differentiated markets for recycled products.

The economic evaluation of the recycling sector needs to recognise issues of boundary setting and the integration of activities across and beyond the sector. These issues are illustrated in Figure 17 using a simplified model of the recycling economy. The interaction of the three inter-related markets (recycling services, landfill waste and recovered products) will determine the development or contraction of the recycling sector.

[6] Energy and water requirements from recycling processes excluded from this analysis by way of simplification

[7] In economic theory, an *externality* is a cost or benefit that is not fully transmitted to the marketplace through a price. This results in a *market failure* whereby the allocation of goods and services in a market is inefficient. The existence of a market failure is often used as a justification for government intervention in the market.

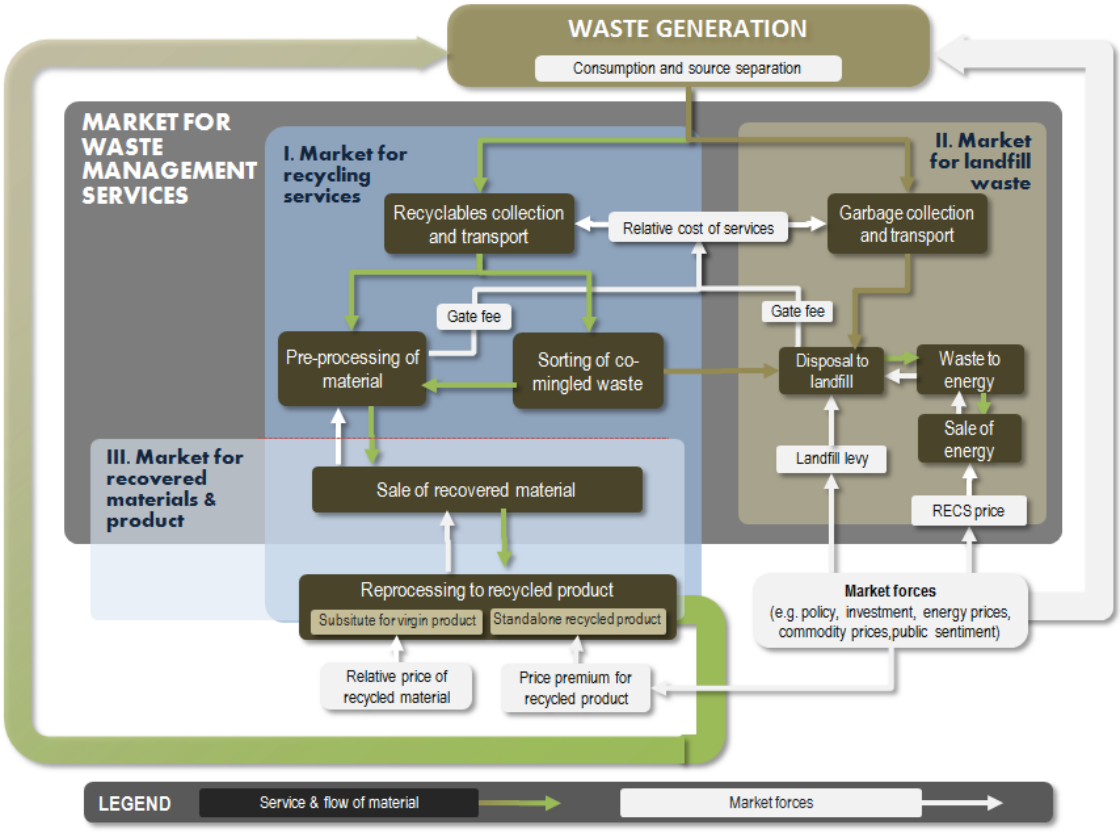


Figure 17 Simplified model of recycling sector economics

In classic economic theory, positions of market equilibrium are reached when economic agents agree to a price for the provision of waste management services. Waste will be recycled if it can be collected, sorted and reprocessed at a cost that is acceptable by the market (i.e. agents who have waste that can be recycled). This simple balance is complicated by the fact that the output of recycling services (i.e. recovered material) is integrated into the manufacturing of a product that will become waste at the end of their lives. Waste management is a service in its own right and the recovered materials can be considered a by-product; however, the by-product can, in certain cases, drive the economic dynamic of the whole system. For the purpose of this study, the following recycling sector dynamics are considered:

I. Market for recycling services

Waste generators (i.e. MSW, C&I and C&D) demand recycling services and face a cost of service. This cost of service reflects not only the supply/demand market position, but the whole chain of activities from waste collection through to recycled product. The market for recycling services is determined by the following elements:

- *Demand for recycling services* which is primarily determined by the relative cost of recycling versus landfill disposal – see discussion on market for landfill waste below.

Secondary drivers are legislated obligations[8] and the non-market value that waste generators may attach to recycling over landfill disposal (i.e. willingness to pay a premium to recycle driven by ethical or environmental considerations).

- *Supply of recycling services* in an open market is determined by the ability of providers to deliver recycling services at a cost that is acceptable to the market, while maintaining a commercial rate of return. A further driver is the demand for the by-product, i.e. for recovered materials or fully recycled products - see discussion on market for recovered products below.
- *Competition and market forces* influence the interaction of supply and demand of recycling services. This may occur as providers utilise differing technologies and processes that deliver the same service with varying levels of efficiency or different services that are perceived as substitutable by clients. Delivering recycling services draws on a range of activities (i.e. collection and transport, sorting, reprocessing) that are subject to specific market forces and may be integrated to various degrees. For example, market dynamics will vary considerably depending on the type of waste (i.e. MSW, C&I and C&D) and the material recovered (i.e. capital investment and reprocessing costs differ by material type).

II. Market for landfill waste: the competing disposal option

Notwithstanding environmental considerations, disposal to landfill is considered a substitute for recycling services. In the case of landfill waste, the cost of providing a garbage service includes collection, transport and a gate fee that incorporates factors such as capital and operational costs, future risks and, in most Australian jurisdictions, a landfill levy. Landfill levies are a policy tool used by government to integrate (all or part of) the externalities associated with landfills into the cost of landfill disposal (thus addressing market failure). This is one market-based tool that allows government to exercise some control over the economic viability of the resource recovery industry (by influencing the economics of a competing industry).

While landfill disposal is a competing option to recycling, the two activities are often undertaken concurrently by the same service provider. This makes it challenging to identify the profitability and drivers of each separate activity, as separate Profit and Loss statements are rarely issued by waste management companies that carry out both activities. According to some sources, recycling activities are much less profitable than landfill activities, but the combination of both is usually required to:

- respond to clients demand for a ‘one stop shop’ waste management solution

[8]The demand is supported by the legal obligation for councils to provide some recycling services for MSW and (sometimes) C&D waste

- eliminate the need for their clients to develop a relationship with a competing waste management company and thereby eliminate the potential for competitors to secure the more lucrative landfill disposal service.

The two markets, landfill waste management and recycling, are therefore intimately linked at multiple levels.

While collection and transport applies to both recycling and landfilling processes, collection of recyclables may require source segregation and more careful handling (e.g. less compacting), which may have a significant impact on the cost differential.

III. Market for recovered products

At the end of the chain, the recycling process produces materials that are on-sold as inputs into manufacturing processes. In some cases (for example organics) the recycling process may directly produce the final product (e.g. compost). The market forces underpinning the demand and price for recovered materials are largely dependent on whether the recovered material is a:

- **Substitute for virgin product:** When the material is easily recovered and valuable (e.g. precious metals) the demand for recovered materials is likely to dominate the economic dynamic of the recycling cycle. This is particularly evident for metallic waste that is typically sold at a "scrap value" that exceeds the cost of collection. Accordingly, the market for recovered material is strongly influenced by the commodity prices for virgin material.
- **Stand-alone recycled product:** At the other end of the spectrum, some products acquire market differentiation because of their recycled content. Consumers are ready to pay a market premium to know that the products they are buying do not draw as heavily on virgin resources. In some cases, public and private initiatives (such as the Australian Packaging Covenant or campaigns by non-government organisations) influence the uptake of recycled products. The market itself is created through a complex set of influences. In effect, consumers make an informed choice based on ethical considerations and understanding of reduced environmental impacts resulting in differentiated demand.

In practice however, the boundaries between these simplified classifications and the various components of the recycling process are blurred. In particular, the reprocessing component can be integrated in the manufacturing process of a new product to the point that it becomes impossible to separate the 'recycled stream' from the 'virgin material stream'. For example, most metals reprocessing will occur at an integrated smelter that accepts both recycled and virgin feed material. Similarly, both integrated and non-integrated mills are used in paper manufacturing. In these instances, part of the value created in reprocessing of recovered material is integrated into the manufacturing process. Data required to separate the added value of reprocessing from the added value of the final product is unlikely to ever be possible to obtain. For integrated industries, this means that the complete value-add from recycling

activities may not be fully apparent.

As an additional element of competition, waste to energy facilities represent both a value-add to waste and a form of raw resource displacement but cannot be considered as recycling. However, they compete for the same 'feed' resources and, should the economics of energy production become more favourable than recycling, this competition may become a serious barrier to recycling.

Market dimensions

Market conditions are also unique to each combination of geography, material type, recycled product type and time period. These dimensions create a complex system of sub-markets that underpins economic activity in the recycling sector. The simplified model described above is however further complicated by practical dimensions including:

- **Waste streams** – composition of waste (and recyclable), source separation and collection practices differ across MSW, C&I and C&D streams.
- **Geography** – recycling infrastructure and policies differ between states/territories and local government areas.
- **Integrated processes**–vertical and horizontal integration, already mentioned but bound to be further complicated by additional service offerings (such as cleaning services).
- **Recovered material** – source separation, contamination and commodity prices differ considerably between different categories of recovered material.
- **Time** – all market forces will vary across time and will naturally force new market equilibrium.

6.3 Turnover

For the purpose of this report, turnover is defined as the revenue from ordinary activities undertaken by companies in the recycling sectors. It comprises essentially the sales of recycling services (removal of waste) and the sales of recovered materials.

Comprehensive and reliable data on recycling sector turnover is limited, which is probably due to:

- a high degree of privately held companies within the industry (i.e. private companies not having public reporting requirements)
- recycling activities being undertaken by divisions of large, vertically integrated companies that do not report disaggregated financial data.

This contributes to the absence of a series of datasets constructed on a regular basis using a consistent methodology and activity boundary.

A collection of available turnover and tonnage data is outlined in Table 4. Direct comparison across estimates of turnover presented in the table is not recommended due to possible differences in data construction (stated assumptions and defined boundaries are not provided by the original authors therefore it is not possible to assess the significance of these differences). Data from the identified studies is mostly derived from survey-based approaches and should be treated with caution due to the potential for an incomplete response rate and incorrect measurement.

Table 4 Publicly available recycling sector turnover data

SOURCE	AUSTRALIAN RECYCLING VALUES	EMPLOYMENT IN WASTE MANAGEMENT & RECYCLING	INSIDE WASTE INDUSTRY REPORT
Scope	Recycling	Recycling	Resource recovery
Year of analysis	2006	2008–09	2010–11
Estimated turnover ($m nominal)	11,500	11,500	6,143
Recycled material (million tonnes)	12.1	24.2	25.0
Calculated turnover per unit of material ($/tonne)	950	530	255
Source	(Hyder Consulting and ACOR, 2008)	(Access Economics, 2009)	(Waste Management & Environment and Hyder Consulting, 2011)

The large discrepancy in turnover per unit of material (i.e. $/tonne of recycled material) is evidence that there are inconsistencies in the aggregation and reporting of recycling cost data. One such inconsistency is the extent to which the 'reprocessing to recycled product' phase has been included in the *Australian recycling values* (Hyder Consulting and ACOR, 2008)and the *Employment in waste management and recycling* figures (Access Economics, 2009). This means that the industrial processes by which recovered materials are reprocessed into 'new' products may have been included in these studies. This phase is explicitly omitted from the *Inside Waste Industry Report 2011–12* (Waste Management & Environment and Hyder Consulting, 2011).

In addition to these datasets, the ABS reports a turnover of $6,893 million for the entire waste collection, treatment and disposal services industry in 2006–07 (Australian Bureau of Statistics, 2007). As noted previously, some recycling activity is captured by this ANZSIC code, however this code is neither exclusive to, nor exhaustive of, the recycling sector. Therefore this figure is considered to be of little value in determining the turnover of the recycling sector.

The magnitude of discrepancy makes it impossible to determine a definitive estimate of sector turnover, particularly without access to the underlying assumptions of each data set. The *Inside Waste Industry Report 2011–12* provides the most recent and detailed estimate of turnover within the Australian resource recovery sector. The report aggregates turnover from 'transport and collection', 'gate fee' and 'sale of recovered material' by establishing per tonne costs for each activity through a survey of the market. Although it over-simplifies the estimates and omits some segments of reprocessing that could arguably be included, this study presents the advantage of being the most explicit and transparent in its assumptions.

Despite its limitations[9], the attribution of turnover estimated in the *Inside Waste Industry Report 2011–12* is summarised below and explored in the following section, in particular across geographies and waste streams.

Table 5 Breakdown of estimated 2010–11 turnover

ACTIVITY	NSW	VIC	QLD	SA	WA	TAS	ACT	NT	AUSTRALIA
Collection, transport and gate fee	$1,050 m	$757 m	$488 m	$280 m	$203 m	$15 m	$97 m	$17 m	$2,906 m
Sale of recovered materials	$1,279 m	$799 m	$465 m	$210 m	$431 m	$12 m	$41 m	$1 m	$3,237 m
Total	**$2,329 m**	**$1,556 m**	**$953 m**	**$490 m**	**$634 m**	**$27 m**	**$138 m**	**$18 m**	**$6,145 m**

Sources:

(Waste Management & Environment and Hyder Consulting, 2011)

Collection and transport costs

The cost of collecting waste differs by source sector (municipal, C&I and C&D), location and destination (i.e. recycling or landfill). As proposed above, however, collection costs compiled from the *Inside Waste Industry Report 2010–11* (although imperfect) are assumed to factor in the full chain of economics associated with reprocessing or disposal. The following tables illustrate the breakdown of costs across waste streams and states/territories.

[9] The authors of the study acknowledge that there is considerable variation in costs surveyed across regions; however it is not made clear whether their categorisation of costs, particularly 'collection and transport', actually factor in downstream costs and benefits (i.e. the collection cost faced by the local councils surveyed may represent the full cost of disposal/recycling).

The following limitations apply to the data:

- Disaggregated C&I collection cost data is not presented, as commercial customers typically pay a combined charge for the all waste (recyclable or not) to be removed and sent to reprocessing facilities or landfills. Moreover, prices applied by private contractors are generally considered commercially sensitive.
- The *Inside Waste Industry Report 2010–11* does not make a distinction between the collection cost of C&D waste to landfill or recovery, however the disposal of each option faces a distinct gate fee as discussed in the following section.

Table 6 Weighted average cost of collection in 2010–11 across the different waste streams

TYPE OF COST	MSW	C&D
Collection of recyclables ($/t)	121	40
Collection of waste to landfill ($/t)	98	40

Source:

(Waste Management & Environment and Hyder Consulting, 2011)

Table 7 Average cost of MSW collection in 2010–11 across jurisdictions

ACTIVITY	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
Collection of recyclables ($/t)	123	124	119	116	116	126	119	74
Collection of waste to landfill ($/t)	100	101	94	98	98	84	106	66

Source:

(Waste Management & Environment and Hyder Consulting, 2011)

The weighted average cost of collecting kerbside recyclables is greater than the collection cost for waste to landfill across all states/territories. The difference is quite consistent at around $30/tonne (except for Tasmania). Possible explanations for this include:

- Greater efficiency or economies of scale in collecting waste to landfill compared to recyclables
- Higher degree of compaction in garbage bins compared to recycle bins. Garbage may also be compacted further at transfer station to further reduce the number of trips.

This adds to the overall cost of recycling.

Gate fees

The difference between gate fees paid for resource recovery and those for waste disposal to landfill are outlined in Table 8 and are an estimate based on a survey of local and regional councils. Averages presented here could mask wide ranges of costs between regions. Disaggregated C&I cost data was not provided in the original publication for the same reasons as outlined above.

Table 8 Weighted average gate fees 2010–11 across the different waste streams

TYPE OF COST	MSW	C&D
Resource recovery gate fees ($/t)	38	49
Landfill gate fees ($/t) – including levy	87	87

Source:

(Waste Management & Environment and Hyder Consulting, 2011)

The gate fee for processing recyclables may fluctuate greatly due to the:

- competitive position of the processing facility in the region (i.e. do they have the monopoly or are there alternative facilities competing for the same clients)
- sophistication (and age) of the facility
- implied linkage of commodity prices and the demand for recycled materials.

Landfill gate fees include policy implemented landfill levies that act as a proxy price for externalities associated with landfilling of waste (variations between states/territories are outlined in Table 9). Landfill levies are capable of influencing investments and future turnover in the recycling industry, as they influence the relative financial viability of the various waste management streams. The observed variance in levies across states/territories reflects the local structure of the waste services market and the political response (or appetite) to intervene. If levies differ substantially across borders there is the potential for cross-border leakage of waste disposal services.

Table 9 Landfill levies in 2011 (for municipal, metropolitan waste to landfill)

ACTIVITY	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
Landfill levy ($/t)	70	30	-	35	28	-	118	-

Source:

(Waste Management & Environment and Hyder Consulting, 2011)

Other factors influencing landfill gate fees are existing landfill storage capacity and management costs faced by landfill operators, including future risks and costs and a return on investment.

After taking into consideration the landfill levies, it is expected that in most cases the recycling facilities gate fees should be lower than landfill gate fees, absorbing at least some of the difference in collection and transport costs mentioned above.

Value of recovered materials

When recovered materials are substitutable with virgin materials as inputs into manufacturing processes, their value is expected to be correlated with commodity market prices. Prices are expected to be more volatile for materials traded on markets with greater connections to global markets[10] such as metals, paper & cardboard and plastics. Prices for more materials exchanged on more localised markets and with set applications such as masonry and organics are expected to be more stable. Accordingly, estimates of the value of recovered material are subject to variations over time and should be treated with caution.

An indicative snapshot of recovered material prices adopted in the *Inside Waste Industry Report 2010–11* is presented in Table 10. These estimates are based on highly aggregated average prices which are expected to vary significantly over time, location and quality of product (this includes quality of the sorting and, if need be, cleaning process and pre-processing).

[10] This volatility is due to exposure to global market trends and variations

Table 10 Estimated on-sale prices of recovered materials in 2010–11

	MASONRY	METALS	ORGANICS	PAPER & CARDBOARD	PLASTICS	GLASS
Price ($/tonne)	15	400	35	225	250	15

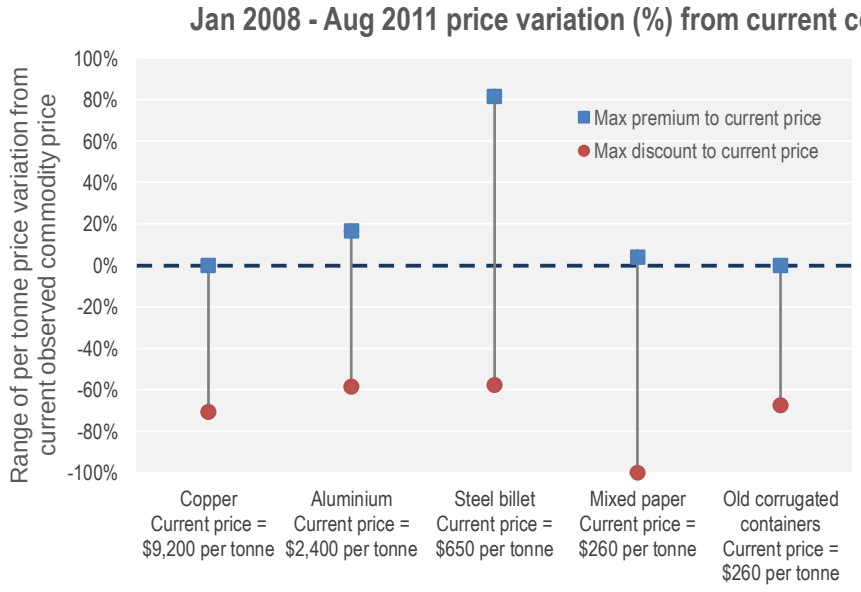
Source:

(Waste Management & Environment and Hyder Consulting, 2011)

Notes:

Glass price per tonne is a Net Balance estimate based on a range of spot prices publicly available.

Time series price data in the Australian market are generally not available free of charge[11]. To illustrate the observed and potential volatility of commodity prices, a comparison of international commodity prices over the period of January 2008 to August 2011 is presented in Figure 18. Although specific to the period studied, these observations demonstrate the significant uncertainty associated with estimating sales revenue (turnover) based on a static or 'average' annual commodity price. The sample period and the level of aggregation makes it impossible to draw general conclusions with certainty, however this illustrates the point that prices of commodities are a major risk when considering the long-term viability of recycling operations.



This chart illustrates the % variation in price (i.e. relative range) over this 32 month period. The maximum premium/discount to the current price indicates the degree that the highest/lowest observed price over the period was compared to the current price. For example, Steel billet prices were observed to range between -60% to +80% of the latest (Aug 2011) market price.

Figure 18 Example of commodity price volatility, (London Metals Exchange) & (RISI, 2011)[12]

[11] Detailed price series data may be available (at cost) from third party providers however was not procured for this report.

[12] RISI info for Japanese paper market.

6.4 Employment

The contribution of the recycling sector to Australian employment is estimated at less than 1%.

A survey-based study by Access Economics in 2009 titled *Employment in waste management and recycling*, estimated that 9.2 FTE employees were directly employed in the recycling sector for every 10,000 tonnes of waste in Australia. This corresponds to an estimate of 22,200 FTEs directly employed by the recycling sector in 2008[13].

Employment generation per tonne of material is higher in the recycling sector than for landfill disposal. Access Economics provides an estimate of 2.8 FTEs directly employed in the landfill disposal process for every 10,000 tonnes of waste in Australia. This corresponds to 6,770 FTEs directly employed in landfill disposal services.

Higher employment rates for the recycling industry have been attributed to there being more phases of activity in the recycling process compared with disposal to landfill. In addition, these extra processes, such as sorting and reprocessing, tend to be more labour intensive (Access Economics, 2009).

Measures of employment are subject to similar issues of boundary setting and that is complicated by broad assumption and extrapolation. Verifying the estimates proposed above is difficult due to a lack of comparable studies. There is also the clouded issue of where the recycling industry crosses into downstream production which is currently not addressed in reported data or estimates. However the following observations are noted from a review of publicly available information:

- 2006–07 ABS census data reports a total of 27,347 employees in "Waste collection treatment and disposal services" (Australian Bureau of Statistics, 2007). This is approximately in line with the Access Economics estimation for combined recycling and landfill employment.
- In 2006, it was estimated that approximately 10,900 people were employed directly by the recycling industry in Australia (Hyder Consulting and ACOR, 2008). However this has since been restated and described as the number of employees directly employed by ACOR member companies (ACOR, 2011).
- In 2011, a survey of ACOR members estimated a total of 22,969 employees in the recycling sector (ACOR, 2011). This figure excluded employees from two of ACOR's larger members and did not explicitly identify whether employees were directly employed in the recycling area of each member business.
- A figure quoted by EPA in the United States suggests that recycling activities create 36 jobs per 10,000 tonnes of waste (EPA USA, 2002), however it is not specified whether this figure is exclusively full time jobs or if a combination of contractor, casual positions and indirect jobs

[13] Based on recycling tonnages estimates (Access Economics, 2009)

are included, which could explain the significantly higher number (in addition to the fact that technological progress has been made in the intervening years).

Some reports measure indirect employment impacts using multipliers. Measuring indirect employment for the recycling sector is particularly problematic due to the aforementioned boundaries issues and the overlap of reprocessing and manufacturing processes. At the scale of the Australian economy, referring to multipliers does not provide useful information, as only a General Equilibrium approach[14] can present a dynamic vision of adjustments between sectors. This report has therefore avoided presenting any multipliers for indirect employment impacts from recycling.

The estimation of sector wages and salaries is not provided in the present study due to the uncertainty in employment figures and lack of quantitative information on the salary profile of sector employees.

The social impact of employment generated by the sector is further discussed in section 8.

6.5 Capital investment

Attracting an adequate level of capital investment to the recycling sector is important to ensure that the processing capacity is adequate to meet demand for recycled services and recycling targets. It is also important to ensure that obsolete facilities are renewed (which usually brings additional benefits in terms of OH&S and environmental performance). In the private sector, capital investment happens when the return on investment for an activity meets expectations of investors and compares favourably to other investment opportunities on the market. Risk perception[15], and other factors, also plays a role in investment choices. Government also traditionally plays a role when 'common good' is at stake, which is often the perception with recycling.

6.5.1 Capital investment drivers

Recycling facilities are capital intensive and their development is limited by issues of capacity and scalability, i.e. a minimum volume of waste may be necessary to feed into a facility of a scale that makes it financially viable. Such 'minimum' investment issues may constitute real barriers in regional areas. Similarly, the capital intensity of the technologies varies greatly depending on the technology and the waste streams. For example, crushing C&D waste or shredding green waste is relatively low technology and requires less investment per unit of waste than, say, plastic sorting and reprocessing. The modularity of facilities also introduces the option of future

[14] A general equilibrium approach would require an analysis of the interaction between supply, demand and prices in a whole economy with interacting markets and is therefore beyond the scope of this study.

[15] i.e. the risk of losing all or part of the capital invested and / or not achieving the expected return.

expansion that may delay capital investment or mitigate risks associated with installing facilities built to meet longer term demand (including the risk of supply shortages). These may be significant drivers of capital investment and play a role in the regional distribution of this investment.

The interplay between landfill and recycling activities may also influence capital investment. Although private operators may be primarily interested in landfill activities, their clients require waste management solutions that incorporate a mix of landfill and recycling services. Accordingly, operators need to maintain a competitive position in both markets which may require investment concurrently in recycling activities. This dynamic is complex and commercially sensitive and was not addressed in the publically available literature.

6.5.2 Estimated current capital investment

Data on historical capital investment in the recycling sector is scarce and fragmented due to the dominant involvement of private sector funding. Most recently, capital investment in the Australian recycling sector was estimated at $6 billion in 2006 (Hyder Consulting and ACOR, 2008) across ACOR members, who made up nearly 80% of the recycling industry (by recovered volume).

Caution must be exercised in using this estimate as it appears to represent a highly abnormal level of annual investment. When presented alongside the authors' estimated turnover of $11.5 billion in 2006 (Hyder Consulting and ACOR, 2008), the estimated $6 billion of capital investment represents an unrealistically high ratio of capital investment to turnover.[16] A more reasonable explanation for the magnitude of this capital investment figure is that it represents the asset value of all capital investment up to 2006. This explanation is consistent with figures provided by ACOR that estimated the capital replacement value from ACOR members in 2011 to be $9.5 billion. Both figures will underestimate the value of total sector capital due the non-exhaustive coverage of ACOR membership across all types of recycling.

6.5.3 Estimated future capital investment

State and territory recycling targets are arguably the best indication of likely future recycling rates. Future capital investment is expected to be closely linked with the projected infrastructure requirements to meet these targets, provided incentives for meeting these targets are right.

The *Inside Waste Industry Report 2010–11* provided an estimate of the capital investment required across each jurisdiction over the 2008–15 period to meet resource recovery targets. These estimates are presented in Table 11.

[16] This would warrant further analysis.

Table 11 Target recovery rates and the estimated capital investment required

	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
MSW target recovery rate (%)	66	65	50	65	70	-	80	-
C&I target recovery rate (%)	63	80	40	75	-	-		-
C&D target recovery rate (%)	76	80	50	90	50	-		-
Year to be achieved	2014	2013–14	2014	2015	2016	-	2015	-
Cumulative investment needed from 2008–15 ($m) to meet targets	320 - 790	150 - 370	55 - 118	-	76 - 114	-	-	-

Source:

(Waste Management & Environment and Hyder Consulting, 2011)

Notes:

Cumulative investment estimates relate to resource recovery, which is broader than recycling and include Alternative Waste Treatment, which are generally excluded from the present study

Queensland targets reflect those indicated in the source data and are consistent with the capital investment requirement shown. These are not consistent with researched figures presented in section 10 of this report which addresses the regulatory environment.

The analysis in the *Inside Waste Industry Report* suggests that SA and ACT are the only states/territories whose existing and planned capacities are sufficient to achieve their targeted recovery rates, although these targets are the highest of all states/territories. The capital investment required in Queensland is not significant, but targets are low compared to other states/territories (except possibly WA). Significant investment is required in Victoria, but NSW is by far the state where most effort will be necessary; these are also the most populated states. This signals that there are good opportunities for growth for the recycling sector in these states.

The capital investment needed is expected to be directed towards:

- MSW – alternative waste treatment facilities
- C&I – sorting (dirty MRFs) facilities
- C&D – mixed reprocessing facilities (Waste Management & Environment and Hyder Consulting, 2011).

Capital investment is expected to come from a mix of private sector investment and public planning and investment. State/territory and local governments have historically contributed to the capital investment requirements of recycling, as they are seen as essential services that were historically delivered by the public sector. These are also heavily regulated areas and ones where market failure can easily occur. In some jurisdictions, where it may not be commercially viable to set up recycling schemes and activities, local government may decide to invest based on community best interest. State and territory governments have provided grants to overcome capital investment barriers to establish recycling infrastructure.

Although there is no data available to rigorously support this conclusion, it is assumed that the majority of investment will be provided by the private sector.

6.6 Findings and recommendations

Economic data concerning the Australian recycling sector is both limited and fragmented. Historical estimates of key indicators of economic activity such as sector turnover, employment and capital investment, have been undertaken by consultants and industry bodies on a commissioned basis and are contingent on various forms of aggregation and assumptions. This has led to significant inconsistencies and a lack of comparability between datasets that is largely attributed to differences in boundary definition and methodology. Data verification is a major blockage in establishing a robust and disaggregated dataset to perform meaningful economic analysis.

The review of available economic data establishes the following:

- Turnover for the Australian recycling sector is likely to be beyond $6 billion annually (at 2010–11 materials prices) and could under specific assumptions (boundaries) be estimated at well beyond $10 billion annually.
- The sale of recovered materials is a major component of industry turnover (above 50%) but is highly dependent on volatile commodity markets for recovered materials.
- The economic drivers for recycling are contingent on both the material prices and the competitiveness of the cost structure for landfill disposal.
- The introduction and expected rise of landfill levies is likely to be a significant factor contributing to the economic viability of the recycling sector. Levies are part of the array of policy instruments that government can draw on to achieve policies and targets.
- Estimates of direct employment from the recycling sector are in the magnitude of 20,000 FTE employees. It is not possible to determine the extent of indirect employment based on available datasets.
- Estimating wages and salaries requires access to private data or a detailed profile of employee skills (in addition to accurate employment estimates). Data was not available to

determine this.

- Data on capital investment is particularly scarce; however is expected to be driven to a significant extent by state/territory and local investment policy.

The centralised collection of data relating to the recycling sector as a separate industry sector should be encouraged as an avenue for consistent and rigorous data collection. Failing this, it is recommended that further data is sought from industry to provide a foundation for a detailed economic evaluation of the Australian recycling sector. This initiative could be led by a combination of industry stakeholders and may include the introduction of standards and specifications to report on disaggregated recycling activity at the facility level.

A consistent reporting structure and definition of activities is fundamental to establishing a useful national dataset. These national recycling 'accounts' should incorporate the key economic metrics discussed in this section and will provide insight into the economic performance and contribution of the recycling sector.

7. Environmental assessment

Recycling in Australia results in a wide variety of tangible and measurable environmental benefits compared to landfill disposal.

A life cycle assessment in 2008–09 of recycling compared with landfill found:

- Energy savings of over 241,000,000 gigajoules (GJ)- equivalent to the energy usage of 5 million homes
- Avoidance of over 15 million tonnes of greenhouse gas emissions (t CO_2–e)- equivalent to taking 3 million vehicles off the road
- Water savings of over 172 gigalitres - equivalent to 10% of Australian household water use
- Avoidance of over 21 million tonnes of solid waste to landfill- equivalent to 37% of all waste currently generated in Australia
- Significant reductions in natural resources use, eutrophication of waterways and airborne pollutants

This section provides a summary of the environmental benefits of recycling compared with landfill disposal. Life cycle assessment (LCA) was used to quantify the environmental benefits of recycling compared with landfill disposal. An LCA measures the impacts associated with every stage of the production of a given material, by accounting for all inputs and outputs at each stage. Section 7.1 includes a description of the key production stages included in the LCA and the potential environmental impacts of these processes.

Table 12 presents a summary of the net environmental benefits of recycling (including the benefits of substituting raw material with recycled material) compared with landfill.

Table 12 Summary of the net annual environmental benefits of recycling in Australia

ENVIRONMENTAL IMPACT	ANNUAL BENEFITS OF RECYCLING IN AUSTRALIA, 2008–09
Energy savings	241,878,104 GJ Equivalent to the energy used by 5 million homes
Greenhouse gas emissions reductions	15,316,746 t CO_2-e Equivalent to taking 3 million vehicles off the road (equivalent to 19% of all Australian vehicles)
Water savings	172,580,603kL Equivalent to: Over 69,000 Olympic swimming pools, or nearly 10% of total Australian household water use
Landfill avoidance	21,723,273 tonnes Equivalent to 35% of all waste generated in Australia
Resource savings	4,312,854 tonnes of trees 349,490 tonnes of crude oil 4,740,518 tonnes of iron ore 991,057 tonnes of bauxite 623,407 tonnes of sand
Eutrophication reduction	8,457,196kg PO_4^{-3} eq. Equivalent to preventing 13.7 million kg of fertiliser being discharged into waterways
Poor air quality (reduction in photochemical oxidation)	19,130,154kg C_2H_2 eq.

7.1 Typical process stages of recycling and landfill

Figure 19 illustrates the typical stages involved in the recycling process from material extraction, product manufacture to landfill or reprocessing. It also includes an example process flow diagram illustrating the recycling process of an aluminium can, from bauxite extraction to landfill disposal or reprocessing. Further description of each stage is provided below.

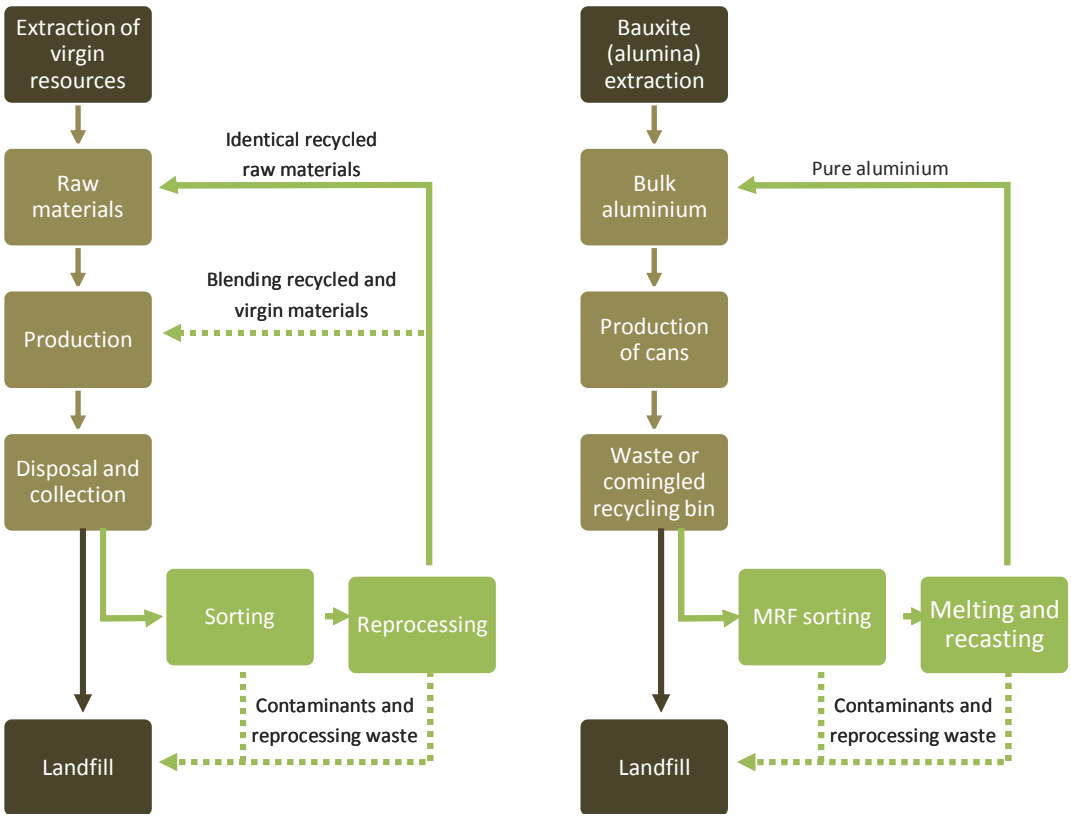


Figure 19 Simplified diagram of a typical waste and recycling process (left), and an example for aluminium cans (right)

7.1.1 Extraction of virgin resources

Extraction of virgin resources involves exploration and mining activities. The extraction of virgin resources for manufacturing typically produces the most significant environmental impacts of the production cycle including significant energy and water consumption, land use, biodiversity and human health risks (Hyder Consulting Pty Ltd, 2008).

Following extraction, virgin resources require processing into useful raw commodities. This may involve the milling of timber into pulp, smelting of iron ore, processing of bauxite into bulk aluminium, refinement of oil into petrochemicals, or crushing and screening of rock aggregate. Energy demands are often highest at this stage of the production process because large

quantities of material must be removed from the natural resources in order to obtain a purified commodity (Department of Environment, Climate Change and Water (NSW), 2010c). The process generates unwanted material that is often disposed of to landfill or tailings dams and may be subject to hazardous waste regulations, necessitating treatment or monitoring.

7.1.2 Raw materials

Raw materials may be either virgin or recycled inputs such as timber pulp (or reprocessed paper pulp), bulk aluminium and steel (or their recycled equivalents), petrochemicals (or reprocessed plastic flakes) and fertiliser compounds (or composted organics).

Recycled materials are typically reprocessed so that they can be mixed with virgin feedstock or used as a replacement for virgin feedstock in production processes.

7.1.3 Production of goods

Production methods and environmental impacts vary greatly depending on the type of material used and goods produced. Aside from the raw materials used in manufacturing, material inputs such as catalysts, cleaning agents and other supplementary materials may be required. Each material used in the production process has its own associated environmental impacts from the energy and water consumed to produce the material, greenhouse gas emissions and waste disposal issues.

For many products, once a recycled material has been reprocessed, manufacturing can occur using the same process as used for virgin input materials. For this reason, the environmental impacts of manufacturing are relatively similar for both virgin and recycled feedstock.

7.1.4 Disposal and collection

The collection of waste or recyclables typically occurs via any of the following methods:

- Kerbside and on-site collection by municipal council trucks or hired waste contractors
- Voluntary consumer delivery to local sorting, transfer and disposal sites
- Specialised collection services for particular materials (for example “drumMUSTER” for empty chemical containers, “Byteback” for electronic goods)

The collection of recyclable material typically requires greater energy and resources compared with landfill waste because of the requirement to segregate the recyclable materials.

LCA methodologies reviewed as part of this study consistently accounted for these differences in collection streams (waste, recycling) and sources (domestic, commercial, industrial).

7.1.5 Sorting

Sorting is the process of separating waste into various material streams to enable reprocessing.

This may occur at a dedicated facility such as an automated Material Recovery Facility (MRF) or at the source of the waste generation. For example, at large commercial and industrial sites, recyclables may be source segregated, enabling the separated material to proceed directly to a reprocessing facility.

Sorting enables recyclable materials to be recovered and reprocessed, avoiding the disposal of this material to landfill. However there is still a proportion of the waste stream that cannot be recovered due to contamination or inseparability and this is accounted for in the LCA studies.

7.1.6 Landfill

Disposal to landfill generally represents the end of the waste cycle. Once buried in landfill, materials either remain inert and idle, or decompose over time. Management of landfill sites requires energy and resources to excavate, fill, compact, contain and monitor waste.

Environmental impacts associated with long-term landfill storage include soil contamination, leaching to groundwater, biodiversity due to land use and emissions of greenhouse gases (particularly methane) from the breakdown of putrescibles. Advanced capped landfill sites may capture methane gas for electricity generation and in some cases produce a net energy supply. However in the absence of methane capture and combustion, landfill sites are responsible for significant greenhouse gas emissions.

7.2 Recycling

Recycling requires the addition of a reprocessing stage to the production cycle.

7.2.1 Reprocessing

Reprocessing is the key stage in the recycling process that converts goods at the end of their useful life back into raw materials. Ideally, reprocessing allows the production of high purity raw materials of equivalent quality to virgin materials.

Reprocessing waste materials provides an opportunity to substitute virgin raw material for recycled material. This greatly reduces the quantity of virgin material required and therefore avoids the environmental impacts associated with extraction of these materials. Reprocessing also avoids material going to landfill and the associated environmental impacts.

Reprocessing that produces an input product that is of the same quality as a virgin material is known as “closed loop” recycling. Reprocessed material may replace virgin materials at the commodity stage, such as bulk aluminium or steel, or as an intermediate material, such as ground glass and plastic flakes.

“Open loop” recycling results in the recycled material being processed into another new product. For example, lower-grade recycled ground glass may be used in insulation batts rather than in the production of new glass. Similarly, reprocessed paper is not always returned to the quality of

the original paper pulp, owing to intensive cleaning and bleaching requirements during reprocessing. Thus some reprocessed paper is used to produce an alternative, lower-grade quality of paper different to the original collected material.

These instances of alternative use of reprocessed materials are accounted for in the LCA publications reviewed, by calculating for the benefit of avoiding the theoretical virgin resource use required for the *alternative* product (not the original virgin source of collected material). Recycling collected materials into alternative products results in significant removal of virgin extraction and landfill disposal requirements, but cannot completely eliminate the need for some virgin extraction and landfill disposal.

7.3 Environmental benefits of recycling

The environmental benefits of recycling are most apparent in the two significant stages of the waste process which are avoided: extraction of virgin materials and disposal of waste to landfill. Undertaking recycling removes or significantly reduces the impacts associated with these two stages.

Recycling however requires additional effort in collection and sorting, and the reprocessing stage to convert recyclable materials into usable manufacturing inputs. From a life cycle perspective, the overall environmental benefit of recycling is thus essentially a balance between the benefits gained and the additional requirements involved, as illustrated in Figure 20.

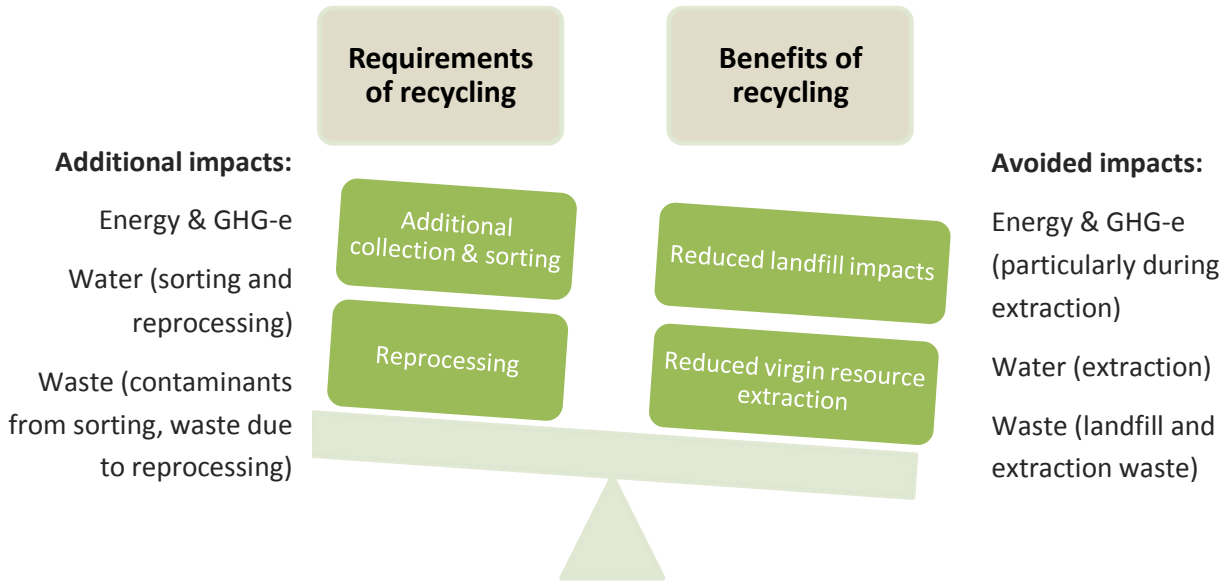


Figure 20 Requirements and benefits of recycling over disposal to landfill

A detailed assessment of the effect of recycling on several environmental indicators is presented in the following sections.

7.4 Life cycle assessment

The extent to which recycling benefits the environment, compared to landfill disposal, is best quantified by a LCA of the two processes. An LCA measures the impacts associated with every stage of the production of a given material, by accounting for all inputs and outputs at each stage. This is a powerful tool for providing a calculated assessment of the two alternative systems (recycling and landfill) and determining whether one is preferable to another.

Table 13 provides detail of the published recycling LCA studies that were used to describe the environmental benefits in this section.

Table 13 Selection of LCA references used in this report

TITLE	REFERENCE
"Environmental benefits of recycling"	(Department of Environment, Climate Change and Water (NSW), 2010b)
"Australian Recycling Values- a net benefits report"	(Hyder Consulting Pty Ltd, 2008)
"Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria"	(Grant, 2005)
"Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Edition "	(US EPA, 2006)
"Environmental benefits of recycling calculator"	(Department of Environment, Climate Change and Water (NSW), 2006)

The scope of materials and level of detail within these references varied, however in general terms the LCAs were in agreement on the relative benefits of recycling common materials. The first three studies listed in Table 13 are of particular relevance to this report as they are based on Australian recycling impacts (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2011b; Grant, 2005). The fourth study is American (US EPA, 2006), and while based on different market operating conditions, was used to provide additional validation that results were reasonable for most materials. The fifth study is an older Australian publication (Department of Environment, Climate Change and Water (NSW), 2006) which has since been superseded (Department of Environment, Climate Change and Water (NSW), 2010b) but was used as a further point of validation.

For the assessment of greenhouse, energy, water and waste impacts of recycling in Australia, the most recent and comprehensive LCA results available (Department of Environment, Climate Change and Water (NSW), 2010b) were used for the majority of materials addressed in this report. Where particular materials were not assessed within this primary source, other studies were used. The study by Grant (2005) provided the only data for the assessment of eutrophication and photochemical oxidation.

Each of the LCA studies provided a comparison of the difference in environmental impacts arising from either recycling or landfill. Results were typically normalised per tonne of recycled material. In this normalised format, results demonstrate which particular materials are the most beneficial to recycle.

This report multiplies these normalised results with the most recent and reliable data for current recycling quantities in Australia (Hyder Consulting Pty Ltd, 2011b), to produce an overall environmental benefit of recycling compared to landfill disposal in Australia. The LCA studies rely on a number of assumptions to calculate the per tonne net difference between recycled and virgin materials. Therefore the overall environmental benefits should be viewed as approximates only.

The key indicators used to assess the environmental benefits of recycling compared with landfill disposal include energy, greenhouse gas emissions, water, landfill waste, mineral/resource savings, biodiversity and health impacts and air quality. These key indicators are discussed in the following sections. The individual sources of quantitative LCA results for each indicator used in this report are included in Appendix F.

7.5 Energy

Recycling in Australia saves over 241,000,000 GJ of energy each year, which is equivalent to the energy consumption of 5 million homes.[17]

7.5.1 How does energy consumption affect the environment?

It is not energy consumption itself which causes environmental impact; it is the collateral effects of energy generation. Depending on the energy source, the environmental impacts may include resource use, greenhouse gas emissions, water use, land use and waste generation (Herzog, Lipman, & Kammen, 2001).

Typically, renewable energy has a lower environmental impact compared with fossil fuel powered energy generation (Herzog, Lipman, & Kammen, 2001). Therefore, high energy usage does not necessarily mean significant environmental impact. However in Australia, the majority

[17]Based on average annual energy usage for Australian households of 48 GJ in 2008–09 (Department of the Environment, Water, Heritage and the Arts, 2008).

of energy is sourced from non-renewable fossil fuels so a reduction in energy requirements will generally reduce stresses placed on the environment.

7.5.2 How does recycling produce energy benefits?

Recycling reduces the requirement for virgin resource extraction and landfill disposal. Each of these stages has significant energy requirements (Grant, 2005). In particular, the energy required to extract natural resources often constitutes a major proportion of energy needed for the entire production cycle.

For example, the energy savings from recycling aluminium are significant. Virgin aluminium is derived from the mineral bauxite, which is mined and processed at high temperatures in order to allow the separation of alumina. This alumina then undergoes electrolysis, an extremely energy-intensive process requiring high electrical currents (Department of Industry, Science and Resources, 2000). Disposal to landfill effectively leads to the "loss" of the embedded energy required to refine the aluminium. In contrast, recycling aluminium only requires melting the metal and re-moulding into the desired product. The energy requirements for this melting process are significantly less than high-current electrolysis of virgin minerals. This leads to the overall aluminium recycling process requiring only a small fraction of the energy of virgin manufacturing (Department of Environment, Climate Change and Water (NSW), 2010b).

Table 14 provides a summary by material category of the Australian energy savings as a result of recycling materials compared with landfill disposal. In 2008–09 metal recycling resulted in the greatest energy savings of all of the material types (over 173,000,000 GJ). The recycling of plastics avoided the energy consumption required to extract virgin petrochemicals and saved over 12,000,000 GJ in 2008–09 and paper recycling avoided energy-intensive wood pulping saving nearly 32,000,000 GJ in 2008–09.

Table 14 Energy savings from recycling instead of landfill disposal (Detailed listing in Table 27)

CATEGORY	ANNUAL ENERGY SAVINGS IN AUSTRALIA, 2008–09 (GJ)
Masonry materials	6,510,064
Metals	173,497,723
Organics	7,762,783
Paper/cardboard	31,926,417
Plastics	12,486,036
Glass	6,420,594
Textiles and rubber	3,274,488
Hazardous Waste	Unavailable
Fly Ash	Unavailable
TOTAL	**241,878,104**

Sources:

LCA publications (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 15 provides a list of the top 5 materials for their energy savings per tonne recycled. Aluminium is estimated to save over 191 GJ per tonne recycled and has the largest energy savings per tonne compared to the other materials recycled.

Table 15 Top 5 materials for energy saving per tonne (Full listing available in Table 44).

MATERIAL	ENERGY SAVING PER TONNE RECYCLED (GJ/TONNE)
Aluminium	191.42
Rubber Tyres	64.08
Mixed plastics	60.62
PP	58.63
HDPE	54.14

Sources:

LCA publications (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005)

7.6 Greenhouse

Recycling saves Australia over 15,000,000 tonnes of carbon dioxide equivalent (t CO_2–e) each year. This is equivalent to the emissions of 3 million vehicles, or 19% of all vehicles in Australia.[18]

7.6.1 How do greenhouse gas emissions affect the environment?

"Greenhouse gases" are atmospheric gases which retain heat from solar radiation. The Earth's natural greenhouse effect maintains temperatures at the surface necessary for life to exist. However, human activities have resulted in significantly higher concentrations of greenhouse gases, primarily from fossil fuel combustion and deforestation. Increased greenhouse emissions above natural levels leads to warming of the earth's atmosphere, which has the potential to cause severe weather events, sea level rise, drought and natural habitat loss (Solomon, 2007).

7.6.2 How does recycling reduce greenhouse gas emissions?

Recycling reduces greenhouse gas emissions (GHG-e) by minimising the need for virgin materials and landfill disposal. The extraction of virgin materials is energy intensive and this energy is typically provided from the burning of fossil fuels which produces GHG-e. The decomposition of waste material over time in landfills, such as paper and organics, produces GHG-e. Recycling these materials prevents these greenhouse gas emissions being generated in the landfill.

Table 16 provides a summary by material category of the GHG-e avoided as a result of recycling compared with landfill disposal. In 2008–09 the recycling of metals resulted in the greatest quantity of GHG-e savings, with over 7.4 million tonnes of CO_2–e avoided. This list is similar to Table 14 because of the close relationship between energy consumption and GHG-e in Australia. As a result the same categories of recycled materials, particularly metals and paper, achieve the greatest benefit to Australia owing to both high savings per tonne, but also large quantities collected and recycled.

[18] Emissions per vehicle based on ABS vehicle data and NGA emissions factors. Calculation presented in Table 45.

Table 16 GHG-e reductions in Australia from recycling instead of disposal to landfill (Detailed listing in Table 27)

CATEGORY	ANNUAL BENEFIT TO AUSTRALIA, 2008–09(t CO_2–e)
Masonry materials	347,197
Metals	7,404,865
Organics	1,762,178
Paper/cardboard	2,704,515
Plastics	371,697
Glass	586,401
Textiles and rubber	54,677
Hazardous Waste	Unavailable
Fly Ash	2,085,216
TOTAL	**15,316,746**

Sources:

LCA publications (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005; US EPA, 2006) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 17 provides a list of the top 5 materials for their GHG-e savings per tonne recycled. Aluminium and copper produce the greatest GHG-e savings per tonne recycled.

Table 17 Top 5 materials for GHG-e saving per tonne (Full listing in Table 45)

MATERIAL	GHG-e SAVING PER TONNE RECYCLED (t CO_2–e/TONNE)
Aluminium	17.72
Copper	3.43
PVC	1.67
PP	1.64
Mixed plastics	1.56

Sources:

LCA publications(Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005; US EPA, 2006)

7.7 Water

Recycling saves Australia over 172,000 mega litres of water each year. This is equivalent to 69,000 Olympic swimming pools, or nearly 10% of Australian household water use.[19]

7.7.1 How does water use affect the environment?

Australia is one of the driest countries in the world and prone to drought and water scarcity. Water is required for the survival of people, plants and animals.

Water used during industrial and manufacturing processes can also be exposed to significant contamination prior to discharge, potentially giving rise to environmental damage to groundwater and river systems. Recycling processes typically involve chemicals and materials which are comparatively less toxic to water supplies than more intensive primary resource extraction (Grant, 2005).

7.7.2 How does recycling provide benefits for water use?

For the materials considered within this study, the primary demand for water generally comes from processing requirements. While water is incorporated as a component of some materials, far greater requirements are associated with chemical reactions, cooling, transport and cleaning processes which support the production of the finished material.

For instance, the production of metals from virgin resources requires large quantities of water during extraction and initial processing. These water demands include processes such as mineral flotation and quenching (Department of Industry, Tourism and Resources, 2008). Similarly, the production of paper goods relies on water during wood pulping to provide a consistent raw material to be processed into finished paper (Spencer, 2009).

Similarly, many reprocessing requirements for recycled goods utilise significant quantities of water for cleaning and separation of collected materials. In some cases, recycling may actually be more water-intensive than virgin production. This is detailed in the materials comparison below.

7.7.3 What are the impacts of recycling different materials?

Some recycling processes require more water than virgin resource production. As indicated by the negative number in Table 18, the recycling of plastics (particularly PET, HDPE and mixed plastics which may be seen in more detail in Table 47), requires more water than virgin material production. This is mainly due to the large volumes of water required to sort the plastic stream into its different plastic types (via flotation using water) and washing using purified water in preparation for reprocessing (Grant, 2005).

---

[19] Olympic swimming pool = 50m x 25m x 2m = 2,500m^3 = 2,500 kL. Total household water usage in Australia = 1,768,251 ML (Australian Bureau of Statistics, 2010)

Table 18 Water savings in Australia from recycling instead of disposal to landfill (detailed listing in Table 27)

CATEGORY	ANNUAL BENEFIT TO AUSTRALIA, 2008–09 (KL)
Masonry materials	10,525,571
Metals	79,570,323
Organics	1,442,516
Paper/cardboard	78,178,777
Plastics	-2,162,102
Glass	2,355,543
Textiles and rubber	2,669,975
TOTAL	***172,580,603***

Sources:

LCA publications (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 19 provides a list of the top 5 materials for their water savings per tonne recycled. Aluminium and PVC produce the greatest water savings per tonne recycled.

Table 19 Top 5 materials for water saving per tonne (full listing in Table 47)

MATERIAL	WATER SAVING PER TONNE RECYCLED (KL/TONNE)
Aluminium	202.03
PVC	67.64
Rubber tyres	52.25
Telephone books	33.10
Paper/cardboard	26.85

Sources:

(Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005)

7.8 Landfill waste

Recycling saves Australia over 21.7 million tonnes of solid waste each year which is equivalent to 37% of all waste currently generated in Australia.[20]

7.8.1 How does solid waste affect the environment?

Solid waste is an easily visualised impact of landfill disposal. Once deposited in landfill, materials may pose a range of environmental risks, including:

- Air quality and odour impacts to the immediate vicinity
- Decomposition of putrescible waste to form methane gas, a greenhouse gas with a high global warming potential
- Leaching of waste chemicals and decomposed materials into natural water systems.

Landfill sites in Australia are becoming increasingly sophisticated in managing and monitoring these environmental risks. Preventative measures include on-site monitoring of air quality, the use of concrete bases and impermeable linings beneath waste, and “capped” landfill cells which capture and combust methane gases for electricity generation (Hanson Landfill Services).

However, with the exception of landfill gas electricity generation, the deposited waste can provide no further benefit. Once sent to landfill, materials become a burden rather than a resource.

7.8.2 How does recycling provide benefits to landfill waste?

No process is perfect and even highly efficient recycling systems result in residual materials which cannot be adequately reprocessed and must be disposed to landfill.

For all common materials addressed in this study, recycling offers significant landfill avoidance compared to virgin manufacturing. The majority of landfill avoidance is due to the product itself being collected for reprocessing rather than sent to landfill. If this were to be considered in isolation, then every tonne recycled would be a tonne diverted from landfill. However, from a full life cycle perspective, there are many additional waste streams generated by both manufacturing and reprocessing which should be taken into account.

For example, in the production of plastics from crude oil, significant impurities in the oil must be separated and potentially disposed in order to obtain feedstock chemicals for plastic production. If the plastic is recycled, reprocessing may allow a high proportion of material to be recovered. Extraction of crude oil is no longer required to the same extent, and disposal of impurities at that

[20]While the overall recycling rate quoted elsewhere in this report is 44%, 37% represents actual landfill avoidance and includes the fact that the recycling process itself may generate additional waste. This figure is based on total waste generation of 57,218,429 t (Hyder Consulting Pty Ltd, 2011b) and LCA result of 21,146,651 t avoided due to recycling (see Table 20).

stage is therefore reduced. However, some fraction of collected plastic is generally contaminated by other materials and requires disposal. Therefore there is still some landfill impact associated with the recycling process.

The overall landfill avoidance achieved by recycling different materials in Australia is shown in Table 20. These figures represent the net landfill avoidance for the full life cycle of material production. In 2008–09 recycling masonry materials resulted in over 10.8 million tonnes of avoided landfill disposal, the largest quantity of all of the material categories.

Table 20 Landfill waste reduction in Australia from recycling instead of disposal to landfill (Detailed listing available in Table 27)

CATEGORY	ANNUAL BENEFIT TO AUSTRALIA, 2008–09 (TONNES)
Masonry materials	10,810,648
Metals	4,668,026
Organics	2,145,257
Paper/cardboard	2,755,293
Plastics	330,258
Glass	959,114
Textiles and rubber	54,677
TOTAL	***21,723,273***

Sources:

(Department of Environment, Climate Change and Water (NSW), 2010b; Grant, 2005) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 21 provides a list of the top 5 materials for their landfill savings per tonne recycled. HDPE and aluminium produce the greatest landfill savings per tonne recycled.

Table 21 Top 5 materials for landfill saving per tonne (Full listing available in Table 48)

MATERIAL	LANDFILL SAVING PER TONNE RECYCLED (TONNE/TONNE)
HDPE	2.70
Aluminium	1.56
Copper	1.10
Concrete	1.09
Bricks	1.07

Sources:

(Department of Environment, Climate Change and Water (NSW), 2010b; Grant, 2005)

7.9 Mineral/resource savings

Each year, recycling saves Australia[21]:

- over 4,000,000 tonnes of trees for paper
- over 300,000 tonnes of oil for PET and HDPE plastic
- over 4,000,000 tonnes of iron ore for steel
- over 900,000 tonnes of bauxite for aluminium
- over 600,000 tonnes of sand for glass

7.9.1 How does resource use affect the environment?

The primary industries such as mining and agriculture give rise to some of the most significant environmental impacts of the materials production cycle. In addition to the collateral energy, greenhouse, water and waste impact, there is the physical removal of resources from the natural environment.

Significant proportions of the resources extracted are non-renewable and will eventually become exhausted. While the timeframe for running out of resources is generally long term, resource scarcity is a serious issue with increased industrialisation rapidly accelerating demand for the non-renewable raw materials (Evans, 2010).

The concept of "peak oil", where world oil production reaches a peak and begins to decline due to a lack of further oil resources, is a well-recognised example (Evans, 2010). Mineral phosphate, one of the key commodities for the production of fertilisers worldwide, is another non-renewable resource which is being rapidly depleted (Cordell, 2010).

7.9.2 How does recycling provide benefits for resource use?

Recycling removes the need to obtain virgin materials. This contributes to the reduction in the environmental impacts associated with resource extraction and agriculture and reduces the demand for scarce resources. For example, recycling of plastics reduces the need to produce virgin plastic from crude oil derivatives and recycling of organic material via composting can act as a substitute for mineral phosphate fertiliser (Department of Environment, Climate Change and Water (NSW), 2010b).

[21]Based on the primary resource incorporated into each material (Hyder Consulting Pty Ltd, 2008). There are also additional resources involved in manufacturing, such as fuel and water, which are represented by energy and water indicators.

The key differences between using virgin resources and recycled inputs to manufacture new products are described below:

- Virgin resources (such as bauxite, iron ore, crude oil) are extracted, heavily processed and refined prior to use. The quantity of virgin resources required is significantly greater than the quantity used to manufacture the product because unwanted materials must be removed via separation and chemical reaction.
- Recycled inputs (such as scrap metal, plastic bottles, garden organics) are comparatively pure materials, in many cases already having the same composition as the required manufacturing inputs and products (new metal, plastic, garden mulch). Losses are encountered in the reprocessing phase primarily due to physical contamination of the collected materials, necessitating separation and disposal. However, the retained bulk material is highly pure after sorting, and only the disposed fraction must be replaced by manufacturing inputs derived from additional virgin resources.

The resource savings achieved by recycling several common materials in Australia are shown in Table 22.

Table 22 Resource savings from recycling instead of disposal to landfill

MATERIAL	RESOURCES SAVED PER TONNE RECYCLED	ANNUAL BENEFIT TO AUSTRALIA, 2008–09
Paper/cardboard	1.13 t of trees	4,312,854 t of trees
Glass	0.63 t of sand	623,407 t of sand
Ferrous metals	1.19 t of iron ore	4,740,518 t of iron ore
Aluminium	4.46 t of bauxite	991,057 t of bauxite
PET	2.17 t of crude oil	177,759 t of crude oil
HDPE	2.19 t of crude oil	171,732 t of crude oil

Sources:

LCA publications (Hyder Consulting Pty Ltd, 2008) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

7.10 Biodiversity

Australia is recognised by Conservation International as one of seventeen mega diverse countries which support a majority of the world's biodiversity (Australian Wildlife Coservancy, n.d.). Biodiversity in Australia is however threatened by a number of factors including:

- habitat destruction and fragmentation: For example, it is estimated about 75% of Australia's rainforests have been cleared or degraded (Department of Environment, Sport and Territories, n.d.)

- pollution: the impact varies for the ecosystem and situation and may arise from:
    - 'micro-pollutants' such as chemical residues that interact with biological systems potentially resulting in birth and growth defects (Department of Sustainability, Environment, Water, Population and Communities, 2011)
    - excessive sediment, nutrient or chemical run-off from agricultural and urban land affecting marine ecosystems (Department of Sustainability, Environment, Water, Population and Communities, 2011)
    - greenhouse gas emissions that contribute to the "unequivocal" warming of the climate system (Intergovernmental Panel on Climate Change, 2007, p.2) that is by 2020 projected to result in significant loss of biodiversity to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics (Intergovernmental Panel on Climate Change, 2007, p.2).

Eutrophication is an example of localised pollution that can affect biodiversity due to its impact on aquatic life and general water quality, and can have far-reaching implications for all living species. Life cycle research has identified eutrophication impacts of recycling compared to landfill, allowing the quantification of the benefits of recycling to water health and hence biodiversity. Eutrophication was therefore selected as an indicator for biodiversity impacts of the recycling sector compared with landfill waste disposal.

Other biodiversity impacts not addressed in detail within this report include:

- Land clearing for agricultural, industrial and residential development, resulting in habitat loss
- Hunting or exploitation of living species for food and biological resources
- Soil and groundwater contamination, leaching of industrial waste and wastewater discharge into natural waterways

7.10.1 Algal blooms and eutrophication

Algal blooms and food chain imbalance is one example of potentially negative impacts on biodiversity. Algae forms in water bodies feeding on simple nutrients such as dissolved nitrates and phosphates. If high concentrations of nutrients are present from industrial discharge or agricultural fertiliser runoff for example, a process known as eutrophication occurs. Eutrophication is the uncontrolled growth of algae ("algal bloom") followed by death and decomposition resulting in the consumption of all available dissolved oxygen within the water. As a result, the water becomes a "dead zone" with no oxygen to support other aquatic life, and large populations of marine species may die. Subsequently, animals higher up the food chain are also affected and the biodiversity of the region may be impacted (Chudleigh & Simpson, 2000).

Man-made eutrophication typically occurs when industrial discharges containing simple

nutrients find their way into natural water systems. Man-made sources of these discharges include:

- agriculture runoff of nitrate- and phosphate-rich fertilisers
- municipal sewage discharged after treatment
- dissolution of nitrogen dioxide from combustion engines, factories and furnaces
- runoff and erosion of organic matter from earthmoving and landfill sites
- discharge of phosphate detergents via municipal or industrial drainage.

Recycling prevents over 8,000 tonnes of phosphate each year entering Australian waterways, resulting in significantly lower chances of eutrophication and "dead zones" occurring within natural water bodies. This is equivalent to preventing 13,000 tonnes of direct fertiliser runoff.[22]

7.10.2 Why is biodiversity important?

Biodiversity relates to the entire spectrum of life on earth, including animals, plants and microorganisms. More specifically, biodiversity is the variety of different living species, and the way in which each species interacts and relies on a number of others to survive.

The most obvious example of this is the food chain. Each species typically relies on a number of other species as a food source, whether plant or animal. If even a single species becomes extinct or is threatened by environmental damage, the impacts may propagate up the food chain and result in food shortages for other animals. Alternatively if a single species dominates a certain habitat, other species may be affected by overpopulation and competition for food. For these reasons, healthy biodiversity should be seen as a maintaining a natural, sustainable balance of living species (Department of Industry, Tourism and Resources, 2007).

Representing the environmental health of complex, interacting ecosystems is an extremely difficult task, since many aspects of human activities impact upon natural biodiversity (Department of Industry, Tourism and Resources, 2007). Society's use of energy, emissions of greenhouse gases, consumption of water and generation of waste are all likely to impact upon the biodiversity of the land from which those resources were obtained. Therefore the majority of environmental indicators presented in this report already have some impact on biodiversity, and reductions achieved from recycling will have associated benefits.

As a result, any reduction in the demand for industrial processes leading to these discharges will result in a decrease in the risk of eutrophication, and hence decreased pressure placed on the natural ecosystem and better conditions for biodiversity to flourish.

---

[22] Based on triple superphosphate fertiliser containing 46% phosphate (P_2O_5) (Agrow Australia). 1 kg of fertiliser therefore contains 0.46 kg of P_2O_5, potentially resulting in 0.62 kg of PO_4^{-3} by mass balance of elemental phosphorous.

7.10.3 How does recycling provide benefits for biodiversity?

Table 23 provides a breakdown by material category of reduced eutrophication from recycling compared with disposal of waste to landfill, with the overall impacts expressed as kilograms of phosphate equivalent (kg PO_4^{-3} eq.). These "equivalents" account for the varied impacts of phosphates, nitrates and other simple nutrients which contribute to eutrophication if discharged in excess.

Table 23 Reduction in eutrophication in Australia from recycling instead of disposal to landfill (Detailed listing in Table 27)

CATEGORY	ANNUAL BENEFIT TO AUSTRALIA, 2008–09 (KG PO_4^{-3} eq.)
Masonry materials	586,275
Metals	5,647,247
Organics	422,867
Paper/cardboard	1,226,409
Plastics	208,763
Glass	303,140
Textiles and rubber	62,495
Hazardous Waste	Unavailable
Fly Ash	Unavailable
TOTAL	**8,457,196**

Sources:

LCA publications (Grant, 2005) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 24 provides a list of the top 5 materials for reduction in eutrophication per tonne recycled. Aluminium and rubber tyres produce the greatest reduction in eutrophication per tonne recycled.

Table 24 Top 5 materials for eutrophication reduction per tonne. (Full listing in Table 49)

MATERIAL	EUTROPHICATION REDUCTION PER TONNE RECYCLED (KG PO_4^{-3} eq./TONNE)
Aluminium	6.879
Rubber tyres	1.223
PVC	1.144
PET	1.088
Copper	1.035

Source:

LCA publications (Grant, 2005)

7.11 Health impacts and air quality

Recycling in Australia reduces airborne pollutants by over 19,000 tonnes each year, resulting in improved air quality and reduced health risks from respiratory illness.

7.11.1 How does air quality affect health and the environment?

Poor air quality may lead to increased health risks due to irritation, respiratory infection, and heart and lung problems (World Health Organisation, 2011). Poor air quality is most commonly associated with highly industrialised areas and cities with a high density of vehicle usage (World Health Organisation, 2011).

7.11.2 How does recycling provide benefits for health and the environment?

Airborne pollutants resulting in poor air quality and associated health risks are primarily associated with heavy industry, materials processing, energy generation (particularly in coal-rich Australia) and vehicle emissions (World Health Organisation, 2011).

As with the other environmental indicators addressed in this study, recycling generally reduces the frequency and intensity of industrial processing by reducing energy demand and the quantity of virgin raw materials required. This subsequently leads to lower emissions of airborne pollutants.

It is difficult to present one indicator of air quality. The LCA reference reviewed represented air quality impacts by the extent of photochemical oxidation caused by manufacturing processes (Grant, 2005). Photochemical oxidation is the process by which airborne pollutants (such as volatile hydrocarbons, nitrogen oxides and other gaseous emissions) react to form airborne particles and ground-level ozone. In high concentrations this results in significantly lower air quality. This effect is a distinctive feature above many major metropolitan cities or industrial

processing areas, visible as a thick haze or “smog”.

The units of measurement of this indicator are kilograms of acetylene (C_2H_2) equivalents. Acetylene is a simple hydrocarbon gas which is used in many LCA studies as a weighted indicator to summarise a variety of airborne hydrocarbon and nitrogen oxide emissions, each contributing to increased risk of photochemical oxidation and poor air quality. Therefore the figures in Table 25 and Table 26 represent a generalised estimate of the improvements in air quality achieved by recycling compared with material disposal to landfill.

Table 25 Reduction in photochemical oxidation in Australia from recycling instead of landfill disposal (detailed listing in Table 27)

CATEGORY	ANNUAL REDUCTION IN AUSTRALIA, 2008–09 (KG C_2H_2)
Masonry materials	694,429
Metals	12,406,739
Organics	1,652,525
Paper/cardboard	2,900,253
Plastics	1,289,976
Glass	160,018
Textiles and rubber	26,214
Hazardous Waste	Unavailable
Fly Ash	Unavailable
TOTAL	19,130,154

Sources:

LCA publications (Grant, 2005) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Table 26 Top 5 materials for photochemical oxidation reduction per tonne (full listing in Table 49)

MATERIAL	PHOTOCHEMICAL OXIDATION REDUCTION PER TONNE RECYCLED (KG C_2H_2 EQ./TONNE)
HDPE	12.408
Aluminium	6.910
Steel	2.712
PET	2.296
PP	2.216

Sources:

LCA publications (Grant, 2005)

7.12 Summary of environmental indicators for individual materials

The environmental indicators of energy usage, greenhouse gas emissions, water usage, waste generation, resource savings, eutrophication and poor air quality have been presented for broad categories of materials recycled in Australia.

Each of these categories includes a number of common individual materials which vary in their contribution to environmental benefits achieved due to recycling. A summary of these individual materials and the corresponding life cycle impacts of all recycling in Australia are presented in Table 27.

The quantities of each of these individual materials recycled in Australia in 2008–09 are presented in Appendix C, and the individual impacts of recycling per tonne of material are presented in Appendix E.

Table 27 Annual environmental benefits due to recycling compared with landfill of different materials in Australia, 2008–09

CATEGORY	MATERIAL	ENERGY (GJ)	GREENHOUSE (t CO_2–e)	WATER (kL)	LANDFILL WASTE (t)	EUTROPHICATION (kg PO_4^{-3} eq.)	PHOTOCHEMICAL OXIDATION (kg C_2H_2 eq.)
Masonry materials	Asphalt	2,796,616	35,251	1,034,043	1,245,551	352,515	15,276
	Bricks	190,164	13,583	855,737	726,698	4,075	4,754
	Concrete	2,142,452	122,426	7,835,252	6,672,207	116,305	220,366
	Clay, fines and rubble	1,353,431	174,442	802,033	2,117,367	112,285	451,144
	Plasterboard	27,402	1,495	-1,495	48,825	1,096	2,890
Metals	Steel	119,779,754	2,404,560	32,810,864	3,980,957	3,797,833	10,796,356
	Aluminium	42,554,046	3,939,284	44,912,726	346,799	1,529,251	1,536,143
	Other non-ferrous	11,163,923	1,061,021	1,846,734	340,269	320,162	74,241
Organics	Food Organics	12,970	18,014	31,705	25,220	7,134	19,888
	Garden Organics	1,004,941	684,215	1,026,323	1,304,285	166,777	481,089
	Timber	6,577,550	827,558	-24,520	490,404	156,929	894,988
	Other Organics	152,989	212,485	373,973	297,479	84,144	234,583
	Biosolids	14,332	19,906	35,035	27,869	7,883	21,976
Paper/cardboard	Cardboard/waxed cardboard	24,710,070	1,513,615	66,069,904	1,698,202	721,121	1,845,872
	Liquid paperboard (LPB)	-32,414	-3,020	87,175	3,121	2,295	6,885
	Magazines	4,131,118	657,223	8,100,359	456,495	224,686	500,526
	Newsprint	1,197,964	190,585	2,348,986	132,377	65,156	145,145
	Phonebooks	290,192	5,730	780,544	8,843	6,508	16,059

CATEGORY	MATERIAL	ENERGY (GJ)	GREENHOUSE (t CO_2–e)	WATER (kL)	LANDFILL WASTE (t)	EUTROPHICATION (kg PO_4^{-3} eq.)	PHOTOCHEMICAL OXIDATION (kg C_2H_2 eq.)
	Printing and writing paper	1,629,485	340,381	791,809	456,256	206,643	385,766
Plastics	PET	4,248,908	87,071	-1,755,322	63,362	88,952	187,714
	HDPE	4,240,228	75,194	-269,836	211,091	56,317	971,880
	PVC	397,548	15,090	612,976	7,160	10,368	2,683
	LDPE	Unavailable	96,574	Unavailable	Unavailable	Unavailable	Unavailable
	PP	2,229,338	62,509	-494,293	29,886	37,034	84,258
	PS	738,054	18,995	-137,712	10,106	8,669	23,402
	Other plastics	631,958	16,264	-117,915	8,653	7,423	20,038
Glass	Glass	6,420,594	586,401	2,355,543	959,114	303,140	160,018
Other	Leather and textiles	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
	Tyres and other rubber	3,274,488	54,677	2,669,975	54,677	62,495	26,214
Hazardous Waste	Quarantine	0	0	0	0	0	0
	Contaminated soil	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
	Industrial waste	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
	Asbestos	0	0	0	0	0	0
Fly ash	Fly ash	Unavailable	2,085,216	Unavailable	Unavailable	Unavailable	Unavailable
TOTAL	**ALL MATERIALS**	***241,878,104***	***15,316,746***	***172,580,603***	***21,723,273***	***8,457,196***	***19,130,154***

Sources:

LCA publications (Department of Environment, Climate Change and Water (NSW), 2010b; Hyder Consulting Pty Ltd, 2008; Grant, 2005; US EPA, 2006) and Australian recycling data (Hyder Consulting Pty Ltd, 2011b)

Notes:

Materials listed as "Unavailable" are those that had recycling quantities available, but no LCA results with which to derive the benefits calculated in this table.
Materials listed as "0" are those for which the quantity of recycling in Australia was not recorded in available data.

8. Social assessment

The social impacts of the recycling sector include:

Positive social impacts

- Creating employment opportunities, particularly for low skilled or employment disadvantaged individuals.
- A strong sense of civic pride and satisfaction felt through participation in recycling
- Improved natural resource base for future generations due to higher recycling uptake.

Negative social impacts

- Noise, air and odour pollution from recycling collection centres and reprocessing facilities.
- Costs to set up recycling infrastructure and education materials for new areas.
- Costs associated with innovations and technologies which are likely to be passed onto end consumers in product prices.

This section of the report provides a summary of the social impacts both positive and negative of the recycling sector for which a reasonable amount of research currently exists. Very few studies of a sizable scale have endeavoured to measure the impacts of the recycling sector or recycling more broadly upon the community. Therefore, the information on the social impacts of the recycling industry is largely anecdotal. This data limitation is also acknowledged in other studies (Hyder Consulting Pty Ltd, 2008, p. 40).

The social impacts of recycling that are cited in literature are largely derived from the environmental and economic benefits that have been discussed in sections 6 and 7of this report.

Positive social impacts

- Creating employment opportunities, particularly for low skilled or employment disadvantaged individuals.
- A strong sense of civic pride and satisfaction felt through participation in recycling (Hyder Consulting Pty Ltd, 2008, p. 36).
- Improved natural resource base for future generations due to higher recycling uptake (Hyder Consulting Pty Ltd, 2008, p. 37).

Negative social impacts

- Noise, air and odour pollution from recycling collection scheme centres and reprocessing facilities (Hyder Consulting Pty Ltd, 2008, p. 35).
- Costs to set up recycling infrastructure and education materials for new areas (Hyder Consulting Pty Ltd, 2008, p. 36).
- Costs associated with innovations and technologies which are likely to be passed to end consumers in product prices (Hyder Consulting Pty Ltd, 2008, p. 38).

8.1 Employment

A significant social impact of the sector flows from job creation, both directly and within associated industries including transport and equipment manufacture.

Social benefits generated by employment and the receipt of a stable income include increased access to goods and services, engagement with society and contribution to one's sense of self-worth (Recyle Iowa, 2001) (Hyder Consulting Pty Ltd, 2008) (Shire of Augusta Margeret River, 2010). These benefits can be attributed to the recycling industry only to the extent that those employed within it would not otherwise be employed or would be employed in a less personally and socially satisfying role. The extent of such benefits will vary depending upon the personal, economic and socio-demographic circumstances of the individual and are thus difficult to quantify (Bidet & Spear, 2003). As direct employment in the recycling sector per 10,000 tonnes of waste is more than three times greater than in the landfill sector (Access Economics, 2009), growth in the

industry could deliver a net gain in employment and thus a rise in the social benefits outlined above.

Select jobs within the recycling sector such as manual sorting are low skilled and anecdotally it is claimed that these roles are often occupied by those who would otherwise have difficulty finding employment. To this end, there are a number of organisations within Australia, many operating on a social enterprise model[23], that employ people experiencing employment disadvantage to collect, receive and disassemble goods for reuse, re-manufacture and/or recycling (Community Recycling Network Australia, 2011).

Whilst not explicitly focused on recycling, studies into social enterprise employment initiatives in Australia, United Kingdom and United States (Fair Business) (The Roberts Enterprise Development Fund) have measured the social benefits of work experienced by the employment marginalised. They include the benefits listed above and others associated with unemployment and under-employment. Depending on the individual, the employment position and the focus of the social enterprise, if relevant, employees may be able to address long standing mental and physical health issues, housing stability and education. For some individuals, their work for a social enterprise can provide a route to mainstream employment.

Green Collect is an environmental services company that offers work and training opportunities to people who have experienced barriers to employment. The company collects and processes office waste from businesses around Melbourne. The following quotes from employees illustrate the social value created by social enterprise employment initiatives. For employees they can deliver an increased sense of belonging:

> *'If you see me smiling all the time, it's because this is the first time I have worked in 20 years'*

And greater self-confidence from having greater control over personal finances:

> *'I'm earning money now and the money I spend is what I've earned.'* (Andrews, 2011).

Employment of people who otherwise face barriers to employment delivers benefits to government (and therefore to tax payers) through tax on increased earnings, reduced spending on social security and concessions and reduced use of government-funded health and welfare services. Community benefits include community regeneration and benefits associated with a healthier and more engaged society (Mestan & Scutella, 2007).

Due to collection constraints and economies of scale, the bulk of materials reprocessing is located near major urban centres, therefore not offering many employment opportunities in regional

[23]Social enterprises are businesses that are set up for the principal purpose of delivering social outcomes through trading activity. Profit-making social enterprises utilise the majority of their profits to advance their social goals.

areas. The bulk of the employment opportunities in regional areas are in collection and transfer of materials.

8.2 Reducing landfill

In reducing the volume of waste sent to landfills the recycling sector may help address some of the social externalities associated with landfills. It is not clear that this impact is significant. Many of the reported amenity impacts of landfill are associated with practices in place some time ago and the regulatory environment and technologies and management practices have improved substantially in recent years (Scholl, 2010).

A number of the social issues associated with landfill also occur during recycling – such as the transport of materials and resulting road hazards, the amenity impacts of facilities and noise and odour emissions – though the magnitude of the issues may differ (Hyder Consulting Pty Ltd, 2008) (Productivity Commission, 2006).

Within the literature, the most significant social impact allegedly associated with landfilling and not yet with recycling is ill health. There are numerous Australian and international studies into increased recorded health risks (e.g. low birth weight, congenital anomalies, cancers) and increased self-reported health symptoms (e.g. fatigue, headaches) among those residing near waste sites. Attribution is however difficult to establish. Meta-analysis of fifty papers (including many multi-study reviews) was unable to conclude whether reported ill health symptoms are an effect of chemicals present within the waste, the stress and fears related to the waste site, or reporting bias (Vrijheid, 2000).

Most recyclable materials are inert and thus if sent to landfill are unlikely to contribute to leachate and landfill gas (Productivity Commission, 2006). Removal of these materials from the waste stream is unlikely to impact reported health risks of landfill associated with chemical pollution.

8.3 Amenity impacts of recycling facilities

There is a risk associated with many industrial facilities, not specifically recycling facilities, of noise, air or odour pollution impacting on nearby residents. These amenity issues are more often associated with some composting facilities, due to the odour released during the biological processes that take place.

Other amenity issues potentially associated with recycling facilities include:

- stockpiled materials presenting a fire or safety hazard that may cause stress for local residents
- traffic congestion associated with truck movements.

The extent of these impacts and whether impacts associated with recycling facilities exceed impacts associated with waste management facilities or industrial facilities in general are unknown.

8.4 Attitudes and behaviours

Social impacts can also be inferred from public attitudes and behaviours towards recycling and recycled products. That individuals and organisations voluntarily and without persuasion engage in recycling and choose to purchase goods containing recycled material, frequently at a small premium, is evidence that it is supported as an inherent social good. In 2009 over 91% of Australian households utilised municipal kerbside recycling services indicating strong community support for this form of recycling (Australian Bureau of Statistics, 2009).

Such support is clearly not uniform across the Australian community and depends on a number of factors such as:

- characteristics of public place, municipal and work-based recycling programs such as the convenience of accessing collection services
- perceived and actual impacts of recycling collection and processing on resident communities which is associated with public understanding of waste and recycling processes
- the level of social cohesion between recycling participants and strength of civic pride within an area
- perceived and actual environmental improvements from recycling that link strongly with social wellbeing (Schnaiberg, Weinberg, & Pellow, 2000) (Hyder Consulting Pty Ltd, 2008) (White, Smith, Terry, Greenslade, & McKimmie, 2009).

Under an economic paradigm, if individuals engage in recycling because they have been persuaded to do so by a campaign this may represent a social cost associated with imposing a heavier (perceived) responsibility on consumers. This represents a welfare loss, which is not necessarily outweighed by perceived benefits of adhering to socially desirable behaviour (Bruvoll & Karine, 2004).

Furthermore, positive attitudes regarding the efficacy of recycling can potentially hinder support for other waste reduction activities. Qualitative research suggests that people do not feel it is necessary to reduce packaging if recycling services are readily available (United Kingdom Cabinet Office , 2000).

9. Regulatory environment

- Recyclers are affected by legislation and policy at the national, state/territory and local level.
- At the national level, the recently introduced National Waste Policy and *Product Stewardship Act 2011* are intended to provide nationally consistent frameworks for improved resource recovery in Australia. *National Environment Protection Measures* for used packaging and the movement of controlled waste create obligations for recycling sector participants to manage and report on waste and recycling.
- At the state and territory level, environment protection legislation establishes the rules within which the sector must operate. Resource recovery legislation, policies and strategies establish recycling goals and targets and provide direction and support for the achievement of the goals.
- At the local level, councils establish local policies and service standards for recycling services. The planning scheme administered by local governments determines whether and where the recycling sector can establish facilities.

The Australian recycling sector operates within an environment that is regulated by the Australian and state/territory governments. The regulatory environment at the national level and within each state and territory is presented below.

Planning regulations, policies and schemes have a substantial impact on the recycling sector. The planning scheme determines whether and where the recycling sector can establish facilities. The planning schemes vary across local government areas, and due to the number of local government areas in Australia it is not possible to provide an outline of the planning schemes within the scope of this report.

9.1 Roles and responsibilities

Waste and recycling policy in Australia is developed and implemented across all levels of Government:

- The Australian Government is responsible for waste legislation, strategy and policy framework at the national level.
- State and territory governments are responsible for waste management and regulation under their legislation, policies, plans and programs.
- Local governments typically act across their municipality under guidance and delegation of the state/territory government, however may develop and manage local strategies, regulations, and programs.

9.2 National

DSEWPaC[24] works collaboratively with state and territory governments on the National Waste Policy through the Environment Protection and Heritage Council (EPHC). In future these arrangements may change in response to the Council of Australian Governments (COAG) process of reforming ministerial councils.

DSEWPaC and the EPHC are supported by the:

- National Environment Protection Council (NEPC) - Commonwealth statutory authority providing assistance in project management and administration of the development of national environmental policy and *National Environment Protection Measures* (NEPMs).
- Council of Australian Governments (COAG) - peak intergovernmental forum in Australia, comprising the Prime Minister, state Premiers, territory Chief Ministers and the President of the Australian Local Government Association. COAG's role is to initiate, develop and monitor

[24] Formerly the Department of Environment, Water, Heritage and the Arts (DEWHA)

the implementation of policy reforms that are of national significance and which require cooperative action by Australian governments.

9.2.1 Legislation and regulation

National legislative frameworks implemented by the Australian Government, either solely or in collaboration with the EPHC include the:

- National Environment Protection Measures (NEPM) – framework-setting statutory instruments defined in the NEPC Act. They outline agreed national objectives for protecting or managing particular aspects of the environment. One example of a NEPM impacting on the recycling sector is the *NEPM for the Movement of Controlled Waste between States and Territories* which ensures wastes are properly identified, transported, and handled in ways that are consistent with environmentally sound practice.
- *Product Stewardship Act 2011* – framework to manage the environmental, health and safety impacts of products, and in particular those impacts associated with the disposal of products. The framework includes voluntary, co-regulatory and mandatory product stewardship. A list of products being considered for coverage by the legislation will be published each year. Products currently on the National Waste Policy Implementation Plan for product stewardship action include televisions and computers, packaging, tyres and mercury containing lights (Environment Protection and Heritage Council, 2010a).

9.2.2 International frameworks

The Australian Government is responsible for meeting obligations to international agreements with waste management implications to which Australia is a signatory. These include:

9.2.2.1 Agenda 21

The *Agenda 21* action plan for sustainable development was adopted by over 178 Governments, including Australia in 1992. *Agenda 21* is divided into four sections, one being 'Conservation and Management of Resources for Development' that includes chapters on the environmental management of toxic chemicals, hazardous wastes and solid wastes. The hierarchy of objectives relating to waste are:

- minimising waste
- maximising environmentally sound waste reuse and recycling
- promoting environmentally sound waste disposal and treatment
- extending waste service coverage.

9.2.2.2 The Basel Convention

The *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1992)* is a global treaty relating to the transfer of hazardous waste across borders. In particular, the *Basel Convention* was developed to restrict the dumping of hazardous waste by developed countries in developing countries. As a signatory of the Basel Convention, Australia is obligated to take measures to ensure that:

- generation of hazardous and other wastes are minimised
- adequate disposal facilities are available for the environmentally sound management of wastes
- persons involved in the management of wastes take necessary steps to prevent pollution and/or minimise the consequences for human health and the environment.

9.2.2.3 The Stockholm Convention

The *Stockholm Convention on Persistent Organic Pollutants (2004)* is an international treaty that aims to protect human health and the environment from persistent organic pollutants (POPs). Under the *Stockholm Convention* the use of 21 chemicals (increased from 12 in late 2010) has been eliminated or restricted. Australia submitted a National Implementation Plan to the Stockholm Convention Secretariat in 2006 outlining actions undertaken to reduce POPs.

9.2.2.4 The Rotterdam Convention

The *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998)* was developed to share global responsibility and foster cooperation in the international trade of certain hazardous chemicals. The convention covers 32 pesticides and 11 industrial chemicals that have been banned or severely restricted for health or environmental reasons. The *Rotterdam Convention* is complementary to the *Stockholm Convention*.

9.2.3 Pricing signals

Pricing signals in Australia are legislatively applied at state/territory level (see details under each state/territory).

9.2.4 Strategies

National waste strategies have been developed under the National Waste Policy framework (see section 9.2.5.1 below for further detail).

9.2.5 Policies, programs and initiatives

9.2.5.1 National Waste Policy

The *National Waste Policy: Less waste, more resources* was developed in 2009 as a framework to reduce waste generation and improve resource recovery in Australia over the decade to 2020. The policy provides the basis for collaboration among the jurisdictions to deliver effective and efficient approaches to national waste issues.

The aims of the policy are to:

- avoid the generation of waste, reduce the amount of waste (including hazardous waste) for disposal, manage waste as a resource and ensure that waste treatment, disposal, recovery and reuse is undertaken in a safe and environmentally sound manner
- contribute to the reduction in greenhouse gas emissions, energy conservation and production, water efficiency, and the productivity of the land.

Six key directions that would benefit from a national or coordinated approach were identified as:

- **Taking responsibility…** for reducing the environmental, health and safety footprint of products and materials across the manufacture-supply-consumption chain and at end of life.
- **Improving the market**... for waste and recovered resources, with local technology and innovation being sought after internationally.
- **Pursuing sustainability**... by generating less waste and improving the use of waste to achieve broader environmental, social and economic benefits.
- **Reducing hazard and risk**… reduction of potentially hazardous content of wastes with consistent, safe and accountable waste recovery, handling and disposal.
- **Tailoring solutions**... to increase capacity in regional, remote and Indigenous communities to manage waste and recover and re-use resources.
- **Providing the evidence**... with meaningful, accurate and current national waste and resource recovery data and information in order to measure progress and educate and inform the behaviour and choices of the community.

The policy outlines sixteen priority strategies to support these directions at a national level through collaboration across all levels of government[25]. The National Waste Policy Implementation Plan allocates the 16 priority strategies to seven National Policy cluster working groups and provides selected milestones for these strategies to 2015, with an initial focus on product stewardship.

[25] Priority strategies can be found at http://www.environment.gov.au/wastepolicy/about/index.html#strategies

9.3 Australian Capital Territory

The Department of Environment, Climate Change, Energy and Water (DECCEW) is responsible for developing and overseeing environmental policies and programs, including preparation of the ACT's waste strategy.

DECCEW is supported by ACT NOWaste. Actions undertaken by ACT NOWaste include:

- strategic planning and policy advice on waste management matters
- planning, development and management of waste assets, infrastructure and services
- research of innovative resource recovery processes
- engaging with the community on waste issues.

The Environment Protection Authority (EPA ACT) is a statutory position occupied by an individual who is responsible for enforcement of the *Environment Protection Act 1997*.

An overview of how key actors interact and influence the operating environment for the recycling sector in the ACT is illustrated in Figure 21 below.

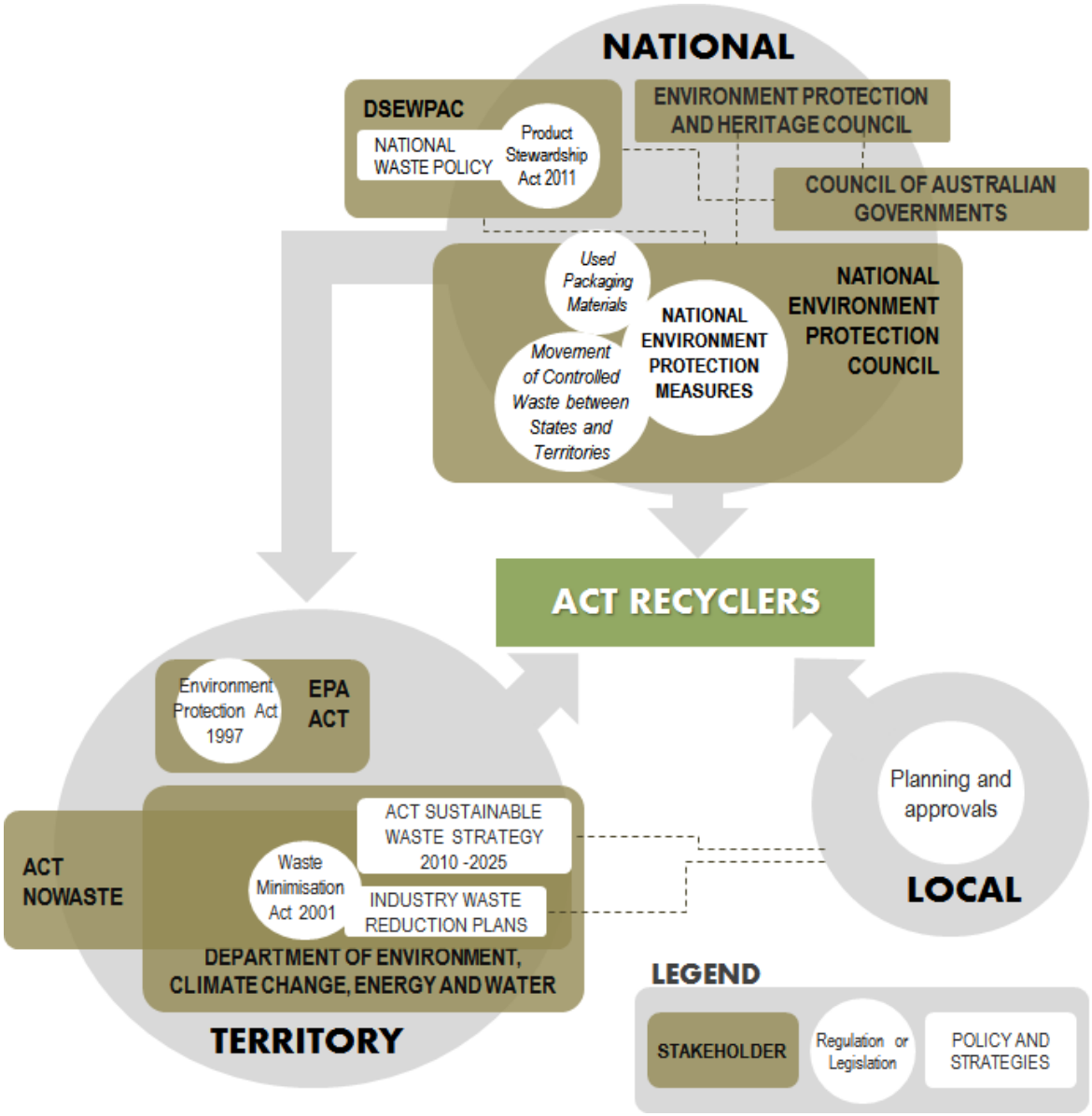


Figure 21 ACT recycling industry operating environment

9.3.1 Legislation and regulation

Primary waste and resource recovery objectives under the *Environment Protection Act 1997* are to:

- prevent environmental degradation and adverse risks to human health and the health of ecosystems by promoting pollution prevention, clean production technology, reuse and recycling of materials and waste minimisation programs
- control the generation, storage, collection, transportation, treatment and disposal of waste with a view to reducing, minimising and, where practical, eliminating harm to the environment.

The *Waste Minimisation Act 2001* provides a more focussed legal framework for waste management, regulation and minimisation. The Act outlines criteria for Industry Waste Reduction

Plans designed to encourage industry members to take responsibility for their waste generation and consumption of natural resources. The *Waste Minimisation Act* also includes provisions on the supply of waste management services and disposal facilities throughout the ACT.

9.3.2 Pricing signals

A levy on landfill waste is used as a price mechanism to encourage recycling. Free recycling drop-off centres are available for paper, cardboard, glass bottles and jars, rigid plastics containers, and steel and aluminium cans. Other priority wastes, e-waste, mattresses and tyres, may attract a nominal fee lower than that of the landfill waste charge.

9.3.3 Strategies

The *Draft ACT Sustainable Waste Strategy 2010 -2025* was released in late 2010 as an update to the original No Waste by 2010 Strategy from 1996. The primary aim of the Strategy is to 'ensure that the ACT leads innovation to achieve full resource recovery and a carbon neutral waste sector'.

The Strategy highlights four overarching outcomes to be achieved by 2025 through application of the principles of the waste management hierarchy:

- less waste generated
- full resource recovery
- a clean environment
- carbon neutral waste sector.

The strategy establishes a region-wide target of at least 90% resource recovery by 2025, with interim targets of at least 80% and 85% in 2015 and 2020, respectively.

9.3.4 Policies, programs and initiatives

The DECCEW also implements a number of local waste and recycling education programs that include the ACTSmart Office and ACTSmart Business.

9.3.5 Incentives

No financial incentives specific to the ACT were identified.

9.4 New South Wales

The Office of Environment and Heritage (OEH)[26], a division of the NSW Department of Premier and Cabinet, is responsible for developing sustainability policy and can act as an environmental regulator for the statutory Environment Protection Authority (NSW EPA).

[26] OEH replaced the former Department of Environment, Climate Change and Water (DECCW).

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in the NSW is provided in Figure 22 below.

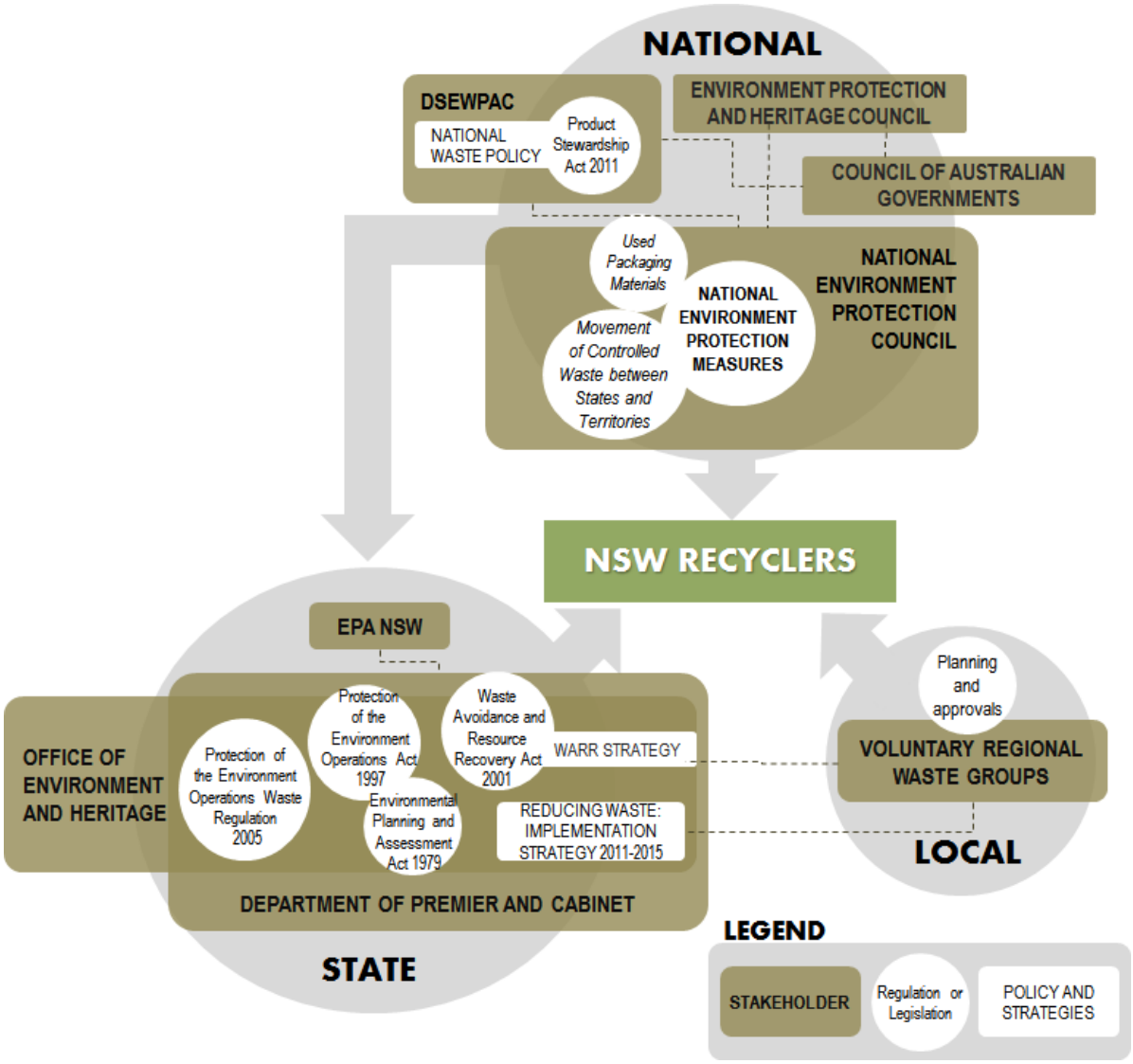


Figure 22 NSW recycling industry operating environment

In addition to these government bodies, Voluntary Regional Waste Groups (VRWG) promote cooperation in waste management in rural and regional areas, including:

- North East Waste Forum
- Midwaste (Mid North Coast)
- Northern Inland Regional Waste
- NetWaste (Central and West)
- Riverina and Murray Regional Organisation of Councils (Murray division)
- Riverina and Murray Regional Organisation of Councils (Riverina West division)

- Riverina Eastern Regional Organisation of Councils
- South East Resource Recovery Regional Organisation of Councils.

Each VRWG comprises representatives from neighbouring councils to provide the opportunity to share resources and knowledge, and coordinate regional and sub-regional waste initiatives. Supporting these groups is Renew NSW, an umbrella group of these eight VRWGs that advises on infrastructure matters in rural areas.

Waste management is divided into three geographic regions within NSW:

- Sydney Metropolitan Area (SMA)
- Extended Regulated Area (ERA), encompassing the Hunter, Central Coast and Illawarra regions
- Regional Regulated Area (RRA) which makes up the remaining regions within the state.

9.4.1 Legislation and regulation

The key legislative acts through which the OEH administers their regulatory and policy framework are the:

- *Protection of the Environment Operations Act 1997 (POEO Act)* - addresses the regulation of waste, including licensing of waste and resource recovery facilities. Objective 3d(i) of the Act seeks to reduce risks to human health and prevent the degradation of the environment through the reduction in the use of materials and the reuse, recovery or recycling of materials.

  Supporting the *POEO Act* is the *Protection of the Environment Operations (Waste) Regulation 2005*, which encompasses Resource Recovery Exemptions, environmental offence provisions and the establishment of waste levies.
- *Waste Avoidance and Resource Recovery Act 2001 (WARR Act)* - defines the waste management hierarchy ranging from avoidance (most preferred) through to resource recovery through reuse, recycling, reprocessing and energy recovery, and disposal (least preferred). The WARR Act identifies the need for periodic strategic planning surrounding waste, with waste strategies to be developed at intervals of not more than five years.
- *Environmental Planning and Assessment Act 1979 (EP&A Act)* - regulates land use and the development of waste and resource recovery facilities.

The *Protection of the Environment Operations (Waste) Regulation 2005* implements the *NEPM for the Movement of Controlled Waste between States and Territories* in NSW. It outlines the tracking requirements for waste being transported within NSW and between NSW and other states and territories.

9.4.2 Pricing signals

A NSW Waste and Environment Levy is paid per tonne of landfill waste disposed of at licensed receiving facilities to encourage resource recovery. Levy deductions are applied to waste taken off-site for legitimate recycling or reuse. The waste levy differs across the SMA, ERA and RRA regions.

Legislation has been passed to increase the current SMA and RRA levies by $10/tonne plus consumer price index (CPI) each year until 2015–16. The ERA levy is set to increase by $11.50/tonne plus CPI each year until 2013–14, where the SMA and ERA levies should reach parity (Lloyd Consulting Pty Ltd, 2010). A proportion of revenue from the levy is funnelled into resource recovery initiatives.

9.4.3 Strategies

9.4.3.1 Waste Avoidance and Resource Recovery Strategy

The NSW Waste Avoidance and Resource Recovery Strategy was first developed under the WARR Act in 2003, and has since been superseded by the 2007 edition (the WARR Strategy). The WARR Strategy includes goals and targets for 2014 for the avoidance or reduction of waste generation and increased recovery and reuse of secondary resources.

Two of the four key result areas in the WARR Strategy relate explicitly to resource recovery, and are outlined in Table 28. The WARR Strategy targets were reaffirmed 2011 in in the *NSW 2021: A plan to make NSW number one*.

Table 28 Key result areas and targets from WARR Strategy

KEY RESULT AREA	2014 TARGETS
1. Increased resource recovery and use of secondary resources	By 2014, to: ▪ Increase recovery and use of materials from the municipal waste stream from 26% in 2000 to 66% ▪ Increase recovery and use of materials from the C&I waste stream from 28% in 2000 to 63% ▪ Increase recovery and use of materials from the C&D waste stream from 65% in 2000 to 76%
2. Reducing toxic substances in products and materials	By 2014, to phase out priority substances in identified products as a first choice, or, if not possible, to achieve maximum recovery for reuse.

In May 2010, the NSW Government commissioned the Review of Waste Strategy and Policy in NSW (the Richmond Review) to determine whether the resource recovery policies and programs supporting the WARR Strategy were sufficient to achieve the 2014 targets and goals. This review proposed 23 recommendations for enhancing the WARR Strategy, and identified issues in strategic planning for waste and resource recovery infrastructure.

9.4.3.2 Reducing Waste: Implementation Strategy 2011-2015

DECCW published *Reducing Waste: Implementation Strategy 2011-2015* (SDIP) in response to the Richmond Review. This implementation strategy represents a further stage of initiatives that focus on those specific waste types, collection systems and infrastructure needs where the potential for improvements has been identified as the greatest. By 30 September 2011, the NSW Government will develop sub-targets for each of the 2014 waste targets to avoid waste generation and increase resource recovery of key types of material.

9.4.3.3 Sydney Metropolitan Strategy

The Sydney Metropolitan Strategy 2010 (SMS) provides a planning framework to manage growth and economic development in a sustainable manner. An objective in the SMS is to minimise and recycle waste through strategic planning and location of infrastructure and Government support for investment in alternative waste technologies.

9.4.4 Policies, programs and initiatives

The WARR Strategy aims to increase resource recovery from the municipal, C&I, C&D and hazardous waste streams. In support of the WARR Strategy objectives, a range of policies and programs have been implemented across households, councils, businesses and within Government departments to promote greater resource recovery capabilities.

9.4.4.1 Infrastructure policies

The *State Environment Planning Policy (Infrastructure) 2007* is a framework for the delivery of private and public infrastructure, and includes criteria which determine the assessment process and requirements for gaining planning approval for waste facilities.

The *State Environment Planning Policy (Major Development) 2005* outlines threshold tests for establishing the consent authority and assessment criteria for proposed waste or resource recovery facilities. For small-scale waste facilities, councils are the authority for assessing and granting approval of proposals. Larger-scale waste facilities are approved by Joint Regional Planning Panels, with requirements including project consistency with the objectives provided in the WARR Strategy.

9.4.4.2 Priority wastes take-back programs

OEH facilitates the collection, treatment and, where possible, resource recovery of hazardous household materials through its Chemical Cleanout program.

9.4.5 Incentives

The NSW Government provides incentives for improved sustainability performance, resource recovery and infrastructure development through grants, funding and cost exemptions; a proportion of which is sourced through landfill levies.

9.4.5.1 Waste and Sustainability Improvement Payment program

Processing and recycling of the municipal waste stream is undertaken by local councils. The Waste and Sustainability Improvement Payment (WaSIP) program provides funding to local council projects that improve waste avoidance, resource recovery and sustainability outcomes across their municipalities. The WaSIP program commenced in the 2009–10 financial year and will run until 2015–16, with a total investment of $256 million. In order to qualify for funding under the WaSIP scheme, councils are required to meet the cumulative Waste and Sustainability Improvement Payment Standards developed each year. Standard requirements include sustainability reporting, undertaking of specific resource recovery schemes, and development and utilisation of waste action plans.

9.4.5.2 Resource recovery exemptions

Resource recovery exemptions negate the requirement for waste facility operators to hold an environmental protection licence or pay the waste and environmental levy if suitable land application or cogeneration opportunities are realised (i.e. for reuse). OEH has worked closely with local councils, public authorities and industry to develop and promote such exemptions.

9.5 Northern Territory

The Environment Protection Agency (EPA NT) is an independent statutory body with mandate to review and reform environmental legislation, regulations and procedures in the NT.

The Department of Natural Resources, Environment, The Arts and Sport is responsible for promoting and encouraging sustainable waste management practices throughout the NT through its Waste and Pollution Management division. This includes developing waste management legislation, policies and strategies in consultation with industry, local government and other key stakeholders.

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in the Northern Territory is provided in Figure 23 below.

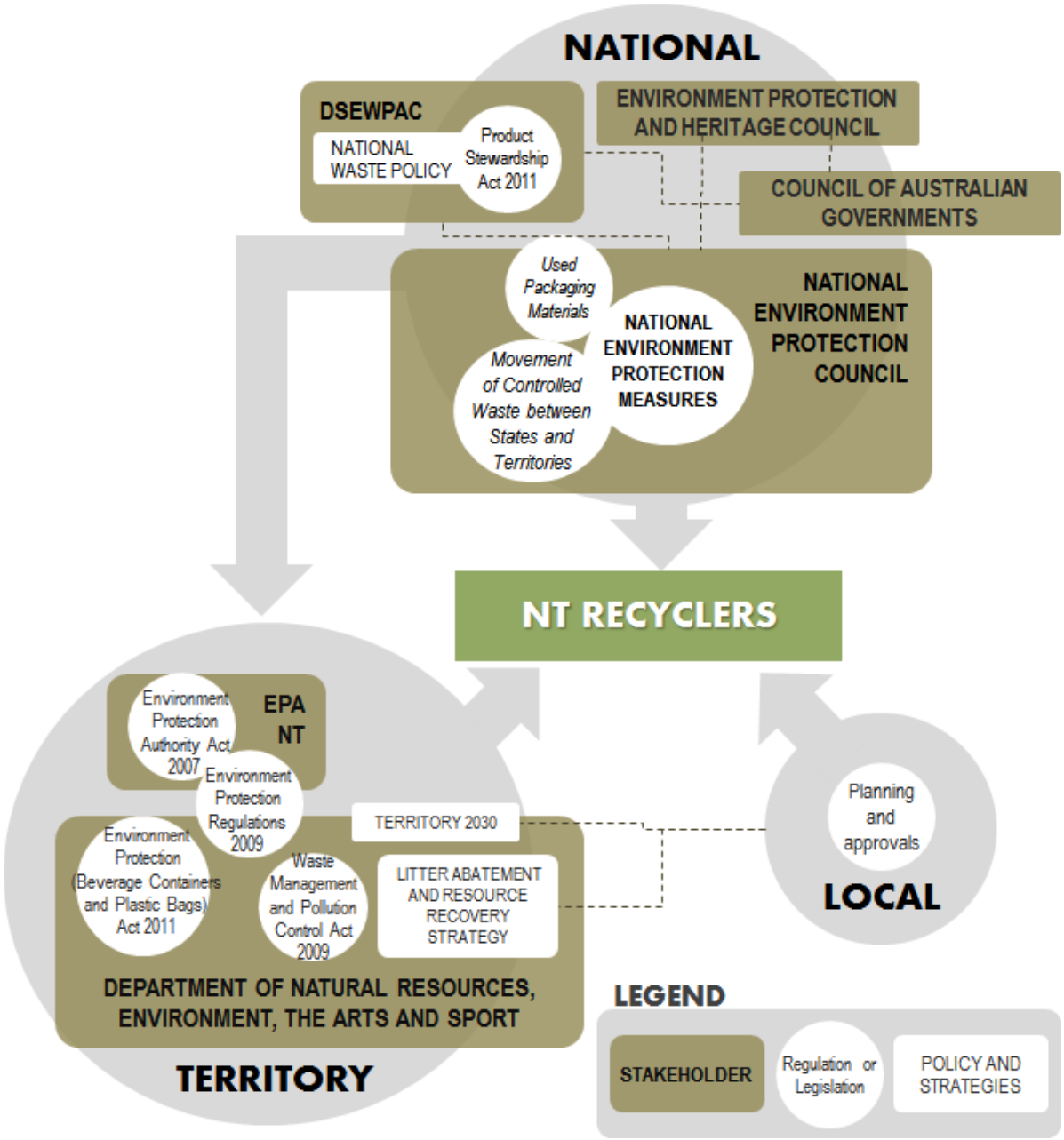


Figure 23 Northern Territory recycling industry operating environment

9.5.1 Legislation and regulation

The main Acts regarding waste and environmental protection within the Northern Territory are:

- *Environment Protection Authority Act 2007*
- *Waste Management and Pollution Control Act 2009*.

In addition the *Environment Protection (Beverage Containers and Plastic Bags) Bill 2010* was passed in February 2011 relating to the establishment of a NT container deposit scheme.

9.5.1.1 Environment Protection Authority Act 2007

The EPA NT must act with regard to principles of ecologically sustainable development, and in a consultative manner with other government agencies, industry and the community, as defined by the *Environment Protection Authority Act 2007*, which establishes and outlines the main functions of the EPA NT.

9.5.1.2 Waste Management and Pollution Control Act 2009

The *Waste Management and Pollution Control Act 2009* encompasses environmental protection licences and approvals; outlines criteria for environmental audit and compliance plans, offences and penalties relating to waste and pollution; and creates two duties relating to waste, pollution and the environment (detailed below).

The main resource recovery objectives of the Act are:

- to avoid and reduce the generation of waste
- to increase the re-use and recycling of waste
- effective manage waste disposal.

The first duty is a 'General Environmental Duty', which requires any person undertaking an activity which causes, or may cause, pollution to take all reasonable steps to minimise the pollution or environmental harm and to reduce the generation of waste. The second is the 'Duty to Notify of Incidences Causing or Threatening to Cause Pollution', which relates to a specific incident, such as a spill, that could threaten the environment.

9.5.1.3 Environment Protection (Beverage Containers and Plastic Bags) Act 2011

The *Environment Protection (Beverage Containers and Plastic Bags) Act* aims to reduce beverage container waste, increase resource recovery, reuse and recycling and to regulate the supply of single use, non-biodegradable plastic bags.

9.5.2 Pricing signals

At present, the NT does not have a landfill levy in place for waste disposed to landfill.

9.5.3 Strategies

In 2009, the Department of the Chief Minister released *Territory 2030*, the first long-term strategic plan developed for the NT. One of the six key areas targeted in the *Plan* is the environment, which includes a target to reduce waste to landfill by 50% on 2010 levels by 2020. Actions identified include improved and increased data collection on waste to landfill and recycling quantities across the NT, providing increased capacity for residential recycling, and promoting waste reduction from development sites. It has been proposed that every two years, the government will publish an

official report tracking progress against each target. In addition, an Independent Review of the Plan will be undertaken every five years.

The *Litter Abatement and Resource Recovery Strategy* (LARRS) was adopted by the Department of Natural Resources, Environment and the Arts (DNREA) in 2003 and includes the specific aim to better manage litter and increase resource recovery rates. The Strategy is accompanied by the LARRS implementation plan.

9.5.4 Policies, programs and initiatives

9.5.4.1 Keep Australia Beautiful Council: Northern Territory

Keep Australia Beautiful Council: Northern Territory (KABC NT) is a non-government, not-for-profit community organisation which develops litter reduction and waste management programs in remote NT communities. KABC NT partner with the NT Government and the Packaging Stewardship Forum of the Australian Food and Grocery Council, to establish resource recovery facilities in remote indigenous communities that do not have recycling collection and reprocessing infrastructure.

9.5.5 Incentives

9.5.5.1 NT Litter and Recycling Grants

The NT Litter and recycling grants program supports the LARRS with $250,000 in annual funding to support community groups and individuals promote local action and improvement on litter and recycling issues.

9.5.5.2 EnvironmeNT Grants

EnvironmeNT Grants are available to schools, community groups, local government and industry members to assist with environmental projects and educational activities in the NT, including resource recovery and waste minimisation projects. Grants are available annually for individual and school projects which may be research and development, educational or infrastructure-related, while operational grants are provided triennially to non-government organisations providing significant *ongoing* environmental services.

Not-for-profit organisations, private businesses, local government bodies, and industry members are eligible for individual grants, typically offered at below $10,000; projects with exceptional merit have the potential for increased funding.

9.6 Queensland

In Queensland, waste and resource recovery issues are managed by the Department of Environment and Resource Management (DERM).

There are also several local government associations (LGA) which have formed Council coalitions to work on regional waste strategies. The Central Queensland Waste Management Group is facilitated by the Central Queensland LGA and has recently developed a waste management strategy. Similarly, the South East Queensland (SEQ) Council of Mayors comprises of councils from a number of SEQ councils provides policy input and advocacy on a range of issues including waste management.

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in Queensland is provided in Figure 24 below.

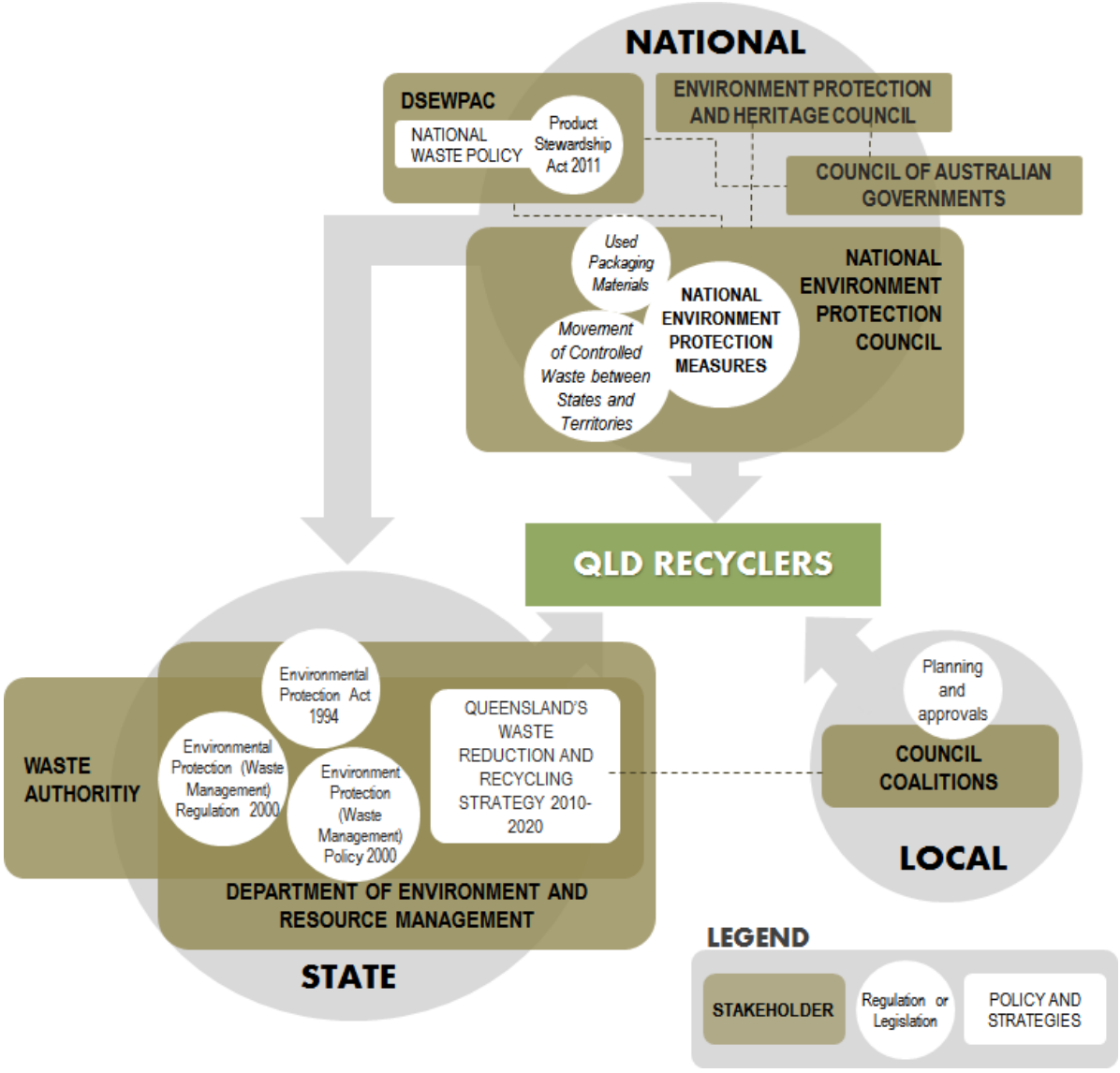


Figure 24 Queensland recycling industry operating environment

9.6.1 Legislation and regulation

The main legislative Act in Queensland surrounding waste is the *Environmental Protection Act 1994*. Supporting this Act is the *Environmental Protection (Waste Management) Regulation 2000*, which was published to address waste issues not clearly defined in the Act. The Regulation includes sections on beneficial use of waste resources and the reuse of post-consumer packaging materials. The Regulation implements the *NEPM for the Movement of Controlled Waste between States and Territories* in Queensland.

9.6.2 Pricing signals

As part of a waste reform package released in 2010, the Queensland Government committed to introducing a waste disposal levy across 34 municipalities with populations greater than 10,000 people. The waste disposal levy applies at the point of waste disposal to encourage waste reduction and focus on resource recovery. The initial levy was priced at $35 per tonne of unregulated waste. It has been estimated that the levy will raise $379 million in revenue in its first four years. The levy is to be introduced from 1 December 2011.

9.6.3 Strategies

Queensland's *Waste Reduction and Recycling Strategy 2010–2020* (QWRRS) is the primary framework for waste management. QWRRS forms a part of the 2010 Queensland Government reform package for waste management and resource efficiency. The strategic goals of QWRRS are to reduce waste, optimise recovery and recycling, and develop sustainable waste industries and under the principles of the waste hierarchy, resource efficiency and capacity building.

Resource recovery targets for 2020 are listed in Table 29 however QWRRS also lists interim targets for 2014 and 2017, measured from a baseline year of 2008.

Table 29 Resource recovery targets from QWRRS

KEY RESULT AREA	2020 TARGETS
Sector-wide recovery targets	By 2020, to: ▪ Increase recycling of municipal solid waste from 23% in 2008 to 65% ▪ Increase recycling of C&I solid waste from 18% in 2008 to 60% ▪ Increase recycling of C&D solid waste from 35% in 2008 to 75% ▪ Increase recycling of regulated waste from 30% in 2008 to 45%

9.6.4 Policies, programs and initiatives

9.6.4.1 The Environment Protection (Waste Management) Policy

The *Environmental Protection (Waste Management) Policy* was released in 2000, and provides a strategic framework and the following principles for waste management:

- The waste management hierarchy: strategies for managing waste, in order of preference are: avoid, reuse, recycle, recovery of energy, treatment and disposal
- The polluter pays principle: the waste generator should, where possible, bear all the costs associated with waste management
- The user pays principle: all costs associated with the use of a resource should, where possible, be included in the price of goods and services developed from that source
- The product stewardship principle: the producer or importer of a product should take all reasonable steps to minimise environmental harm from the production, use and disposal of the product.

The Policy also outlines criteria for environmental management decisions concerning waste, recommended contents of waste management and industry waste reduction programs, and provides for the state and local governments to undertake strategic planning for waste management.

9.6.5 Incentives

The revenue obtained through the introduction of the waste levy in 2011 will be used to fund programs for business and industry to reduce waste generation, to encourage industry investment in recycling infrastructure and to develop environmental projects and initiatives.

9.6.5.1 Waste Avoidance and Resource Efficiency Fund

The Waste Avoidance and Resource Efficiency (WARE) Fund allocates $159 million over the first four years of the strategy's implementation (2010–14) to assist in infrastructure investment and upgrades for business and local governments to meet waste and resource recovery challenges; promote best practice waste management; and improve waste and resource recovery data collection across the state.

9.7 South Australia

The primary state government bodies responsible for waste management are:

- Zero Waste South Australia (ZWSA) - responsible for strategic planning, grant provisions and education in waste-related issues, and the
- Environmental Protection Agency South Australia (EPA SA), an environmental regulator responsible for the control of waste.

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in South Australia is provided in Figure 25 below.

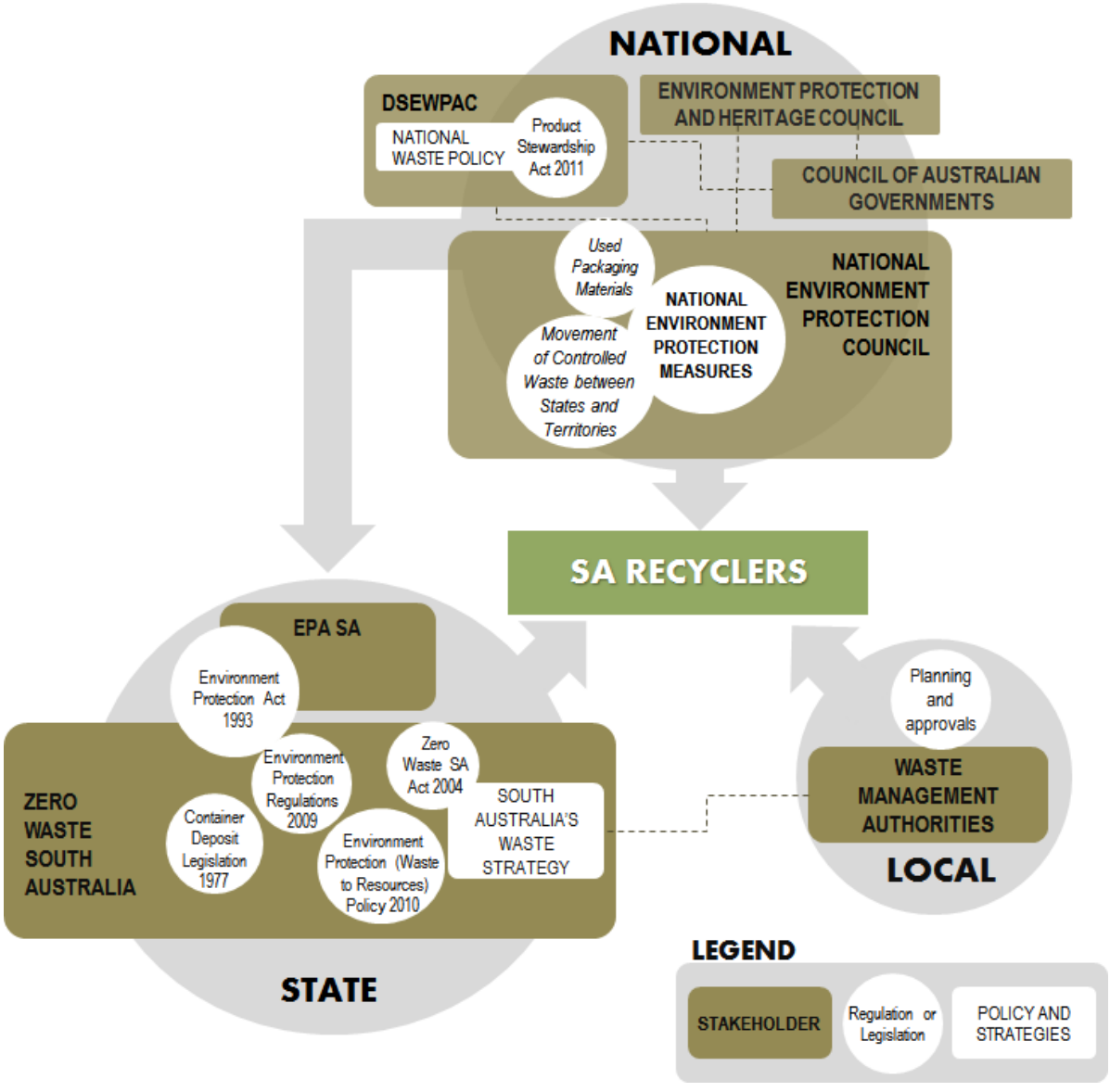


Figure 25 South Australia recycling industry operating environment

Local government associations and waste management authorities can also play a role in planning and budgeting within their jurisdictions. Waste management authorities within South Australia include:

- Adelaide Hills Region Waste Management Authority
- Eastern Waste Management Authority Inc (East Waste)
- Fleurieu Regional Waste Authority
- Northern Adelaide Waste Management Authority
- Southern Regional Waste Resource Authority
- Waste Care SA.

9.7.1 Legislation and regulation

The *Environment Protection Act 1993* provides a basis for EPA SA regulation of the waste and resource recovery industry. The Act outlines the responsibilities of individuals when undertaking activities that may pollute the environment and defines who needs to pay the waste depot levy. The Act also implements the *NEPM for the Movement of Controlled Waste between States and Territories* in South Australia.

The *Environment Protection Regulations 2009* support the *Environment Protection Act* by including further information relevant to the waste levy including exemptions and how much should be paid. The *Zero Waste SA Act 2004* established both ZWSA and the Waste to Resources Fund in which a portion of the waste levy is transferred to.

The *Container Deposit Legislation 1977* (CDL) allows consumers to receive a 10 cent refund for each beverage container returned to a recycling depot.

9.7.2 Pricing signals

Waste depot licence holders are subject to a waste levy on waste received for disposal in South Australia. The levy is collected by EPA SA with half transferred to the *Waste to Resources Fund* for projects and grants undertaken by ZWSA.

9.7.3 Strategies

South Australia's Strategic Plan (SASP) was first released in 2004 and outlines the state's overarching aspirations and targets for 2014. Incorporated in the Plan is the objective to reduce waste to landfill by 25% by 2014.

9.7.3.1 South Australia's Waste Strategy

The dedicated waste and resource recovery strategy supporting SASP is *South Australia's Waste Strategy 2005–2010* (SAWS), which was first released in 2005 covering a five-year period. This

strategy drove a significant reduction in waste to landfill across South Australia. The successor *Draft South Australia's Waste Strategy 2010–2015* (currently in draft stage) emphasises two main objectives:

- maximise the value of resources
- avoid and reduce waste.

Targets to support these two objectives have been established in the Strategy.

Table 30 Waste-to-landfill diversion targets from the draft SAWS 2010–2015.

KEY RESULT AREA	2015 TARGETS
Sector-wide recovery targets	By 2015, to: ▪ Increase recovery and use of materials from the municipal waste stream from 55% in 2009 to 65% ▪ Increase recovery and use of materials from the C&I waste stream from 60% in 2009 to 75% ▪ Increase recovery and use of materials from the C&D waste stream from 80% in 2009 to 90%

9.7.4 Policies, programs and initiatives

In 2010, the *Environment Protection (Waste to Resources) Policy 2010* was released to support the legislation and strategy. A number of take-back programs for priority wastes have been implemented in South Australia to assist in meeting the objectives in the Policy, SAWS and SASP by reducing the amount of waste disposed to landfill and increasing resource recovery.

9.7.4.1 Environment Protection (Waste to Resources) Policy 2010

The *Environment Protection (Waste to Resources) Policy 2010* aims to achieve sustainable waste management through the application of the waste management hierarchy.

One of the key enhancements that the Policy provides to SASP and SAWS is to prohibit the disposal of certain waste types to landfill. The EPA has imposed a progressive ban on a number of priority waste items (rolled out over a three year period from 2010), with ZWSA responsible for formulating strategies that will develop the required markets or infrastructure for treatment or reprocessing of banned products.

9.7.4.2 Priority wastes take-back programs

ZWSA, in collaboration with local governments, provides a free household hazardous waste collection service for the treatment and diversion of waste to landfill for recyclable items such as

batteries, light globes and motor oil. Temporary collection points are set up in different regions of the state, while a permanent waste depot is open monthly.

9.7.5 Incentives

The South Australian waste levy provides funding programs for infrastructure, research and development, and education regarding waste minimisation and resource recovery.

9.7.5.1 Metropolitan Infrastructure Grants

Metropolitan Infrastructure Grants are designed to assist with funding for new and existing resource recovery facilities. These facilities can be sorting or processing facilities, transfer stations, container deposit depots, and smaller scale recycling centres for priority wastes. $1.2 million has been made available in 2010 and 2011 for these grants.

9.7.5.2 Recycle Right at Work

The Recycle Right at Work program provides funding to waste collection companies to introduce new services for paper and cardboard recycling, source separated co-mingled dry recycling, and/or source separated organics recycling across small to medium businesses. Recycle Right at Work provides subsidies for the purchase of new recycling bins and financial incentives for companies to achieve recycling targets based on waste audits. Over two years, $3 million has been made available for this program, which is partially funded by the Australian Packaging Covenant.

9.7.5.3 Resource Efficiency Assistance Program

This grant program provides funding assistance to medium to large businesses for measuring their resource usage through waste, energy, water and plant efficiency audits. This provides organisations with information to help them increase their resource efficiency and reduce waste.

9.7.5.4 Kerbside Performance Incentives

Kerbside Performance Incentives provide funds to local councils to assist them in implementing best practice kerbside collection and recycling systems. Initiatives which have previously received funding include food waste collection trials.

9.7.5.5 Regional Implementation Program

Regional Implementation Program grants are provided to rural regions to assist with infrastructure and implementation of waste recovery for recycling. In the 2010–11 financial year, $1.6 million was allocated to this program.

9.7.5.6 Container deposit refund

The container deposit refund was increased from 5 cents to 10 cents in 2008 to further encourage recycling and litter reduction. The scheme began in 1977 and applies to a broad range of beverage

containers up to 3 litres. Those specifically exempt containers include plain milk and wine glass containers; and pure fruit juice and flavoured milk in containers with a capacity of one litre or greater.

9.8 Tasmania

The Environment Division of the Department of Primary Industries, Parks, Water and Environment (DPIPWE) is responsible for developing policies, monitoring and regulating environmental performance associated with waste reduction and resource recovery.

The Environment Protection Authority (EPA TAS) is responsible for ensuring implementation of the statutory framework. EPA TAS also works in collaboration with the Waste Advisory Committee (WAC) to coordinate the implementation of and reporting progress on actions developed in the state strategy.

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in Tasmania is provided in Figure 26 below.

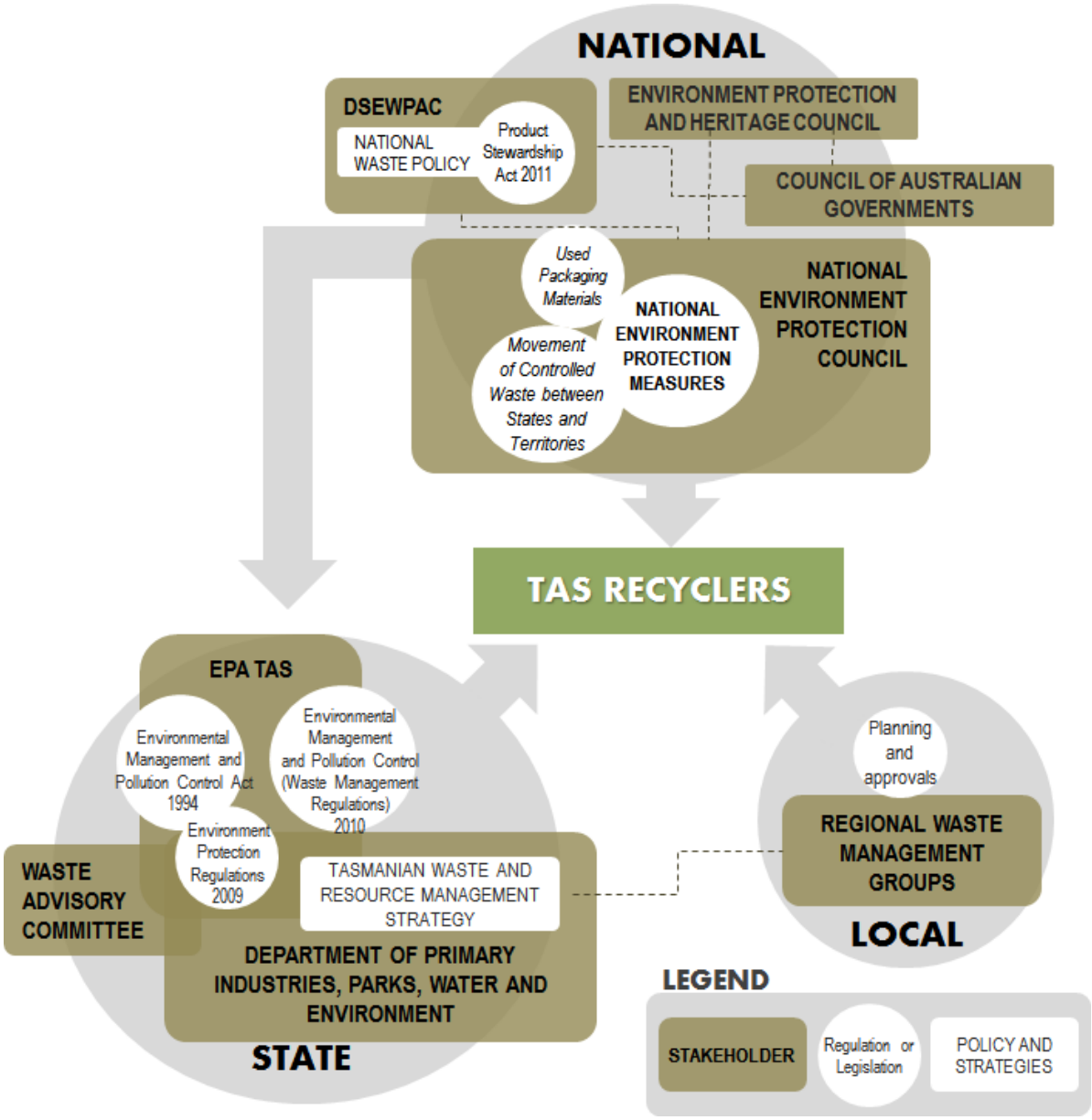


Figure 26 Tasmania recycling industry operating environment

Three regional waste management groups operate in Tasmania:

- Cradle Coast Waste Management Group (CCWMG) covering the north-west
- North Tasmanian Waste Management Group (NTWMG) covering the north
- Southern Waste Strategy Authority (SWSA), covering the south.

The objective of these bodies is to facilitate improvements in waste reduction and resource recovery, regional cooperation and coordination amongst member municipalities, and to assist in policy and education for the community.

TasWaste is the umbrella consortium of these bodies tasked with delivering a range of state-wide programs and providing a consistent message to all Tasmanians in regards to waste management.

9.8.1 Legislation and regulation

The main legislation concerning waste management is *the Environmental Management and Pollution Control Act 1994*. The Act seeks to prevent environmental degradation and adverse risks to human and ecosystem health through pollution prevention, clean production technology, reuse and recycling of materials, and waste minimisation programs. The Act also implements the *NEPM for the Movement of Controlled Waste between States and Territories* in Tasmania.

EPA TAS introduced the *Environmental Management and Pollution Control (Waste Management Regulations) 2010* that prescribe requirements and offences relating to the management of waste through all phases, including recycling and reuse.

9.8.2 Pricing signals

There is no binding state legislation regarding a waste levy in Tasmania, however several Tasmanian councils have voluntarily introduced a local government levy for a waste disposed to landfill within their municipalities to fund each of the regional waste management groups and their programs.

9.8.3 Strategies

The primary waste management strategy is the *Tasmanian Waste and Resource Management Strategy 2009*, released by DPIPWE. In addition, each of the three regional waste management bodies produces a regional waste strategy.

9.8.3.1 Tasmanian Waste and Resource Management Strategy 2009

The *Tasmanian Waste and Resource Management Strategy 2009* (TWRMS) provides a framework for solid waste minimisation and resource recovery based on six primary objectives:

- improved partnerships, coordination and planning
- waste avoidance and sustainable consumption
- waste minimisation and resource recovery
- improved regulation and management of residual wastes
- improved data collection and management systems
- reduction of greenhouse gas emissions.

The TWRMS does not currently specify quantitative targets for resource recovery due to a lack of current available data however it is expected that waste reduction targets should be established by the end of 2012.

9.8.3.2 North Tasmanian Regional Waste Management Strategy

The *North Tasmanian Regional Waste Management Strategy 2009–2013* is a five year strategy released by NTWMG to reflect the common waste management objectives of the eight councils in the region. The strategy represents projects which can be delivered more efficiently and effectively under one regional program.

The four goals developed in the strategy are to:

- divert putrescible, organic, C&D and C&I wastes from landfill
- improve community education and feedback on waste-related activities
- provide regional planning and/or coordination of waste or resource recovery infrastructure and services
- work with government(s) to shape waste management policies, regulation and education.

In order to achieve these goals, the strategy contains actions which are planned for implementation across the five year period, however no quantitative targets have been articulated.

9.8.3.3 Southern Waste Strategy Authority: Five Year Strategy

The *Southern Waste Strategy Authority Five Year Strategy 2006–11* was developed by SWSA. The priority objectives in this strategy are to:

- encourage the maximum extent of sustainable resource recovery from all waste streams in Southern Tasmania
- contribute to a consistent policy and planning environment within the state by clarifying the roles and responsibilities of state versus local government with respect to solid waste management
- minimise the adverse impacts of the environment and the community arising from local government waste management activities.

The priority strategies that provide a framework to achieve these objectives include raising public awareness of waste issues, improving the monitoring and data collection regarding waste and recycling quantities, and the development of regional policies on waste issues. There is also emphasis on encouraging businesses to improve resource recovery for C&I waste.

9.8.3.4 Cradle Coast Regional Waste Management Strategy

The *Cradle Coast Regional Waste Management Strategy 2009–2013* is a five year strategy which highlights six goals to facilitate meeting the objectives of the CCRWMG:

- optimise the Region's economics of collection, processing and disposal
- diversion of materials from landfill

- work with community to take ownership of waste avoidance and reuse
- work with industry and agriculture sector to facilitate waste management value added solutions which encourage Regional investment
- provide Regional planning and/or coordination of waste and resource recovery infrastructure and services
- work with Governments(s) to shape waste management policies, regulation and education.

Supporting these goals is a number of strategies and actions which include designing data collection and survey actions to enhance knowledge of the sector and investigations into additional waste stream collection and alternative waste technologies.

9.8.4 Policies, programs and initiatives

No significant programs or initiative have been launched since the *Resource Recovery Project* offered grants under the *Living Environment Program* from 2005 to 2008.

9.8.5 Incentives

No significant financial incentives specific to Tasmania were identified.

9.9 Victoria

The primary government bodies responsible for waste policy development, strategic planning and regulation in Victoria are the Department of Sustainability and Environment (DSE) and the statutory authority Sustainability Victoria (SV). Responsibility for the development and implementation of the statutory framework for waste in Victoria falls under the Environment Protection Authority of Victoria (EPA Victoria).

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in Victoria is provided in Figure 27 below.

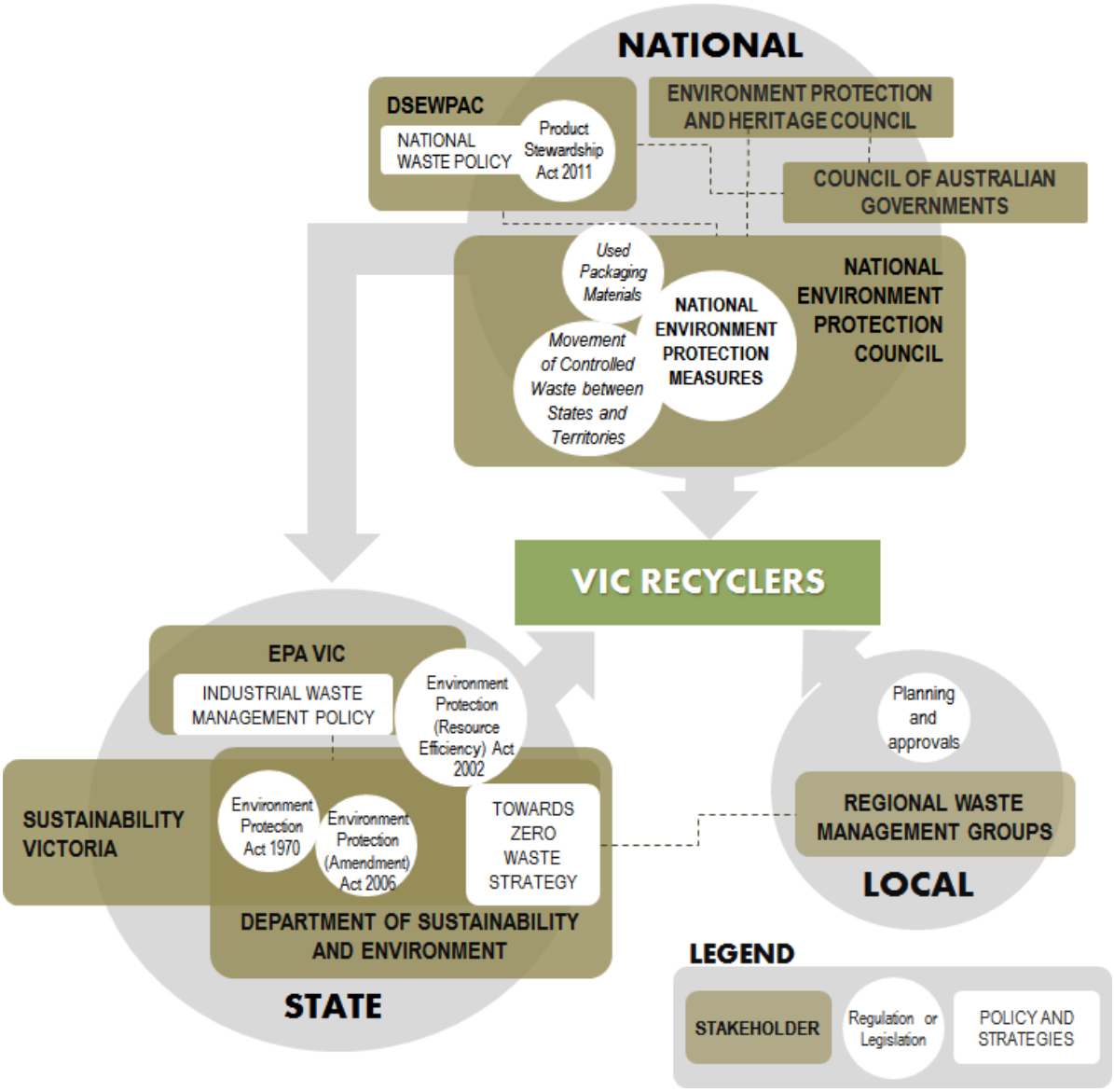


Figure 27 Victoria recycling industry operating environment

Regional waste management groups (RWMG) in Victoria are comprised of council members from across neighbouring municipalities who seek to develop, facilitate and implement strategies and programs at a regional level. RWMGs also provide community education regarding waste and sustainability issues. In addition to the Metropolitan Waste Management Group, there are an additional twelve regional waste management groups:

- Barwon Regional Waste Management Group
- Calder Regional Waste Management Group
- Central Murray Regional Waste Management Group
- Desert Fringe Regional Waste Management Group

- Gippsland Regional Waste Management Group
- Grampians Regional Waste Management Group
- Highlands Regional Waste Management Group
- Mildura Regional Waste Management Group
- Mornington Peninsula Regional Waste Management Group
- North East Victorian Regional Waste Management Group
- Resource GV (Goulburn Valley Regional Waste Management Group)
- Waste Reduction Group (South West Regional Waste Management Group)

9.9.1 Legislation and regulation

The *Environment Protection Act 1970* (the Act) and the *Environment Protection (Amendment) Act 2006* (the Amendment) are the main legislative Acts in Victoria relating to waste. The Act seeks to minimise environmental damage through sustainability goals, programs and engagement. Principles of environment protection, added to the Act in 2001, include product stewardship and the waste hierarchy. The Amendment Act included reforms to metropolitan waste management and increased levies for prescribed industrial wastes.

The *Environment Protection (Resource Efficiency) Act 2002* allows EPA Victoria to develop waste management policies across the state, including municipal waste.

9.9.2 Pricing signals

Landfill levies in Victoria are paid into the *Environment Protection Fund* and used exclusively for environment protection activities, including best practices waste management. Funds are distributed in accordance with the *Environment Protection (Distribution of Landfill Levy) Regulations 2010* to receivers including RWMGs, MWMG, Sustainability Victoria, and the EPA. Funds above and beyond those paid to these receivers are allocated to a general sustainability fund account.

The *Environment Protection Amendment (Landfill Levies) Act 2011* outlines the incremental increases in the levy between the 2011–12 and 2014–15 financial years.

9.9.3 Strategies

9.9.3.1 Towards Zero Waste Strategy

The Towards Zero Waste Strategy (TZW), published in 2005, is the major framework that guides waste management in Victoria. Its three primary objectives are to:

- generate less waste

- increase the amount of materials recycled and reprocessed
- reduce damage to the environment caused by waste.

TZW establishes both state-wide and sector-wide voluntary targets (refer Table 31) for the recovery of solid waste materials through recycling and reprocessing. The aim of these targets is to motivate households, businesses and industry to better manage waste, as well as to drive and influence policy and infrastructure planning processes.

Table 31 Resource recovery targets from TZW Strategy

KEY RESULT AREA	2015 TARGETS
State-wide recovery target	75% by weight solid waste recovered for reuse, recycling and/or energy generation
Sector-wide recovery targets	By 2014, to: ▪ Increase recovery and use of materials from the municipal waste stream from 35% in 2002–03 to 65% ▪ Increase recovery and use of materials from the C&I waste stream from 59% in 2002–03 to 80% ▪ Increase recovery and use of materials from the C&D waste stream from 57% in 2002–03 to 80%

TZW also defines priority industry sectors, materials and products based on the amount of waste generated by the sector, or the capacity for improved resource recovery, respectively.

9.9.3.2 The Metropolitan Waste and Resource Recovery Strategic Plan

The Metropolitan Waste Management Group (MWMG) was formed by merging four RWMGs in metropolitan Melbourne and its activities span across 30 member councils.

In 2008, the Metropolitan Waste and Resource Recovery Strategic Plan (MWRRSP) was developed with a focus on waste issues in metropolitan Melbourne due to the bulk of the waste being generated, recovered and reprocessed in the city. The MWRRSP consists of:

- The Metropolitan Plan emphasises the importance of a cooperative waste management system across households, businesses and industry to meet the targets in the TWZ Strategy. It names source separation as one of the key directions Victoria must move in to increase resource recovery and reduce contamination.
- The Municipal Solid Waste Infrastructure Schedule examines the systems in place for MSW collection, treatment and disposal. It focuses on kerbside collection of MSW and offers modelled scenarios for different kerbside collection and reprocessing options. The schedule also outlines potential barriers to achieving greater recovery rates for MSW, including the need for market developments for recycled end products.

- The Metropolitan Landfill Schedule highlights the need for better planning, location and management of landfills, taking into consideration that landfills will still play a role in waste management in the foreseeable future.

9.9.4 Policies, programs and initiatives

9.9.4.1 Industrial Waste Management Policy (Movement of Controlled Waste between States and Territories)

The Industrial Waste Management Policy (IWMP) implements the *NEPM for the Movement of Controlled Waste between States and Territories*. The IWMP provides a nationally consistent framework in Victoria for the management of the movement of controlled wastes between the Victoria and other states and territories originating from commercial, trade or business activities.

9.9.4.2 Priority wastes take-back programs

Victoria is trialling several take-back programs beyond those offered nationally, including Byteback, Batteryback and Detox Your Home. These programs are typically managed by Sustainability Victoria in partnership with industry players.

- Byteback provides a free take-back service for computer hardware and ancillary equipment at locations across Victoria. The program is expected to integrate into the National Television and Computer Product Stewardship Scheme.
- Batteryback is a free service for householders to drop off unwanted batteries for recycling at participating retail stores. The service is stated as being a trial to gain data and gauge community response and is due to cease on 31 May 2012.
- Detox Your Home is a program for collection, treatment and, where possible, reprocessing of household chemical products. Items include, but are not limited to, batteries, fuels, and gas cylinders, and can be dropped off at permanent collection facilities or provided to the mobile collection service at scheduled locations and times.

9.9.5 Incentives

Financial incentives are available for local government and industry to drive initiatives and infrastructure developments that will assist in meeting the TZW targets.

9.9.5.1 Beyond Waste Fund

EPA Victoria's Beyond Waste Fund, formerly the Waste Reduction Fund, allocates $14 million over four years (2010–14) to fund waste avoidance, reduction and reuse initiatives. Applications include the development of infrastructure, research and development of technologies and processes, capacity building and market development projects.

9.9.5.2 Driving Investment for New Recycling Fund

The Driving Investment for New Recycling Fund is administered by Sustainability Victoria and provides $14 million over four years (2010–14) to Victorian councils, waste management groups and the waste and recycling industry for projects relating to new infrastructure or upgrades that will increase capacity and enhance capability for collection, sorting and reprocessing of waste in Victoria.

9.9.5.3 Metropolitan Local Government Waste and Resource Recovery Fund

The Metropolitan Local Waste and Recovery Resource Fund is a MWMG fund supporting the implementation of best practice waste collection and management by local government. A total of $5.5 million is allocated between 2010–14 to infrastructure projects, community education projects and research, development and innovation projects to improve resource recovery in the municipal waste stream.

9.10 Western Australia

The Waste Authority in Western Australia was established in 2008 (to replace Waste Management Board) and is responsible for:

- developing, promoting, reviewing and facilitating the implementation Western Australia's waste strategy
- engaging and educating the community on waste minimisation and resource efficiency and recovery
- administering funds from the Waste Avoidance and Resource Recovery Account (the WARR Account).

The Department of Environment and Conservation supports the Waste Authority and assists with policy development and project coordination.

An illustrative overview of how key actors interact and influence the operating environment for the recycling sector in Western Australia is provided in Figure 28 below.

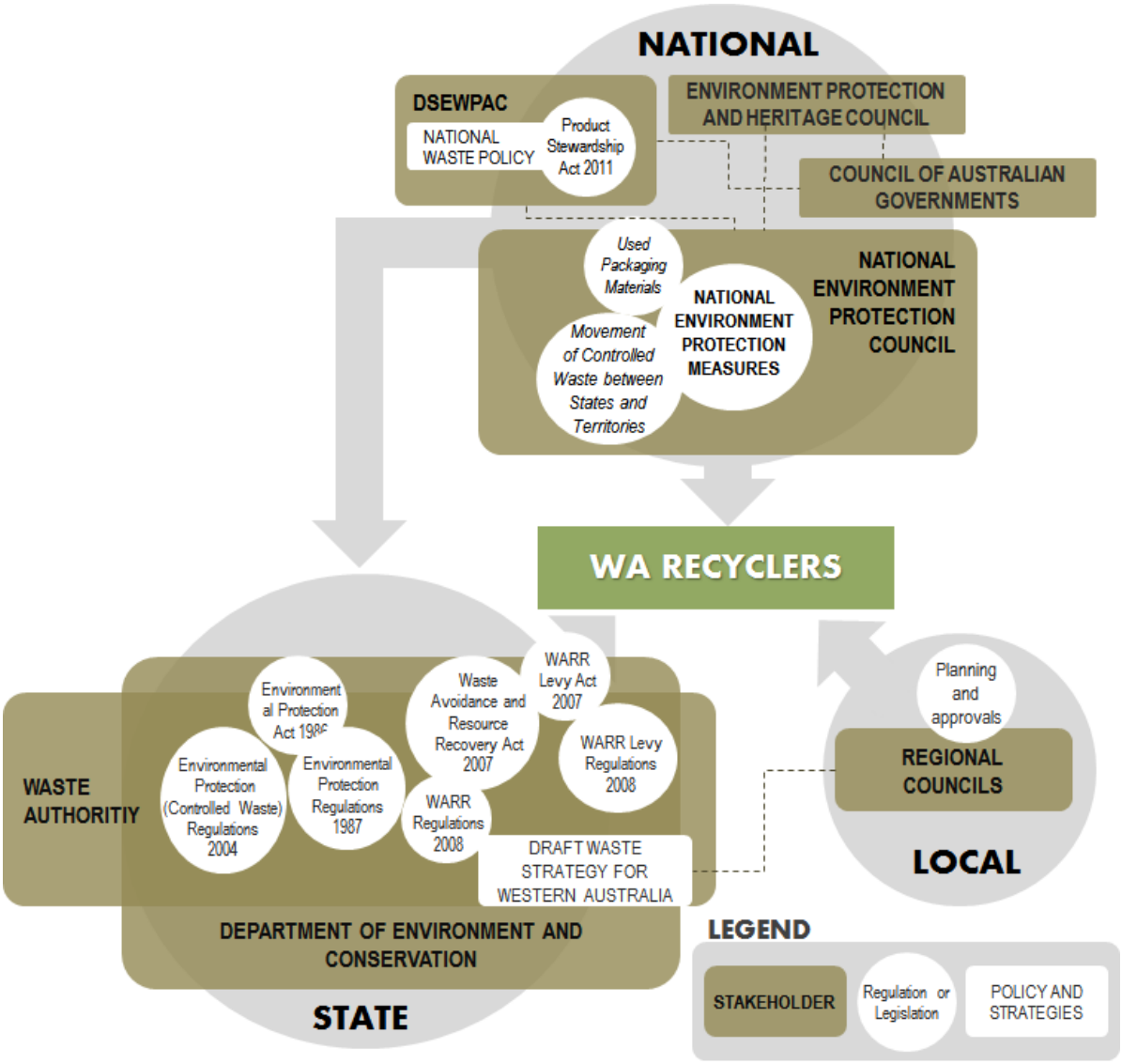


Figure 28 WA recycling industry operating environment

There are also ten Regional Councils which coordinate waste strategy and service provision on behalf of their member councils. These Regional Councils are:

- Bunbury - Harvey Regional Council
- Eastern Metropolitan Regional Council
- Mid West Regional Council
- Mindarie Regional Council
- Murchison Regional Vermin Council
- Pilbara Regional Council

- Rivers Regional Council
- Southern Metropolitan Regional Council
- Tamala Park Regional Council
- Western Metropolitan Regional Council

9.10.1 Legislation and regulation

The *Environmental Protection Act 1986* and its supporting *Environmental Protection Regulations 1987* are the primary legislative documents relating to environmental sustainability and protection. They are supported by key legislation specific to waste and resource recovery in WA:

- *Waste Avoidance and Resource Recovery (WARR) Act 2007*
- *WARR Levy Act 2007*
- *WARR Regulations 2008*
- *WARR Levy Regulations 2008.*

The primary objectives of the WARR Act are to move towards a waste-free society by promoting the most efficient use of resources (including resource recovery and waste avoidance) and through adherence to the waste hierarchy. The WARR Act led to the establishment of the Waste Authority and the WARR Account.

The *Environmental Protection (Controlled Waste) Regulations 2004* implements the *NEPM for the Movement of Controlled Waste between States and Territories* in WA by regulating the transportation of wastes that may cause environmental or health risks.

9.10.2 Pricing signals

The landfill levy in Western Australia applies to the disposal of all wastes generated and/or received in the Perth Metropolitan Area. The levy has been applied since 1998, and has increased steadily to promote waste diversion from landfill. Since the establishment of the WARR Act in 2007, levies have been paid into the WARR Account to provide funding and grants administered by the Waste Authority.

The *Waste Avoidance and Resource Recovery Levy Regulation Administration Policy 2009* outlines the procedures and requirements for the assessment and calculation of the landfill levy, financial assurances and the application of exemptions.

9.10.3 Strategies

The WARR Act requires that the Waste Authority develops a waste strategy that includes:

- targets for waste reduction, resource recovery and diversion from landfill
- continuous improvement of waste services as benchmarked against best practice.

The final Waste Strategy for Western Australia (WSWA) is still pending final release upon approval from the Minister of Environment[27].

9.10.3.1 Waste Strategy for Western Australia

The draft WSWA aims to achieve best practice waste management in Western Australia by 2022 by encouraging waste avoidance, resource recovery and responsible disposal where recovery is not possible. The principles underlying the strategy include:

- promoting the most efficient use of resources, including resource recovery and waste avoidance
- consideration of resource management options against the waste management hierarchy
- identifying and supporting solutions that offer value for money when social, environmental and financial considerations are taken into account.

The Draft WSWA outlines target dates for market development projects in recovered materials, establishing alternative waste management models for infrastructure development in large population areas, and product stewardship schemes. Due to data challenges, only the following resource recovery targets have been provided quantitatively.

Table 32 Resource recovery targets from Draft WSWA

TARGET FOCUS	TARGETS
Sector-wide recovery target	▪ In metropolitan Perth, the recovery rate for MSW will increase from 45% in 2006–07 to 70% by 2016 ▪ The recovery rate for C&D waste will increase from 14% in 2006–07 to 50% by 2016 and to 70% by 2020 ▪ The recovery rate for C&I waste will continuously increase over the lifespan of the strategy
Region-wide recovery targets	In regional areas with a population over 25,000, the recovery rate will be at least 45% for waste by 2016

[27] As of November 2011 responses to the second draft strategy closed in April 2010 and were still being analysed. See http://www.zerowastewa.com.au/whoswho/authority/strategy/

9.10.4 Policies, programs and initiatives

The Waste Authority is involved (with Government and industry stakeholders) in the administration of specific programs and supporting grant schemes (see section 9.10.5) associated with recycling and resource recovery.

9.10.4.1 Priority wastes take-back programs

Western Australia's Household Hazardous Waste Program enables households to drop off hazardous waste items at depots located throughout the Perth metropolitan area for safe disposal and recycling. The program has been in operation since 2003 and governed by the Waste Authority Household Hazardous Waste Committee (established 2010). At the time of writing, the Committee is noted to be preparing program details for 2011–2012 and beyond.

9.10.5 Incentives

The Waste Authority supports a number of grants schemes through funds in the WARR Account. The WARR Account is mainly credited through landfill levies, penalties and fines under section 76 of the WARR Act, and through returns on investment of money from the WARR Account.

9.10.5.1 The Strategic Waste Initiatives Scheme

The Strategic Waste Initiatives Scheme provides funding assistance for business and industry, local governments and other organisations with infrastructure, research and development, and innovation projects which increase resource recovery and improve waste management across Western Australia. At the time of writing the structure of the program is under review with view to developing a more target approach.

9.10.5.2 The Community Grants Scheme

The Community Grants Scheme provides up to $20,000 per project for community groups and individuals to avoid or reduce waste generation, increase resource recovery, and reduce the impact of waste on the environment.

9.11 Assessment of the regulatory environment

The following issues and challenges were identified through desktop research and consultation.

9.11.1 National harmonisation

The aspiration to establish a national system of regulation was identified by stakeholders. National harmonisation would develop a more effective administrative structure for the recycling and resource recovery industry. Under this system there is strong agreement among Government and industry stakeholders to accommodate flexibility at the regional and local level, in a similar manner to the framework developed for product stewardship under the National Waste Policy.

The preferred hybrid structure highlights the dual focus of harmonising state/territory regulation while ensuring that an overarching national framework is in place. Stakeholders cite the mitigation of waste leakage (e.g. across border to due to inconsistent landfill levies) and reduced administrative burden on industry (due to regulatory consolidation) as sources of economic benefit.

Resistance to a rigid set of national regulations is primarily attributed to concerns that states/territories with more advanced and well-functioning regulation may be compromised under a uniform national structure. Similarly, there is widespread acknowledgement that differences in operating conditions are best monitored at the local or state/territory level.

9.11.2 Policy and planning conflicts

Legislation and policies across Australia are pursuing often ambitious targets for resource recovery. The achievement of these targets is reliant on the existence of resource recovery facilities. Securing planning approvals to establish facilities is becoming more challenging for the sector, particularly due to community concern and political risk around amenity impacts of facilities such as noise and odour. There are recent examples of the companies having to invest substantial amounts of money and time over a number of years to secure site approvals. This is a concern to both industry and government. One stakeholder expressed the view that the policy and planning 'need to hold hands more'. The development of a consistent and streamlined planning process to support the introduction of new resource recovery facilities was expressed as desirable and even necessary to enable for strategic planning and investment.

9.11.3 Other regulatory issues

A series of broader themes emerged from discussions with a range of stakeholders:

- The rapid introduction of new technologies such as AWTs is seen as a potential loophole for regulation. Government stakeholders are concerned that guidelines and regulation are either not in place or ill-informed to deal with potential underperformance of new technologies.
- There is a need for regulation to support the policy view that waste and recycling should be considered an essential service.

10. Standards & specifications

- There are a wide range of standards and specifications that influence the recycling industry in Australia. These can affect the sector as a whole or may be targeted at certain jurisdictions or specific material streams.
- The need for national harmonisation and the development of improved standards and specifications has been identified at both the stakeholder level and in the National Waste Policy.
- Engagement and collaboration with industry and across jurisdictions is a critical driver to enhancing the value that standards and specifications present to the recycling sector.
- The issues and needs identified included:
    - development of product performance standards
    - national and jurisdictional consistency
    - promotion of existing standards and specifications
    - stakeholder engagement in development of new standards and specifications.

This section provides a summary of the principles, specifications, better practice guidelines and standards relating to the recycling sector and discusses the perceived needs in terms of the development of additional principles, specifications, better practice guidelines and standards.

Standards and specifications strongly influence the operation of the recycling industry, the form and quality of the products/outputs of the industry and the potential markets for recycled products.

There are a wide range of principles, specifications, better practice guidelines and standards applicable in Australia that influence the recycling sector as a whole, certain jurisdictions or specific material streams.

10.1 National standards, specifications, guidelines and principles

Table 33 outlines the standards, specifications, guidelines and principles that have application across Australia.

Table 33 National standards, specifications, guidelines and principles

INSTRUMENT	DESCRIPTION
GENERAL	
Waste hierarchy	The waste hierarchy is an internationally recognised framework which classifies waste management strategies according to their desirability. There are various forms of the hierarchy but the generally accepted principles, in order of preference are: avoid, reuse, recycle, recovery of energy, treatment and disposal. The waste hierarchy is enshrined in environmental protection regulations in many of the states/territories and underpins waste and recycling policies and strategies.
AS/NZS 3831-1998 Waste Management Glossary of Terms	Specifies definitions for commonly used waste terms such as those involving collection, sorting, disposal, recycling, waste stream, waste management and waste minimization.
The Australian Council of Recycling (ACOR): Recycling Materials Specifications	ACOR has developed standards pertaining to the kerbside collection of recycled materials: Kerbside recycling specifications *Aluminium* ▪ Used Beverage Containers Specifications (Aluminium) *Glass* ▪ Unbeneficiated Cullet Specifications (Glass) ▪ Beneficiated Cullet Specifications (Glass)

INSTRUMENT	DESCRIPTION
	Paper ▪ Australian Recovered Paper Specifications (AuRPS) *Plastics* ▪ HDPE Bottle Recyclable Feedstock Specifications ▪ LLDPE and LDPE Film Recyclable Feedstock Specifications ▪ P.E.T. Recyclable Feedstock Specifications ▪ PVC Bottles Recyclable Feedstock Specifications *Steel* ▪ Steel Can Specifications
ACOR: Recycling Materials Manufacturers Guide	ACOR has developed the following guidance documents for manufacturers' recycling: ▪ Recycling Guide for Fillers Marketing in Aluminium ▪ Recycling Guide for Fillers Marketing in Steel Cans ▪ Recycling Guide for Fillers Marketing in HDPE ▪ Recycling Guide for Fillers Marketing in PET
AS 4123 – 2008: Mobile Waste Containers	Addresses dimensions and design, performance requirements, testing methods, colours, markings and recycled content of an mobile waste container.
CONSTRUCTION	
ISO 15392:2008: Sustainability in building construction - General Principles	Identifies and establishes general principles for sustainability in building construction. It is based on the concept of sustainable development as it applies to the life cycle of buildings and other construction works, from their inception to end of life.
ISO FDIS 15392:2008: Sustainability in building construction - General Principles	Applicable to buildings and other construction works individually and collectively, as well as to the materials, products, services and processes related to the life cycle of buildings and other construction works.
ISO 21930-2007 and ISO FDIS 21930: Sustainability in building construction - Environmental declaration of building products	Provides the principles and requirements for type III environmental declarations (EPD) of building products.

INSTRUMENT	DESCRIPTION
ISO TS 21931-1-2010: Sustainability in building construction - Framework for methods of assessment of the environmental performance of construction works -- Part 1: Buildings	Provides a general framework for improving the quality and comparability of methods for assessing the environmental performance of buildings and their related external works. It identifies and describes issues to be taken into account in the use and development of methods of assessment of the environmental performance for new or existing buildings in their design, construction, operation, maintenance and refurbishment, and in the deconstruction stage
ISO TS 21929-1-2006: Sustainability indicators -- Part 1: Framework for development of indicators for buildings	Framework for development of indicators for buildings Provides a framework, makes recommendations, and gives guidelines for the development and selection of appropriate sustainability indicators for buildings.
ISO DIS 21930: Sustainability in building construction – Environmental Declaration of building products	Contains specifications and requirements for the EPD of building products. Where this International Standard contains more specific requirements, it complements ISO 14025 for the EPD of building products.
HB 155-2002: Guide to the use of recycled concrete and masonry materials	This Handbook consolidates available information needed for the consideration of recycled concrete and masonry materials in construction applications. It is intended to provide the potential user general guidance on engineering evaluation requirements, environmental issues and economic considerations for determining the suitability and current uses of recycled concrete and masonry materials.
AS 3600-2009: Concrete structures	Specifies minimum requirements for the design and construction of concrete building structures and members that contain reinforcing steel or tendons, or both.
Green Building Council of Australia's Green Star rating tools	The Materials Category of the Green Star rating tools consist of Credits which target the consumption of resources through selection, use, reuse and efficient management practices of building and fit out materials. The credits reward reduction, reuse and the use of recycled and recyclable materials wherever possible.
National Road Pavements Guidance: Austroads' Guide to Pavement Technology Part 4E: Recycled Materials	The Guide was released in 2009 and profiles recycled pavement products manufactured from various wastes (not exclusively C&D) that are accepted through registered recycling and reprocessing facilities. It addresses the specification, manufacture and application of a range of pavement products made from the recovery of C&D waste and RAP. Additionally, but beyond the scope of this review which is focused on C&D waste, it also addresses the use of waste from other sources in pavement production, such as recycled

INSTRUMENT	DESCRIPTION
	glass containers, and industrial slags and ash.
PLASTICS	
ISO 15270:2008: Plastics - Guidelines for the recovery and recycling of plastics waste	Guidance for the development of standards and specifications covering plastics waste recovery, including recycling. The standard establishes the different options for the recovery of plastics waste arising from pre-consumer and post-consumer sources. It also establishes the quality requirements that should be considered in all steps of the recovery process, and provides general recommendations for inclusion in material standards, test standards and product specifications.
AS 1886 Supp 1-1994: Glossary of terms relating to plastics - Plastics recycling terminology (Supplement to AS 1886-1991)	Provides definitions of terms used within Australia that relate to the recycling of plastics.
AS 5810-2010: Biodegradable plastics – Biodegradable plastics suitable for home composting	This Standard specifies requirements and procedures to determine whether a plastic material is biodegradable in home composting conditions and provides the basis to allow labelling of materials or products made from plastics as 'home compostable', for use in home composting systems.
PAPER & PACKAGING	
AS 4082-1992: Recycled paper - Glossary of terms	Specifies definitions of terms for use in conjunction with recycled paper. Terms used when describing sources of recycled fibre, manufacturing processes and finished paper characteristics are included.
ISO 15360-1:2000 and 15360-2:2001: Estimation of stickies and plastics in recycled pulp	Stickies are materials that are retained on a laboratory screen of given slit aperture and which adhere to objects that they touch. Plastics are non-adhesive polymers that are retained on a laboratory screen of a given slit aperture, but excluding cellulosic materials.
AS ISO 16103-2007: Transport packaging for dangerous goods - Recycled plastics material	Adopts ISO 16103:2005 as an Australian Standard. Specifies requirements and test methods for recycled plastics materials to be used as transport packaging for dangerous goods, including guidance on a quality assurance program.
RECYCLABILITY	
AS/NZS 4701:2000: Requirements for domestic	Sets out general requirements applying to used domestic appliances intended for sale for reconditioning (reuse), salvaging of parts only

INSTRUMENT	DESCRIPTION
electrical appliances and equipment for reconditioning or parts recycling	(recycling), (or in New Zealand, historic collections), so that an appropriate safety outcome for the public is achieved without preventing the recycling or resale of electrical appliances or parts which may not be safe to use.
ISO 22628:2002: Road vehicles - Recyclability and recoverability - Calculation method	This International Standard specifies a method for calculating the recyclability rate and the recoverability rate of a new road vehicle, each expressed as a mass fraction of the vehicle. Under this procedure, performed by the vehicle manufacturer when a new road vehicle is put on the market, potentially, the vehicle can be recycled, reused or both (recyclability rate), or recovered, reused or both (recoverability rate).
ENVIRONMENTAL CLAIMS	
HB 207.1:2000: Environmental management - Environmental labels and declarations - Type III environmental declarations	Identifies and describes the elements and issues concerning Type III environmental declarations. Because the methodology underpinning Type III environmental declarations is still under development, this document was produced as a technical report by ISO and was adopted as a handbook in Australia and New Zealand. Identical to and reproduced from ISO/TR 14025:2000.
AS/NZS ISO 14021:2000: Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)	Specifies requirements applying to the development of environmental claims, expressed in either words or symbols, about products and services. Includes both general requirements and specific details for selected claims, along with verification methodologies. This Standard is an adoption with national modifications of ISO 14021:1999.
ORGANICS	
AS 4454-2003: Composts, soil conditioners and mulches	Specifies minimum requirements to be met prior to labelling a product as a composted or pasteurized product. It also specifies physical and chemical requirements and documentation which includes information to be supplied to the consumer and health warnings. Guidance is given on best practice for composting and vermicast systems designed to produce a quality product achieved by following an approved process.
AS 3743-2003: Potting mixes	Specifies physical, chemical, biological and labelling requirements for potting mixes packaged for retail sale including information to be supplied to the consumer and health warnings. Includes requirements for regular and premium grade mixes as well as special purpose mixes.
AS 4419-2003: Soils for landscaping and garden use	The Standard specifies physical and chemical requirements such as bulk density organic matter, wettability, pH, dispersibility, toxicity, nitrogen drawdown index and permeability for low density, organic and natural soils or soil blends. Guidance is given on the selection and use of soils.

INSTRUMENT	DESCRIPTION
AS/NZS 4422-1996: Playground surfacing	Specifies general requirements for surfacing to be used in children's playgrounds and specific requirements for areas where impact energy attenuation is necessary.
Guide to developing a process control system for a composting facility	A package of 15 information sheets published by the Recycled Organics Unit to guide the design of an efficient process control system for different types of composting facilities.
PROCUREMENT	
Australian and New Zealand Government Framework for Sustainable Procurement	The Australian and New Zealand Government Framework for Sustainable Procurement provides a set of national principles to assist Australian and New Zealand governments to integrate the principles of sustainability into the procurement of goods, services and construction. The four guiding principles are: Principle 1 - Adopt strategies to avoid unnecessary consumption Principle 2 - In the context of whole-of-life value for money, select products and services which have lower environmental impacts across their life cycle Principle 3 - Foster a viable market for sustainable products and services by supporting innovation in sustainability Principle 4 - Market development

10.2 State/territory standards, specifications, guidelines and principles

Table 34 summarises the standards, specifications, guidelines and principles that apply within each of Australia's state and territories. There are also specifications that local governments have in place, however due to the number of local governments it is not possible to provide an outline of the specifications at local government level within this report.

Table 34 Standards, specifications, guidelines and principles in jurisdictions

INSTRUMENT	DESCRIPTION
Australian Capital Territory	
No region specific standards, specifications, guidelines or principles	
New South Wales	
RTA3051	Granular Base and Sub-base Materials for Surfaced Road Pavements NSW
Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage 2010 (Greenspec)	The aim of this Specification is to encourage local government professionals and other key players within both the private and public works engineering sector to use recycled concrete, brick and asphalt materials.
EIS Guideline: Landfilling	Development is located so as to avoid land-use conflicts, including whether it is consistent with any regional planning strategies or locational principles included in the publication
Protocols for Recycling Redundant Utility Poles and Bridge Timbers	From New South Wales Waste classification guidelines developed by the Timber Development Association NSW http://www.environment.nsw.gov.au/waste/envguidlns/index.htm accessed September 2011.
Preferred Resource Recovery Practices by Local Councils	Provides a guide to the preferred minimum service levels for kerbside resource recovery and residual waste collections for single unit dwellings.
Environmental guidelines: Composting and related organics processing facilities	The focus of these guidelines is on the appropriate environmental management of organics processing facilities.
Northern Territory	
Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory 2003	Developed by the *Department of Natural Resources, Environment, The Arts and Sport* with the primary aim of conserving resources through effective avoidance and resource recovery. The guidelines encourage the salvage from waste of materials for reuse and recycling, and outline how these processes can be integrated to landfill design.
Queensland	
MRS35 - Recycled Materials for Pavements	Main Roads Specification Specification for the design, construction, maintenance and operation of road transport infrastructure in Queensland by or on behalf of the state of Queensland. The specification applies to the material requirements for recycled materials to be used in pavements for road construction, rehabilitation and maintenance.

INSTRUMENT	DESCRIPTION
South Australia	
Standard for the production and use of Waste Derived Fill	Developed by EPA SA defining information and processes required by the EPA to support the beneficial reuse of a range of wastes specifically recovered for use as fill.
DTEI Specification: Part 215 Supply of Pavement Materials	Published by the Department for Transport, Energy and Infrastructure specifying the allowance of recycled material in pavement for transport-related construction and maintenance activities under the care, control and management of the Commissioner of Highways in South Australia.
Waste-derived materials	Guiding principles for determining approval processes and product standards Guiding Principles published by the EPA SA to be applied to the development of all policies, guidelines and standards relating to waste. The Guiding Principles are intended to ensure that resource recovery is suitable for an intended beneficial use, will maximise value and minimise any adverse impacts (EPA SA).
Tasmania	
No region specific standards, specifications, guidelines or principles	
Victoria	
Guide to Best Practice at Resource Recovery Centres	On behalf of Sustainability Victoria, Blue Environment developed an updated guide to reflect current industry practices and changed legislative requirements. Features of the guide included incorporation of sustainability design, planning and management of resource recovery infrastructure.
Environmentally Sustainable Design and Construction (ESDC) Principles and Guidelines 2003	Developed by the DSE to 'integrate environmental sustainability into the planning, design and construction processes for all new capital work'. Recycling and reuse targets are set out for ecological impacts to preserve natural features of site, building materials conservation, waste minimisation and landscaping
Guidelines for sustainable separation and processing of bin collected organics	Provides information based on the experiences of councils and processors to assist municipalities who intend to introduce this type of kerbside organics collection service and to facilitate sustainable processing of kerbside collected recyclable organic materials.
Resource Smart guide to best practice for organics recovery	Promotes best practice in the management of recovered garden, food and other organics.
Western Australia	
Main Roads Western Australia Specification 501 – Pavements	Developed by Main Roads Western Australia that includes specification of alternative pavement materials (including crushed recycled concrete) for sub-base and basecourse.

10.3 Issues and needs relating to standards and specifications

Strategy 5 of the *National Waste Policy: Less waste, more resources Implementation Plan 2010* aims to 'facilitate the development of a suite of agreed national principles, specifications, best practice guidelines and standards to remove impediments to the development and operation of effective markets for potential wastes' (Environment Protection and Heritage Council, 2010a, p. 15).

To inform this process, the following issues and challenges were identified through desktop research and discussions with stakeholders.

10.3.1 Performance standards

The Australian Council of Recycling (ACOR) states that recovered resources are often discriminated against on the basis of being 'recycled', rather than being assessed on their performance (Australian Council of Recyclers, 2006, p. 13). This can be the case regarding construction or road applications, for example, where Ordinary Portland Cement is specified rather than a performance standard against which all products can be measured.

The local government sector and some segments of the public sector such as water authorities are regarded as particularly conservative and resistant to change regarding adopting a performance-based approach to procurement. Given the significant role of these sectors in procurement relating to civil engineering and construction, a performance-based approach could have a significant impact on demand for recovered resources.

10.3.2 National and jurisdictional consistency

National harmonisation is a strong theme that emerged from the desktop research and consultation undertaken for this project, on a number of fronts including the regulatory environment and standards and specifications.

The lack of nationally consistent and utilised waste and resource recovery definitions is cited as a challenge. Each state/territory has their own definitions enshrined in their respective legislation and policy documents. Different states/territories even have systems and factors for converting volume to weight. National legislation, strategy, policy, and program documents as well as international guidelines (e.g. from UN, OECD) publish their own definitions. Further, Standards Australia has published a Waste Management Glossary of Terms (Waste Management Association of Australia, 2009a, p. 3&4).

Similarly, there is a strong view that a more sophisticated approach to capturing recycling information at a national level is necessary to improve the usefulness of data from landfill and recycling facilities, and to facilitate cooperation and communication between jurisdictions.

10.3.3 Promotion of existing standards and specifications

In addition to the need for new standards or specifications, there was also an acknowledged need to promote existing standards, build the capacity of the recycling industry to apply the standards and build awareness of and perceived value in standards and specifications. Both industry and government could play a role in promoting the adoption and value of standards and specifications.

As an example, there are standards and certification schemes in place for recycled organics products, however the awareness of these standards is low and there are currently limited drivers for the industry to adopt these standards in the absence of awareness and perceived value within the market place.

10.3.4 The process for developing standards and specifications

Stakeholders commented that the process of developing standards and specifications is both capital and resource intensive and complex. Engagement and collaboration with industry and across jurisdictions is seen as a critical driver to improve confidence in the standards and specifications associated with recycling and resource recovery. This is supported by the success of initiatives such as Greenspec in NSW that actively engaged industry to co-lead the development of specifications for the supply of recycled materials in the construction industry; and reported apprehension toward specifications revised solely through Government bodies.

The theme of industry involvement extends to developing support programs that encourage professions such as engineering to recognise industry standards. Government bodies also noted a move toward industry based lobbying for standards and specifications to endorse certain reprocessed materials.

10.3.5 Priority areas

In addition to the issues and needs discussed previously in this section, the following specific need was identified through discussions with government and industry participants:

- An international definition or classification for waste paper that is traded (often internationally), so that customers have certainty about the quality of their purchase. There are classifications for old corrugated cardboard that could be modified to waste paper. The classification would define the proportion of waste paper versus contaminants, indicating quality.

11. Barriers affecting the sector

- A range of barriers were identified, however common themes emerged.
- The barriers most frequently identified included:
  - Distance (collection / processing / market)
  - Contamination
  - End markets
  - Government support
  - Labour costs and shortage
  - Competition
  - Lack of investment / infrastructure
  - Behaviours
  - Individual business uptake
- While barriers are frequently discussed by industry and government, there is very little robust evidence available to quantify the impact of these barriers on the sector

This section provides a summary of the barriers affecting the recycling sector that were presented in literature and identified through stakeholder consultation undertaken as part of this study. Table 35 provides a description of the general themes that were identified in the literature and through consultation. The barriers are not listed in any particular order.

Table 35 Description of barriers identified

BARRIER IDENTIFIED	DESCRIPTION
Distance (collection/ processing/market)	The 'tyranny of distance' with respect to collection and transport of materials to reprocessing facilities, and from reprocessing facilities to markets. Particularly relevant for rural collection of materials and states/territories without local reprocessing or markets for particular materials.
Behaviours	Concern for the environment translates only in a limited way to actual resource recovery behaviours. Behaviours are likely to be focused around those that are tangible and accessible, with high convenience for the community, and waste disposal and resource recovery costs not being differentiated in rates notices (Hyder Consulting Pty Ltd, 2009b, pp. 116–117).
Contamination	Contamination of materials collected for recycling and of final product for sale reduces the quality of the material and confidence of the market in the materials' suitability for purpose.
Lack of investment/infrastructure	Development of infrastructure and technologies limited by: ▪ Lack of certainty of market and industry's unwillingness to bear total risk ▪ Price and therefore profit margin of recyclable material doesn't allow the adoption of innovation and technology that would result in increased recovery and competitiveness of the market. ▪ Collection contracts for businesses are often 2–3 years, which doesn't give the collection and processing companies sufficient confidence in the supply of the material for significant investment.
Landfill cost	The cheapness of the alternative (landfill) to recycling (GHD Pty Ltd, 2009, p. 97).
End markets	Availability of end markets and development of markets for the sale of products from reprocessing facilities to give certainty to recycling businesses and increase the range and quantities of materials able to be recycled.
Standards and regulations	Barriers with respect to standards and regulations include: ▪ Uncertainty of the regulatory environment ▪ Lack of standards for recycled products ▪ Lack of encouragement for recycling through regulatory controls ▪ The *National Waste Report 2010* cites an industry survey undertaken by

BARRIER IDENTIFIED	DESCRIPTION
	Access Economics which found that an uncertain regulatory environment was one of two main impediments to employment in the sector. The report also recommended a consistent definition of waste and waste classifications would provide more certainty to the industry (Environment Protection and Heritage Council, 2010b, p. 232).
Government support	Support from regulatory authorities for recycling operations is noted with respect to: ▪ Infrastructure development costs, where industry players are generally expected to take 100% risk for what the industry argues is a public utility. ▪ Lack of subsidies and incentives for recycling businesses ▪ Regulatory authorities' use of recycled materials and inclusion of recycled materials in specifications.
Recyclable material supply	Industry's lack of surety of supply of materials for recycling. Aside from government contracts, it is noted there is no clear path towards a surety of supply (Hyder Consulting Pty Ltd, 2009b, pp. 118–119).
Labour costs and shortage	Costs and availability of labour for manual sorting of materials.
Rural collection	Distance specifically associated with the transport of materials for recycling from rural and non-metropolitan areas to population centres where the sorting and reprocessing infrastructure is available.
Individual business uptake	Uptake of recycling services by the commercial and industrial sector. In general paper and cardboard is well recycled by businesses; other material streams are not commonly collected. It has been identified this is largely due to a perception that recycling should be significantly cheaper than landfilling, and not being a high priority for businesses.
Site location and planning	Site location and planning difficulties arise from: ▪ Lack of public acceptance of resource recovery facilities in proximity to residential areas ▪ Industry's lack of certainty about planning policy ▪ Difficulties in obtaining development approval when all other aspects (location, community agreement, capital costs) are in place.
Non-compliant operators	Non-compliance of operators to regulatory requirements causing: ▪ Complying operators to be less cost competitive ▪ Undermining confidence of end markets where products are not meeting product specifications ▪ Negative impacts on planning approval requirements as regulators increase

BARRIER IDENTIFIED	DESCRIPTION
	planning restrictions.
Virgin material price	Virgin materials may be cheaper than recyclable material, leading to reduced demand (Hyder Consulting Pty Ltd, 2009b, p. 113) (Environment Protection and Heritage Council, 2010b, p. 232).
Local demand for end product	In some areas of Australia, particularly geographically remote and less populated areas, there is insufficient demand to develop a market for products and/or a local industry.
Lack of research	Research into uses and processes for recycled materials, specifically for market development and development of standards to give markets confidence in the materials.
Available capacity	Capacity of existing infrastructure to cope with current and expected material quantities, including both storage of materials to be processed, processing capacity, and storage of recyclables.
Away from home collection	Lack of collection of recyclables that are produced 'away from home' such as in general public areas, shopping centres and at events, despite significant generation of recyclable material in these areas.
Price volatility of recyclable material	Some materials are subject to volatile prices, increasing uncertainty for businesses.
Market acceptance of product	Willingness of the market to accept new products and change purchase and design specifications from existing virgin sources to recyclable materials.
Ability to stockpile	Some materials are able to be stockpiled enabling businesses to take advantage of high prices. However regulations regarding stockpiles have limited the extent recycling businesses can do this.
Data availability	Availability and comparability of data to allow projections and certainty in determining appropriate infrastructure.

Sourced primarily from interviews with stakeholders, (Hyder Consulting Pty Ltd, 2009b, pp. 116–117), (Nolan-ITU Pty Ltd, 2000) (GHD Pty Ltd, 2009)

11.1 Location-specific barriers

Different Australian states and territories are affected by different barriers. Table 36 summarises the barriers described in Table 35 that have been identified for each state and territory (Y indicates the barrier has been identified for that state/territory). The barriers for each state and territory are discussed further below.

Table 36 Barriers identified to increased recycling by state/territory

BARRIER	NO.	NT	QLD	NSW	ACT	VIC	SA	WA	TAS
Distance (collection/processing/market)	3	Y	Y					Y	
Behaviours	4	Y	Y	Y		Y			
Contamination	1						Y		
Lack of investment/infrastructure	5		Y	Y		Y	Y	Y	
Landfill cost	2		Y		Y				
End markets	1				Y				
Standards and regulation	2		Y		Y				
Government support	1							Y	
Recyclable material supply	1						Y		
Labour costs and shortage	0								
Rural collection	2	Y							Y
Individual business uptake	4		Y	Y	Y	Y			
Site location and planning	2				Y			Y	
Non-compliant operators	1			Y					
Virgin material price	0								
Local demand for end products	1						Y		
Lack of research	1				Y				
Ability to stockpile	0								
Away from home collection	1								Y
Volatility of recylate price	1							Y	
Market acceptance of product	0								
Available capacity of infrastructure	0								
Data availability	2					Y			Y

11.1.1 Northern Territory

Specific barriers affecting recycling in the Northern Territory include:

- Size and geography of the territory resulting in prohibitive transport costs.

- Low population not yielding significant recycling volumes for economies of scale.
- A perception amongst business that recycling requires too much effort.

Source: (NT Recycling Solutions, 2009).

11.1.2 Queensland

Specific barriers affecting recycling in Queensland include:

- Low landfill costs undermining increased resource recovery (APC Environmental Management, 2006, p. 47). The Queensland government is introducing a landfill levy in late 2011 which should reduce the impact of this barrier in future.
- Regulations and policy aren't in place to encourage recycling. For example, regulations don't require materials to be sorted prior to landfilling.
- Recycling is not perceived as an important issue for businesses in the state.
- The size and geography of Queensland is not favourable for cost-effective collection, reprocessing, and marketing of material.
- Lack of investment in reprocessing facilities has resulted in material being transported out of the state for reprocessing. For example some material is transported from central Queensland to Victoria for reprocessing.
- Lack of 'away from home' recycling (for plastics in particular).

Source: (Hyder Consulting Pty Ltd, 2011a).

11.1.3 New South Wales

Specific barriers affecting recycling in New South Wales were identified in the Richmond review, which has informed the New South Wales waste strategy (Department of Environment and Climate Change (NSW), 2008). These include:

- Significant volumes of recycling are going to landfill from households, such as food and garden waste, and it was identified that lack of understanding of householders and existing collection services are barriers to removing this material from the waste stream.
- Other than paper and cardboard recycling, the uptake of recycling services from businesses is low. Barriers identified to further uptake included space for additional bins and a perception that recycling should be significantly cheaper than landfilling.
- Lack of investment in infrastructure. This included limited commercial and industrial reprocessing, and permanent depot facilities. Short term recycling contracts (two to three years) with the commercial and industrial sector also reduces certainty required for investment in infrastructure. Difficulty in securing land and planning limitations were also identified as barriers to investment in infrastructure.

- Lack of coordination amongst regulatory authorities resulting in missed opportunities for increased recycled, for example the digital TV switchover not being coordinated with the national television and computer product stewardship scheme.
- Non-compliant operators make it difficult for recycling businesses complying with regulatory requirements to be competitive, resulting in an uneven playing field.

Sources: stakeholder consultation with OEH, (Department of Environment, Climate Change and Water (NSW), 2011).

11.1.4 Australian Capital Territory

Specific barriers affecting recycling within the Australian Capital Territory are identified through surveys of waste and recycling businesses. These included:

- Low take-up of recycling by businesses, beyond paper and cardboard recycling.
- A lack of available markets for problem materials, such as hard timbers, which can be collected and processed. Additional research is required to develop markets.
- Access to land for reprocessing and materials storage, with particular note of land in appropriate locations close to material source.
- Landfill pricing is too low. The landfill is territory-owned, and ACT is looking at using pricing (rather than a levy) to encourage recycling.
- A perception that there are not significant policies to encourage increased uptake of recycling services by the C&I sector.

Sources: stakeholder consultation with ACT NOWaste, (Inovact Consulting Pty Ltd, 2010).

11.1.5 Victoria

Specific barriers affecting recycling in Victoria include:

- Businesses not addressing waste and recycling issues.
- Lack of infrastructure for reprocessing and transfer station drop-off facilities.
- Lack of focus on end markets in development of C&I recycling infrastructure.
- Lack of community awareness about existing opportunities for recycling.
- Lack of legislative requirements for reprocessors to provide quality data.

Sources: stakeholder consultation with SV and EPA, (Department of Sustainability and Environment, 2009).

11.1.6 South Australia

Specific barriers affecting recycling in South Australia include:

- Lack of local demand for recycled products.
- Sourcing significant quantities for economies of scale.
- Contamination, particularly of recovered plastics.

Source: (Rawtec Pty Ltd, 2009).

11.1.7 Western Australia

Specific barriers affecting recycling in Western Australia include:

- Relatively small size of population and industry does not provide the economies of scale required to support collection and local reprocessing.
- Lack of local reprocessing sector and end markets for materials.
- The volatility of prices for recyclable materials. This is particularly evident in Western Australia, due to the requirement for materials to be transported long distances for reprocessing reducing the margin able to be applied on the recyclable materials.
- Development of local infrastructure to reduce the need to transport materials out of the state is challenging due to a difficult development process; lack of long term security for industrial siting; and difficulty securing finance for the high capital costs for reprocessing facilities.
- Collection of recyclable materials from geographically remote areas. The small quantities of materials generated and the geographic distances to major centres means that a recycling service is not available in many remote locations.

Source: stakeholder consultation with Department of Environment and Conservation WA.

11.1.8 Tasmania

Barriers to recycling include:

- Improving the understanding and measurement of waste/recycling (including government, industry, population) through obtaining waste data. There is currently no overall waste authority in Tasmania to oversee this.
- Lack of recycling bins in public locations to collect 'away from home' waste.
- Collection of recyclables in remote/non-metro areas not services by kerbside trucks.

Sources: stakeholder consultation with Department of Primary Industries, Parks, Water and Environment.

11.2 Material specific barriers

The barriers described in Table 35 that have been identified for particular recycling streams are summarised in Table 37 (Y indicates the barrier has been identified for that material). The materials addressed include paper, plastics, glass, organics, construction and demolition, metal, rubber (tyres) and e-waste. The barriers identified for each stream are further discussed below.

Table 37 Barriers identified by material type

BARRIER	NO.	PAPER	PLASTICS	GLASS	ORGANICS	C&D	METAL	RUBBER	E-WASTE
Distance (collection/processing/market)	8		Y	Y	Y	Y	Y	Y	Y
Behaviours	3			Y	Y	Y			
Contamination	5	Y	Y	Y	Y	Y			
Lack of investment/infrastructure	0								
Landfill cost	3					Y	Y	Y	
End markets	4			Y	Y	Y		Y	
Standards and regulation	3				Y	Y		Y	
Government support	4		Y		Y	Y		Y	
Recyclable material supply	3	Y	Y				Y		
Labour costs and shortage	4		Y		Y		Y	Y	
Rural area collection	2					Y	Y		
Competition	4	Y			Y		Y	Y	
Individual business uptake	0								
Site location and planning	2					Y			
Non-compliant operators	2				Y	Y			
Virgin material price	3	Y				Y		Y	
Local demand for end products	2	Y	Y						
Lack of research	2				Y			Y	
Ability to stockpile	2		Y			Y			
Away from home collection	1						Y		
Volatility of recyclable material price	1						Y		
Market acceptance of product	2				Y	Y			
Available capacity of infrastructure	1								Y
Data availability	0								

11.2.1 Paper and cardboard

Barriers to increased recycling of paper and cardboard include:

- Contamination of collected material.
- Competitive cost of virgin materials, particularly for higher grade materials which require greater sorting of input material.
- Reductions in quantities of material for collection.
- Local demand for product and cost effective manufacturing.

Source: (Rawtec Pty Ltd, 2009).

11.2.2 Plastics

Barriers to increased recycling of plastics include:

- Variable prices for recyclable materials.
- Increasing variability of plastic feedstock, particularly packaging.
- Sourcing appropriate quality feed plastic and contamination.
- Labour costs and shortage.
- Local demand for product and cost effective manufacturing.

Sources: (Cardno (WA) Pty Ltd, 2008) (Rawtec Pty Ltd, 2009) (Hyder Consulting Pty Ltd, 2011a) and PACIA.

11.2.3 Glass

Barriers to increased recycling of glass include:

- Contamination of packaging glass by plate glass which isn't able to be recycled in the same way. For instance household cookware, glassware, and light globes are placed in glass recycling bins by householders as they are unaware that they are unsuitable for typical glass reprocessing.
- Crushing of glass during collection, transport and sorting (Hyder Consulting Pty Ltd, n.d). Some broken glass is being disposed of to landfill from MRF processing as it is too small for optical sorting (APC Environmental Management, 2006, p. 29). The crushed glass is also causing maintenance issues at materials recovery facilities (Steering Committee for the Review of the NSW Waste Strategy and Policy, 2010, p. 42).
- Cost of transporting glass long distances due to the weight of the material.

Sources: (Hyder Consulting Pty Ltd, n.d) (APC Environmental Management, 2006, p. 133).

11.2.4 Organics

Barriers to increased recycling of organics include:

- Contamination largely due to lack of awareness around correct disposal and management of a source-separated organics stream. Visible contamination comprising solid materials such as plastics, stones and metals, can reduce product value given that urban amenity applications require a degree of aesthetics. Non-visible contamination, from residual chemicals and pesticides, adds to production costs and reduces product quality and integrity.
- Contamination of organics by household waste, weed seeds and pathogens currently inadequately addressed by the collection systems. It is suggested that the absence of standards or quality assurance limits the end market options, and doesn't encourage demand.
- Competition for markets typically dominated by chemical fertilisers. This is particularly evident in farming areas where farmers have existing relationships and history with the chemical fertiliser industry. Farming equipment is also set up for chemical fertilisers rather than compost application.
- Distances and associated collection costs to sources of organic material and significant end-markets, particularly extensive agricultural areas.
- Lack of government support, incentives, or enforcement of regulations.
- Lack of research into applications for organic materials for the development of new and existing markets. For example opportunities for organic material in bio-remediation applications.
- Labour costs and shortage.

Sources: (Cardno (WA) Pty Ltd, 2008) (Nolan-ITU Pty Ltd, 1999) (Environment Protection and Heritage Council, 2010b, p. 189) (Hyder Consulting Pty Ltd, 2010) (Recycled Organics Unit, 2009).

11.2.5 Masonry materials

Barriers to increased recycling of masonry materials include:

- The price of landfill disposal relative to mixed load sorting.
- Contamination of materials resulting from mechanised demolition processes and mixed loads. Plasterboard and soil are major contaminants.
- Fluctuations and peaks in both the supply of waste material for processing and in the market applications for product can lead to significant stockpiling issues.
- Cost of transport from material sources to processing facilities due to the heavy weight of masonry materials, particularly from non-metropolitan areas or where a site is far from the central city.

- Unwillingness to use recycled materials rather than virgin materials.
- Low landfill gate fees restricting supply of materials for recycling.
- Competition with virgin materials, particularly when quarries are located closer to the markets than C&D recycling facilities and virgin products are therefore more cost competitive.
- Lack of standards and national consistency of standards for recycled materials in civil engineering applications.
- Lack of regulatory consistency. In Victoria, a specific licence to operate is not required but development and other planning models apply to siting of the facility. In South Australia all waste or similar facilities must be licensed and all operators are required to operate under the same guidelines. In Western Australia any facility reprocessing more than 1,000 tonnes of product, must be licensed to operate. In New South Wales facilities processing more than 30,000 tonnes per annum or 150 tonnes a day are required to be licensed whereas in Queensland a different set of standards apply and the processing quantity is 20,000 tonnes per annum.
- Market development opportunities with local government have not been fully realised. The vast majority of roads are under the management of local governments, who are generally conservative with regards to material choice.

Sources: (Cardno (WA) Pty Ltd, 2008) (Alex Fraser Pty Ltd, Recycling Industries Pty Ltd, Queensland Recycling Pty Ltd) (Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution, 2011).

11.2.6 Metal

Barriers to increased recycling of metal recycling include:

- Competition between small metal recyclers.
- Availability of source materials.
- Labour costs and shortage.
- Volatility of prices for recycled materials.
- Domestic collection in rural and regional areas.
- 'Away from home' disposal of aluminium cans.

Sources: (Cardno (WA) Pty Ltd, 2008) (Sustainability Victoria, 2010) (Hyder Consulting Pty Ltd, 2010).

11.2.7 Rubber (tyre) recycling

Barriers to increased recycling of rubber include:

- Labour costs and shortage.
- Transport costs, particularly for off-road tyres which are often used at geographically remote mine sites.
- Low landfill levies.
- Local government restrictions (for example around stockpiling of material) and lack of consistency in transporting controlled waste discouraging recovery.
- Price of recycled rubber is often higher than alternative materials.
- Lack of standards around the use of recycled materials in construction applications. For example, tyre crumb for use in asphalt.
- Lack of knowledge relating to applications such as tyre crumb behaviour in road applications in hotter climates.

Sources: (Cardno (WA) Pty Ltd, 2008) (Hyder Consulting Pty Ltd, 2010).

11.2.8 E-waste

Barriers to increased recycling of e-waste include:

- Capacity and capability for dealing with increases in quantities of materials expected.
- Size and weight of the products reducing the environmental benefit of recycling if large transport distances are required for processing.
- Securing and maintaining upstream supply stocks for new industry players.

Source: (Wright Corporate Strategy Pty Limited in collaboration with Rawtec Pty Limited, 2010).

12. Data collection and reporting

- Recycling data is compiled both on a geographic (e.g. by state/ territory) or material type basis
- Reporting for licence requirements and annual voluntary surveys are the primary mechanisms of collecting data
- There is generally a high response rate to voluntary surveys (typically 80% to 97% reported); however a number of representatives, mostly from government agencies, noted a desire to move to mandatory reporting to achieve better data coverage and quality
- In addition to providing data, the recycling industry also requires data. This information, viewed as being of relevance to the sector as a whole and appropriately provided by a centralised body, was cited as:
    - Aggregated data that is compiled for data collection exercises.
    - The profile of waste streams supplied to the recycling industry, including quantities and composition, permissible uses and competing uses, to enable informed evaluation by the recycling sector of opportunities and investment.
    - Trends and emerging issues related to waste streams supplied to the recycling industry e.g. changing profile of consumer packaging.

This section provides a summary of:

- the data the recycling sector reports
- the data the recycling sector collects, beyond that which they report
- the additional data the recycling sector could reasonably easily collect
- the additional data the recycling sector could reasonably easily report.

Due to the scope of this study being largely a desktop based exercise, it has not been possible to comprehensively address all four of the items listed above. The information presented in this section relating to the data that the recycling sector reports is comprehensive because this information is frequently publicly available. The information relating to the other items listed above was discussed with representatives from industry and their input has been presented in this report.

12.1 The data the recycling sector reports

12.1.1 Data reporting for industry and government data collection exercises

Many participants in the recycling sector report data to industry and government representatives conducting data collection exercises. In 2009, the Waste Management Association of Australia conducted a review of data collection across the waste management and resource recovery industries across Australia and identified 217 data collection activities, 144 of which were recurrent (Waste Management Association of Australia, 2009b, p. 2).

In many cases, recycling companies are likely to be collecting the data that they report to these data collection exercises for reasons beyond the fact that they are asked to report the data. Therefore, it should not be interpreted that the sole or primary purpose for the collection of the data discussed in this section is for reporting.

This reporting from the recycling sector is generally required on a state/territory basis or a material basis e.g. plastics, organics. It is the most comprehensive source of data on the activities and performance of the recycling sector, but as it is largely voluntary, it is not exhaustive.

Table 38 provides a summary of the information that is most commonly reported by the recycling sector in response to these data collection exercises.

Table 38 Most common questions for state/territory and material surveys

SURVEY QUESTIONS	
Input material	Tonnes total material received
	Material types
	Source: sector
	Source: state or territory/council
Processed material	Reprocessed quantity
	Reprocessing losses
	Stockpiled material
Output material	Destination market sector of the reprocessed material

Table 39 and Table 40 provide comparative summaries of the types of data that recycling sector participants collect and report to data collection activities (a "Y" indicates data is reported). The states and materials addressed in these tables are those for which surveys are undertaken, and therefore for which data is publicly reported[28]. Following these tables, a detailed discussion of the data that recycling sector participants report to jurisdiction specific and material specific data collection exercises is provided.

[28] Not all data collected as part of these surveys is publicly reported. Some data is not released for reasons of commercial confidentiality or perceived relevance to a public audience.

Table 39 Comparison of data reported through government and industry surveys across a sample of states

	SURVEY QUESTIONS	NO. SURVEYS	NSW	SA	WA	QLD	VIC	NATIONAL
Input material	Tonnes total material received	5	Y	Y	Y		Y	Y
	Estimated accuracy of the data	2		+/- %	Y			
	Material types	3	Y			Y		estimated %
	Tonnes per material type	2	Y			Y		
	Material form	0						
	Split of packaging vs. non-packaging material	2		% or tonnes	Y			
	Split between pre & post-consumer	2		% or tonnes	Y			
	Source: sector	5		Y	Y	Y	Y	Y
	Source: state/council	2		Y	Y			
	Source: metropolitan or non-metropolitan	1			% or tonnes			
	Source: products (if known)	2		Y	Y			
	Source: imported	1					Y	
	Source: other facilities	1	Y					
Processed material	Reprocessed quantity	4		Y	Y	Y	Y	
	Reprocessed quantity sold	0						
	Reprocessing losses	3		% or tonnes	Y	Y		
	Stockpiles	3		Y	Y		Y	
	Stockpiled material	3		Y	Y		Y	
Output material	Product from reprocessing	1					Y	
	Material destination	1				Y		
	Geographic destination market of the reprocessed material	2		Y	Y			

	SURVEY QUESTIONS	NO. SURVEYS	NSW	SA	WA	QLD	VIC	NATIONAL
	Product destination of the reprocessed material	2		Y	Y			
	Destination market sector of the reprocessed material	3		Y	Y		Y	
	Material disposed to landfill (residual)	1					Y	
General questions	FTE employees	3			Y		Y	Y
	Occupations of staff	1						Y
	Annual turnover	1			Y			
	Estimation of the size of the recycled materials markets	1		Y				
	Estimation of the strength of the recycled materials markets	1		Y				
	Potential to expand reprocessing capacity, barriers	1		Y				
	Direct 'reuse' of the material by the market	1		Y				
	Recycling activity trends, market access and any barriers	2		Y	Y			
	Other players in the market	2		Y	Y			
	Gate fees for specific material	1			Y			
	Strength of market	1			Y			
	Material availability	1			Y			
	Research and development sending	1					Y	

Table 40 Comparison of data reported through government and industry surveys across a sample of materials

SURVEY QUESTIONS		NO. SURVEYS	ORGANICS	STEEL CANS	PLASTICS
Input material	Tonnes total material received	3	Y	Y	Y
	Estimated accuracy of the data	0			
	Material types	2	Y		Y
	Tonnes per material type	1	Y		
	Material form	1			Y
	Split of packaging vs. non-packaging material	0			
	Split between pre & post consumer	0			
	Source: sector	1			Y
	Source: state/council	2		Y	Y
	Source: metropolitan or non metropolitan	1		Y	
	Source: products (if known)	0			
	Source: imported	0			
	Source: other facilities	0			
Processed material	Reprocessed quantity	0			
	Reprocessed quantity sold	1	y (m^3)		
	Reprocessing losses	0			
	Stockpiles	0			
	Stockpiled material	0			
Output material	Product from reprocessing	1	Y		
	Material destination	2		Y	Y
	Geographic destination market of the reprocessed material	0			
	Product destination of the reprocessed material	0			

SURVEY QUESTIONS		NO. SURVEYS	ORGANICS	STEEL CANS	PLASTICS
	Destination market sector of the reprocessed material	0			
	Material disposed to landfill (residual)	0			
General questions	FTE employees	0			
	Occupations of staff	0			
	Annual turnover	0			
	Estimation of the size of the recycled materials markets	0			
	Estimation of the strength of the recycled materials markets	0			
	Potential to expand reprocessing capacity, barriers	0			
	Direct 'reuse' of the material by the market	0			
	Recycling activity trends, market access and any barriers	0			
	Other players in the market	0			
	Gate fees for specific material	0			
	Strength of market	0			
	Material availability	0			
	Research and development sending	0			

12.1.1.1 Reporting to data collection exercises in jurisdictions

Recycling sector participants in all states/territories except for Tasmania and the Northern Territory are asked to report data to data collection exercises conducted or commissioned by state/territory authorities. In addition to the material streams listed in this section, some jurisdictions do contribute to material specific data collection exercises that are typically undertaken by industry associations across multiple states/territories. These are outlined in section 12.1.1.2.

12.1.1.1.1 New South Wales

Recycling sector participants are asked to report data to materials-based surveys commissioned by the NSW Department of Environment, Climate Change and Water, now the Office of Environment and Heritage (OEH). Some of these surveys are conducted annually while others are conducted on an ad hoc basis. These surveys are voluntary. Material streams that the recycling sector has been asked to report on at various times since 2003–04 are:

- C&D/building materials
- glass
- paper
- textiles
- rubber
- metals
- ash and slag.

12.1.1.1.2 South Australia

Recycling sector participants are asked to report data to the annual Recycling Activity in South Australia survey commissioned by Zero Waste South Australia. This survey is voluntary and the response rate is not provided in the report. Material streams that the recycling sector is asked to report on are:

- masonry
- metals
- organics
- paper and cardboard
- plastics
- glass
- fly ash

- foundry sands
- leather and textiles
- tyres and other rubber.

12.1.1.1.3 Western Australia

Recycling sector participants are asked to report data to the annual Recycling Activity in Western Australia survey commissioned by the Western Australian Government Waste Authority. This survey is voluntary and the response rate is not provided in the report. Material streams that the recycling sector is asked to report on are:

- C&D materials
- organics
- metals
- paper and cardboard
- textiles
- glass
- plastics
- rubber.

12.1.1.1.4 Queensland

Recycling sector participants are asked to report data to the Department of Environment and Resource Management (DERM). This survey is voluntary and in 2007–08 responses were received from 71 of 73 companies. The 2007–2008 report notes that the data is of variable quality, and includes data gaps (Department of Environment and Resource Management (QLD), 2009). Material streams that the recycling sector is asked to report on are:

- paper and packaging material collected for recycling
- segregated green waste
- C&D waste.

12.1.1.1.5 Victoria

Recycling sector participants are asked to report data to the Victorian recycling industries annual survey conducted by Sustainability Victoria. This survey is voluntary and the response rate for the 2008–09 survey was 80%. Material streams that the recycling sector is asked to report on are:

- masonry

- metals
- organics
- paper and cardboard
- plastics
- glass
- fly ash
- foundry sands
- leather and textiles
- tyres and other rubber.

12.1.1.1.6 Northern Territory

Recycling sector participants are not asked to report data on a regular basis as part of a data collection exercise.

12.1.1.1.7 Tasmania

Recycling sector participants are not asked to report data on a regular basis as part of a data collection exercise, and as such there are currently no complete datasets for Tasmania for the total amount of waste diverted from landfill through recycling, re-use, or resource recovery. Estimates of waste diverted from landfill are drawn from data supplied by landfill operators to the Environmental Protection Authority (Department of Primary Industries, Parks, Water and Environment).

Improving data collection is recognised as a major barrier/goal for Tasmania.

12.1.1.1.8 Australian Capital Territory

Recycling sector participants are asked to report data annually to ACT NoWaste. Voluntary surveys of approximately 120 organisations are undertaken, and there is a very strong response rate. The recycling sector is asked to report on all material streams that the sector handles.

12.1.1.2 Reporting to material specific data collection exercises

Recycling sector participants that handle certain materials are asked to report data to material specific data collection exercises that are typically undertaken by industry associations. The reporting undertaken by various recyclers is discussed below.

12.1.1.2.1 Recyclers of organics

Recycling sector participants in New South Wales, Western Australia, Queensland, and South

Australia that produce recycled organics products are asked to report data as part of the Organics recycling in Australia Industry statistics exercise conducted by Compost Australia (in partnership with Recycled Organics Unit). The response rate to the survey is high (99% of facilities for the 2009 report) (Recycled Organics Unit, 2009).

12.1.1.2.2 Recyclers of newsprint

Norske Skog, the only recycler of newsprint in Australia, reports data on the recycling rate for newsprint that is published by the Publishers National Environment Bureau on an annual basis.

12.1.1.2.3 Recyclers of packaging

Recycling sector participants that recycle packaging materials are asked to report data annually to the Australian Packaging Covenant to determine consumption and recycling of the following packaging materials:

- paper and cardboard
- glass
- plastic
- steel
- aluminium.

Where possible, the Australian Packaging Covenant utilises data that is already available. For example, packaging specific data that is reported to the National Plastics Recycling Survey is utilised for the Australian Packaging Covenant annual reporting.

12.1.1.2.4 Recyclers of plastics

Plastics reprocessors are asked to report data annually to the National plastics recycling survey commissioned by PACIA. The 2009–10 survey achieved over 95% market coverage (Hyder Consulting Pty Ltd, 2009a).

12.1.1.2.5 Recyclers of ash

Members of the Ash Development Association of Australia are asked to report annually on fly ash recycling.

12.1.1.2.6 Recyclers of paper

Recyclers of waste paper and cardboard are asked to report data and other information to the Pulp and paper strategic review and the *Pulp & paper edge market intelligence report* published by Industry Edge.

12.1.2 Data reporting to meet legislative requirements

Recycling sector participants can be subject to reporting requirements under legislation.

Within each Australian government jurisdiction, the government regulates companies engaging in activities or operating premises whose emissions have the potential to cause environmental harm. This is typically achieved through the licensing of activities or premises that is supported in environmental protection legislation. License holders in all jurisdictions except for Queensland are required to submit periodic reports (a representative from the Queensland Department of Environment and Resource Management advised that a requirement for license holders to report on material inputs and outputs is likely to be established in the regulations introduced to support the waste management legislation being implemented as part of the waste reform program). The reporting is most focused on compliance with license conditions, primarily protection of segments of the environment relevant to that industry, for example air emissions and discharges to water. Reporting of data is most commonly limited to the types and quantities of materials handled. The Australian Capital Territory, the Northern Territory, South Australia, Tasmania and Victoria require data on types and quantities of materials and Western Australia requires holders of a license for the transportation of controlled waste to report on type and quantity of waste.

Recycling sector participants involved in the movement of specified waste materials across state/territory borders are required to report data under the *NEPM for the Movement of Controlled Waste between States and Territories*. This data must be reported to the appropriate government body (typically an environment protection organisation or department). The data required to be reported includes material weight and type, and re-use and recovery in Australia and through export, facility information, and type of treatment (National Environment Protection Council, 2011).

12.1.3 Data reporting for contractual requirements

Data reporting requirements are often established in contractual requirements for recycling services. Contracts between local governments and recycling service providers for the provision of services such as kerbside recycling collection, hard waste collection or household chemical collections predominantly contain requirements for data relating to materials handled, materials recycled and destination of materials handled. In South Australia, model contracts and tendering information are available to help local governments incorporate reporting requirements for state statutory and funding obligations into waste and recycling contracts (Local Government Association of South Australia).

Contracts between product scheme operators e.g. Cartridges for Planet Ark and Mobile Muster and recycling service providers typically require reporting of data relating to materials handled, materials recycled and destination of materials handled.

The data collected for contractual requirements is generally not publicly disclosed. Local

governments in some states/territories report aggregated data to state government agencies. For example, in Victoria, local governments report data to Sustainability Victoria annually as part of the Victorian local government annual survey. Product stewardship scheme operators often publish annual reports containing materials received (in tonnes) and recovery rates.

12.1.4 Data reporting for publicly listed companies

Some waste and recycling companies are publicly listed and are required by the *Corporations Act 2011* to publicly disclose information. Most publicly listed companies publish an annual report containing financial disclosures and some publicly listed companies publish a sustainability report containing non-financial disclosures. These reports typically do not include detail data related to waste or recycling, whether this is financial or non-financial.

12.2 Data the recycling sector collects

Beyond the data that has been outlined in Section 12.1, the recycling sector collects data that is necessary for the operation of its business. This data relates to:

- business operations e.g. operating costs, turnover and employment and wages
- market intelligence e.g. customer profiles, materials generation (quantity and profile of waste generated by potential customers), markets and prices for services (e.g. kerbside recycling contracts) and outputs (e.g. waste paper and cardboard), competitor profiles and strategies
- the operating environment e.g. policies and legislation
- new developments e.g. technologies and land available for purchase that is suitable for facility siting.

Larger companies with more resources and a more professional approach to the operation of their business are more likely to collect all the data listed above. Smaller companies on the other hand often only collect data relating to their business operations.

One stakeholder representing an industry association commented that they are constantly frustrated by the lack of data from industry participants and it seems unfathomable that individual companies don't collect more data beyond their own business operations.

12.3 Data the recycling sector could collect

During discussions with industry, representatives were asked to indicate what data, beyond what is currently collected and reported, could easily be collected. Responses to this question are provided below.

- Smaller companies are unlikely to have the resources and possibly the capacity to collect additional data beyond what was discussed in Section 12.1. It's not possible to apply the same expectations for data provision to small and large companies.

- Compost Australia advised that the annual survey of organics reprocessing companies reflects the limitations of the data that most industry participants are able to collect.
- There would need to be a compelling business case or value for additional data collection. Requests from government were not considered to be a compelling business case for individual companies, however it was acknowledged that the amount and type of data produced by the sector is inadequate for strategic, sector-wide planning purposes.

12.4 Data the recycling sector could report

During discussions with industry, representatives were asked to indicate what data, beyond what is currently collected and reported, could easily be collected and subsequently reported, either in a limited capacity (to a third party such as government or an association) or to the public. Responses to this question are provided below.

- One large recycling company indicated that they believed industry participants would report data such as annual turnover, capital investment and employment, if there was a compelling reason for its requirement and anonymity of company-specific data could be assured. This data would be disclosed to a third party such as a government agency or an industry association.
- The majority of industry participants stated that they are unlikely to report information relating to markets and customer segments. Market intelligence is in many cases the only differentiation between companies and the basis of a company's business model.
- 'Data provision fatigue' was cited as an inhibitor to increased reporting.
- It was acknowledged that, if the sector was profiled by the Australian Bureau of Statistics as other sectors such as manufacturing and pharmaceuticals are, industry participants would be required to report data of a commercially sensitive nature.

12.5 Data the recycling sector would like to receive

During discussions with industry stakeholders it was made clear that, in addition to providing data, the industry also requires data. This information was viewed as being of relevance to the sector as a whole, and appropriately provided by a centralised body. The information that was cited as beneficial to the industry as a whole was:

- Aggregated data that is compiled for data collection exercises.
- The profile of waste streams being generated and supplied to the recycling industry to enable informed evaluation by the recycling sector of opportunities and investment. This information includes waste quantities and composition, permissible uses and competing uses.
- Trends and emerging issues related to waste streams supplied to the recycling industry e.g. changing profile of consumer packaging.

13. Future outlook

- A comparison of the current level of recycling and the recycling targets in place across Australia indicates that there is significant capacity for increased levels of recycling.
- The opportunities for increased levels of recycling include commercial and industrial materials, organics and products (such as appliances).
- Recycling is viewed as a critical component of our economy's transition towards reducing its reliance on virgin, non-renewable materials, similar to the challenge of reducing our reliance on non-renewable sources of energy sources.
- There are significant information gaps relating to the size, characteristics and performance of the recycling sector. In particular, key economic and financial metrics that are critical to understanding the economics of any sector are either not or only partially available for the recycling sector. It is therefore not possible to construct a complete and robust assessment of the contribution of the recycling sector to the achievement of social, environmental and economic outcomes in Australia. It is also difficult for government and the industry to make decisions relating to future recycling capacity, infrastructure requirements and industry development requirements.
- Some segments of the recycling industry are perceived to be financially marginal. The vision for the recycling sector in the future is that businesses are based on robust business models and less susceptible to fluctuations in commodity prices.
- Professionalism was a recurrent theme that emerged from the stakeholder consultation. The recycling sector in the future was visualised as more focused on technology and having robust business models driven by market demand rather than what can be supplied.

This section discusses the challenges and opportunities for the recycling sector in the future.

The recycling sector is an important element of Australia's future industrial and environmental landscape. A thriving recycling sector will enable Australia, and other countries around the world, to reduce reliance on finite resources and to maximise the value that we extract from the resources that we do use.

There are a number of challenges and opportunities for the recycling sector now and into the future. The following discussion is largely based on opinions expressed by the government and industry stakeholders consulted.

13.1 Opportunities

13.1.1 Potential to increase recycling quantities

There is a strong perception among both government and industry that there is significant potential to increase the quantity of material recycled. The 2008–09 recycling rate across Australia of 44% (Hyder Consulting Pty Ltd, 2011c, p. 41) would appear to support this.

Recycling targets within each of the Australian jurisdictions are the most suitable indication of the likely recycling rates in the future. Table 41 provides the recycling targets in each of the jurisdictions compared with the most recent recycling rate. This comparison demonstrates that there is a significant planned increase in the recycling rate, across most jurisdictions and particularly relating to MSW and C&I materials.

Table 41 Recycling rates and targets across Australia

	MSW CURRENT	MSW TARGET	C&I CURRENT	C&I TARGET	C&D CURRENT	C&D TARGET	TOTAL CURRENT	TOTAL TARGET
ACT	-	-	-	-	-	-	76 in 2008–09	80 by 2015
NSW	44 in 2009	66 by 2014	52 in 2009	63 by 2014	73 in 2009	76 by 2014	-	-
QLD	23 in 2008	50 by 2014	18 in 2008	40 by 2014	35 in 2008	50 by 2014	-	-
SA	55 in 2009	65 by 2015	60 in 2009	75 by 2015	80 in 2009	90 by 2015	-	-
VIC	48 in 2009–10	65 by 2013–14	65 in 2009–10	80 by 2013–14	80 in 2009–10	80 by 2013–14	66% in 2009–10	75% by 2013–14
WA	45% in 2010	70 by 2016	-	-	14 in 2006–07	50 by 2016	-	-

Sources:

Current data for Victoria: (Sustainability Victoria, 2011).

ACT total current: (Hyder Consulting Pty Ltd, 2011c, p. 35).

South Australia current figures: (Zero Waste SA, 2010).

Western Australia current figures: (Western Australian Waste Authority , 2010, p. 16).

All other data: (Waste Management & Environment and Hyder Consulting, 2011).

Notes:

The MSW target for WA is for the Perth metropolitan area only.

South Australia total currents are for Adelaide metropolitan area only.

Data for Tasmania and NT is not available.

During discussions with stakeholders, organics and products were identified as waste streams demonstrating significant potential to contribute to an increase in recycling. A discussion of these is provided below.

13.1.1.1 Organics

A number of stakeholders indicated that there is significant potential to increase organics recycling. In 2008–09, 33% of the organic waste generated in Australia was recycled. Data published in the *Inside Waste Industry Report 2011–12* identified that organics recycling and recovery is a major focus of the sector in the future. 72% of the capital expenditure required to achieve state/territory-based resource recovery rates is associated with organics, composting and alternative waste treatment facilities (Waste Management & Environment and Hyder Consulting, 2011).

While there is significant potential to increase organics recycling, there are also barriers inhibiting

investment. Compost Australia, the national body for the organics processing and recycling industry, cited difficulties in some jurisdictions obtaining planning approvals and licenses to operate organics facilities due to concerns about odour impacts. Weak end markets for recycled organics products, particularly for lower grade products, also inhibit investment in organics recycling.

13.1.1.2 Products

In addition to increasing the recycling rates for the commonly recycled materials, some stakeholders mentioned the need to focus on product streams where the potential to recycle is yet to be fully realised. Products, such as televisions and computers, are more complex to recycle than materials because they are of mixed composition (rather than a soft drink can, as an example, that is composed only of aluminium), potentially requiring manual dismantling and the use of sophisticated machinery to shred and separate into material streams. This complexity has meant that in many instances it has not been financially viable for the sector to recycle these products, and valuable materials are being disposed of to landfill. The National Product Stewardship Framework, which will encourage and in some instances require industries to be responsible for the end-of-life management of products, is seen as an important vehicle for driving increased recycling of products.

13.1.2 An integrated approach to resource efficiency

A more integrated approach to resource efficiency is viewed as critical to increasing recycling. The challenge as articulated by the Australian Council of Recycling is for our economy to reduce its reliance on virgin, non-renewable materials, similar to the challenge of reducing our reliance on non-renewable sources of energy sources. It views the recycling sector as critical to addressing this challenge.

Waste avoidance, sustainable design and manufacture, and recycling need to be considered holistically so that we can reduce our reliance on non-renewable resources, and sustainably manage those resources that we do consume. This would require more communication and cooperation across the supply chain, with the manufacturing sector and the recycling sector collaborating on product design and material selection to maximise recycling and the use of recycled content. Collaboration between companies would also be required to maximise opportunities for beneficial reuse of industrial by-products. A closed loop system where all materials can be captured and reprocessed into new products was the stated ideal.

The recycling rate is currently the most commonly cited metric to represent waste, recycling and resource efficiency outcomes. The recycling rate represents the quantity of materials that are being captured for another use, however it does not capture the materials that are avoided through resource efficiency and sustainable design. Industry associations consulted during the development of this report referred to efforts to develop a more meaningful and appropriate metric to represent the full resource savings that arise from resource efficiency and sustainable design efforts.

Within the more traditional recycling sector, it was viewed that there was potential for increased collaboration to increase recycling. Examples cited were the industry utilising consolidated collection methods such as transfer stations or collection events to more cost effectively collect materials, and reprocessors collaborating with other reprocessors based on their respective comparative advantages.

13.2 Challenges

13.2.1 Data availability

The conduct of this study, which was intended to bring together all existing research relating to the recycling sector, has identified significant information gaps relating to the size, characteristics and performance of the recycling sector. There is no centralised and up-to-date repository of data and information relating to the sector. The data that is available is generally collected through surveys and research which requires the voluntary provision of data by individual companies. Provision of data can be inhibited by resource constraints, concerns about maintaining commercial confidentiality and competitive advantage and a lack of perceived benefit from providing information. It is therefore not possible to construct a complete and robust assessment of the contribution of the recycling sector to the achievement of social, environmental and economic outcomes in Australia. It is also difficult for government and the industry to make decisions relating to future recycling capacity, infrastructure requirements and industry development requirements.

Many stakeholders consulted, particularly government representatives, expressed a desire for the establishment of mandatory data reporting requirements for the recycling sector. There are currently limited opportunities for mandatory data reporting. Providers of recycling services on behalf of local governments may be required to provide data as a condition of contract. Recycling activities or premises that are licensed may be required to provide data to the relevant regulator. Sector wide mandatory data reporting could require the introduction of legislation to achieve this. Alternatively, the Australian Bureau of Statistics (ABS) has the authority, granted through the *Census and Statistics Act 1905* to conduct statistical collections and, when necessary, to direct a person or an organisation to provide statistical information. If the ABS was to conduct research into the recycling sector, as it does for other sectors such as manufacturing and retail trade, data reporting would effectively be mandatory.

A smaller number of stakeholders, particularly industry representatives, indicated a preference for voluntary reporting that is centrally coordinated. This approach would reduce duplication of effort and the burden placed on recycling sector participants. Reporting would remain voluntary and it is not possible to state whether a more complete data set would be attained.

A key outcome of the development of this study has been the identification and evaluation of available data relating to the recycling sector. Key findings relating to data gaps and inadequacies are provided below.

- It is not currently possible to determine the number of industry participants in the recycling sector. This is in large part due to the previously acknowledged difficulty of defining the sector. When compared to other industry sectors such as retail trade and the wine and grape industry, this is fundamental information that the industry association generally has available or the ABS has determined.
- While the barriers affecting the recycling sector are frequently discussed, there is very little robust evidence available to quantify the impact of these barriers on the sector and its participants. A lack of evidence inhibits the ability of the sector to engage with government on issues such as regulatory reform and industry development.
- Very few studies of a sizable scale have endeavoured to measure the impacts of the recycling sector or recycling more broadly upon the community. Therefore, the information on the social impacts, both positive and negative, of the recycling sector is largely anecdotal.
- Key economic and financial metrics that are critical to understanding the economics of any sector are either not or only partially available for the recycling sector. These metrics include turnover, value-add, profitability (i.e. income and expenses), capital investment and employment.

13.2.2 Financial sustainability

Increasing recycling inevitably requires a strong and viable sector, however some segments of the recycling industry are perceived to be financially marginal. This view was more frequently cited by government representatives. The vision for the recycling sector in the future is that businesses are based on robust business models and less susceptible to fluctuations in commodity prices.

While there was broad recognition of the role for governments to support the sector to increase recycling (through a variety of approaches not limited to financial support), in the future the industry would ideally be thriving and support would be the exception rather than the rule.

13.2.3 A sophisticated and professional sector

Professionalism was a recurrent theme that emerged from the stakeholder consultation. It was widely acknowledged that recycling has become a more mainstream and professional industry in recent years. Stakeholders encouraged the industry to continue with this move towards being a more professional and sophisticated industry.

The recycling sector in the future was visualised as more focused on technology and having robust business models driven by market demand rather than what can be supplied.

A sophisticated and professional industry was seen as more capable of operating facilities in an environmentally and socially responsible manner.

Limitations

Net Balance Management Group Pty Ltd (Net Balance) has prepared this report in accordance with the usual care and thoroughness of the consulting profession. This report has been prepared for use by the Department of Sustainability, Environment, Water, Population and Communities.

The Report is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the project brief. The methodology adopted and sources of information used by Net Balance are outlined in this report.

Please note that all results have been reported as recorded. Any percentages that do not add up to exactly 100% are the result of rounding errors.

This report was prepared in November 2011 and is based on the conditions encountered and information reviewed at the time of preparation. Net Balance disclaims responsibility for any changes that may have occurred after this time. Whilst Net Balance makes every endeavour to ensure the accuracy, currency and reliability of information, we make no representations or warranties of any kind, express or implied, about the completeness, accuracy, reliability, with respect to this report.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A References

Access Economics. (2009). *Employment in waste management and recycling.*

ACOR. (2011). *Australian Packaging Covenant: Action Plan 2011.*

ACOR. (2011). Stakeholder interview.

Agrow Australia. (n.d.). *Triple Super Phosphate 0-46-0 TSP, Typical Analysis*. Retrieved August 17, 2011, from Agrow Australia: http://www.agrow.com.au/assets/pdf/TSP_2009.pdf

Alex Fraser Pty Ltd, Recycling Industries Pty Ltd, Queensland Recycling Pty Ltd. (n.d.). *National Waste Policy Submission.*

Andrews, D. (2011, September 6). Executive Director, Green Collect. (N. B. Katherine Evans, Interviewer)

APC Environmental Management. (2006). *Queensland used glass sourcing study for Queensland EPA.* Queensland EPA.

Australian Aluminium Council Ltd. (n.d.). *Aluminium - Material: Recycling*. Retrieved 9 19, 2011, from http://aluminium.org.au/recycling

Australian Bureau of Statistics. (2007). *8226.0 - Electricity, Gas, Water and Waste Services, Australia, 2006–07.* http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8226.02006-07?OpenDocument.

Australian Bureau of Statistics. (2007). *9208.0 Survey of Motor Vehicle Use, Australia, 12 months ended 31 Oct 2007.*

Australian Bureau of Statistics. (2009). *4602.0.55.002 Environmental issues: waste management and transport issues.* Canberra: ABS.

Australian Bureau of Statistics. (2009). *9309.0 Motor Vehicle Census, Australia, 31 March 2009.*

Australian Bureau of Statistics. (2010). *4610.0 - Water Account, Australia, 2008–09.*

Australian Bureau of Statistics. (2011). *8698.0 Waste Management Services, Australia, 2009–10.*

Australian Council of Recyclers. (2006). *Submission to the Inquiry into waste generation and resource efficiency.* Australian Council of Recyclers.

Australian Food & Grocery Council. (2009). *Hospitality Pubs and Clubs Glass Recycling Project Victoria: Final Report & Business Case.* Canberra: National Packaging Covenant.

Australian Wildlife Coservancy. (n.d.). *Australia's biodiversity crisis*. Retrieved 12 19, 2011, from Australian Wildlife Conservancy: http://www.australianwildlife.org/Wildlife-and-Ecosystems/Australias-Biodiversity-Crisis.aspx

Bidet, E., & Spear, R. (2003). The Role of Social Enterprise in European Labour Markets. *EMES*

Network Working Paper No. 03/10.

Blue Environment. (2009). *Guide to best practice for organics recovery.* Melbourne.

Blue Environment Pty Ltd. (2011). *Waste Management 2020 and Beyond.* Southern Waste Strategy Authority.

Bluescope Steel. (n.d.). *Recycling in the steel industry*. Retrieved 06 21, 2011, from BlueScope Steel: http://www.bluescopesteel.com/go/about-bluescope-steel/student-information/recycling-in-the-steel-industry/recycling-in-the-steel-industry#001

Bruvoll, & Karine. (2004). The Cold Shiver of Not Giving Enough: On the Social Cost of Recycling. *Land Economics, Vol. 80, No. 4*, 539-549.

Cardno (WA) Pty Ltd. (2008). *Review of total recycling activity in Western Australia 2006–07.* Department of Environment and Conservation (WA).

Cardno Pty Ltd. (2008). *Detailed investigation into existing and potential markets for recycled construction and demolition materials.* Department of Environment and Conservation (WA).

Chudleigh, P., & Simpson, S. (2000). *The National Eutrophication Management Program – A Review.* Land and Water Resources Research and Development Corporation.

Clean Up Australia Ltd. (2009). *Glass recycling fact sheet.*

Community Recycling Network Australia. (2011). *Community Recycling Network Australia*. Retrieved September 1, 2011, from http://www.communityrecycling.com.au/

Compost Australia. (n.d.). *Market development action plan: 2008–2011.*

Cordell, D. (2010). *The Story of Phosphorus: Sustainability implications of global phosphorus scarcity for food security.* Linköping University Electronic Press.

Department of Climate Change and Energy Efficiency. (2011). *National Greenhouse Accounts Factors.*

Department of Environment and Climate Change (NSW). (2007). *NSW Waste Avoidance and Resource Recovery Strategy 2007.*

Department of Environment and Climate Change (NSW). (2008). *NSW Resource Recovery Industries survey 2005–06.*

Department of Environment and Resource Management (QLD). (2009). *The state of waste and recycling in Queensland 2008.*

Department of Environment and Resource Management (QLD). (2010a). *What Does an Industry Waste Levy Mean for Queensland?*

Department of Environment and Resource Management (QLD). (2010b). *Queensland's Waste*

Reduction and Recycling Strategy 2010–2020.

Department of Environment, Climate Change and Water (NSW). (2006). *Environmental Benefits of Recycling Calculator.*

Department of Environment, Climate Change and Water (NSW). (2008). *Identifying potential agricultural and horticultural markets for composted garden organics in NSW.*

Department of Environment, Climate Change and Water (NSW). (2009). *NSW Resource Recovery Industries Survey 2008–09: Paper reprocessing fact sheet.*

Department of Environment, Climate Change and Water (NSW). (2010a). *Disposal based survey of the commercial and industrial waste stream in Sydney.*

Department of Environment, Climate Change and Water (NSW). (2010b). *Environmental benefits of recycling.* Sydney.

Department of Environment, Climate Change and Water (NSW). (2010c). *Environmental benefits of recycling: Appendix 1 – Metals.*

Department of Environment, Climate Change and Water (NSW). (2010d). *NSW Resource Recovery Industries Survey 2008–09: Organics reprocessing fact sheet.*

Department of Environment, Climate Change and Water (NSW). (2010e). *NSW Waste Avoidance and Resource Recovery Strategy; Discussion draft: Strategic Directions and Implementation Plan 2011–2015.*

Department of Environment, Climate Change and Water (NSW). (2010f). *Waste Avoidance and Resource Recovery Strategy Progress Report : Volume 2.*

Department of Environment, Climate Change and Water (NSW). (2011). *Reducing waste: Implementation Strategy 2011–2015.*

Department of Environment, Sport and Territories. (n.d.). *Conserving Australia's biological diversity: teachers notes and display materials*. Retrieved 12 19, 2011, from Department of Sustainability, Environment, Water, Population and Communities: http://www.environment.gov.au/education/publications/biodiversity/

Department of Industry, Science and Resources. (2000). *Energy efficiency best practice in the Australian aluminium industry.* Department of Industry, Science and Resources.

Department of Industry, Tourism and Resources. (2007). *Biodiversity Management- Leading Practice Sustainable Development Program for the Mining Industry.* Department of Industry, Tourism and Resources.

Department of Industry, Tourism and Resources. (2008). *Water Management- Leading Practice Sustainable Development Program for the Mining Industry.* Department of Industry, Tourism and Resources.

Department of Primary Industries, Parks, Water and Environment. (n.d.). *The Tasmanian Waste and Resource Management Strategy.*

Department of Sustainability and Environment. (2009). *Metropolitan Waste and Resource Recovery Strategic Plan.* Victorian Government.

Department of Sustainability, Environment, Water, Population and Communities. (2011). *2011 Australian State of the Environment Report - Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities.* Canberra: Department of Sustainability, Environment, Water, Population and Communities.

Department of the Environment. (1996). *Industry profile: Pulp and paper manufacturing works.*

Department of the Environment, Water, Heritage and the Arts. (2008). *Energy use in the Australian residential sector 1986-2020.*

Dulverton Waste Management. (2009). *Regional Waste Management Strategy: Five Year Strategy 2009–2013.* Cradle Coast Authority.

EcoRecycle Victoria. (2005). *Towards zero waste: Annual survey of Victorian recycling industries 2003–2004.*

Environment Protection and Heritage Council. (2009). *National Waste Policy: Less waste, more resources.* Adelaide: NEPC Service Corporation.

Environment Protection and Heritage Council. (2010a). *National Waste Policy: Less waste, more resources implementation plan.* Adelaide: NEPC Service Corporation.

Environment Protection and Heritage Council. (2010b). *National Waste Report 2010.* Adelaide: NEPC Service Corporation.

EPA SA. (2010). *Waste Information Sheet: Container deposit legislation—a South Australian environmental success story.*

EPA USA. (2002). *Resource conservation challenge: campaigning against waste.*

European Commission. (n.d). *Background paper: Aluminium scrap.*

Evans, A. (2010). *Resource Scarcity, Climate Change and the Risk of Violent Conflict.* Center on International Cooperation, New York University.

Fair Business. (n.d.). *Fair Repairs.* Retrieved September 1, 2011, from Fair Business: http://fairbusiness.org.au/uploads/Fair%20Repairs%20SROI_two%20page%20FINAL_v2.pdf

GHD Pty Ltd. (2004). *Analysis of Markets for Recycled Organic Products: Update Report 2004.* Department of Environment and Conservation (NSW).

GHD Pty Ltd. (2009). *Waste Technology and Innovation Study Final Report.* Department of the Environment, Water, Heritage and the Arts.

Grains Research and Development Corporation. (2010, May). *Recycled organic fertiliser: fact sheet.* Retrieved June 14, 2011, from Grains Research and Development Corporation: http://www.grdc.com.au/uploads/documents/GRDC_FS_RecycledOrganics.pdf

Grant, T. a. (2005). *Life Cycle Impact Data for Resource Recovery from C&I and C&D Waste in Victoria.* RMIT University Centre for Design.

Hanson Landfill Services. (n.d.). *Sustainable Waste Management*. Retrieved September 2011, from http://www.hansonlandfill.com.au/Sustainability.aspx

Harper, C. A. (2002). *Handbook of plastics, elastomers, and composites.* McGraw-Hill Professional.

Herzog, A., Lipman, T., & Kammen, D. (2001). Renewable Energy Sources. In *Our Fragile World: Challenges and Opportunities for Sustainable Development.* EOLSS Publishers Co Ltd.

Hyder Consulting and ACOR. (2008). *Australian recycling values - a net benefits assessment.*

Hyder Consulting Pty Ltd. (2008). *Australian recycling values - a net benefits assessment.* Australian Council of Recyclers (ACOR) and the Department of the Environment and Heritage through the Natural Heritage Trust Program.

Hyder Consulting Pty Ltd. (2009a). *2009 National Plastics Recycling Survey 2008 Calendar year.* PACIA.

Hyder Consulting Pty Ltd. (2009b). *Waste and recycling in Australia: Amended Report 2009.* Department of the Environment, Water, Heritage and the Arts.

Hyder Consulting Pty Ltd. (2010). *Recycling activity in South Australia 2008-09 Financial year.* Zero Waste South Australia.

Hyder Consulting Pty Ltd. (2011a). *National plastics recycling survey: July 2009 to June 2010 survey period.* PACIA.

Hyder Consulting Pty Ltd. (2011b). *Waste and recycling in Australia 2011: Incorporating a revised method for compiling waste and recycling data (Final report).* Department of Sustainability, Environment, Water, Population and Communities.

Hyder Consulting Pty Ltd. (n.d). *Review of total recycling activity in Western Australia 2007–08 and 2008–09.* Waste Management Board of Western Australia.

Hyder Consulting Pty Ltd, EnCycle Consulting, Sustainable Resource Solution. (2011). *Construction and Demolition Waste Status Report.* Department of Sustainability, Environment, Water, Population and Communities.

Inovact Consulting Pty Ltd. (2010). *Increasing Recycling by Business in the ACT: An analysis of barriers from the perspectives of businesses and waste service providers.* ACT Government.

Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: Synthesis Report - Contribution of Working Group I, II and III to the Fourth Assessment Report of the*

Intergovernmental Panel on Climate Change [Pachauri, R.K. and Reisinger, A. (Eds)]. IPCC, Geneva, Switzerland.

Kutz, M. (2011). *Applied Plastics Engineering Handbook: Processing and Materials.* Oxford, UK: Elsevier.

Lloyd Consulting Pty Ltd. (2010). *Strategic Waste Options and Triple Bottom Line Analysis: Part 2 MSW and Organics.* Lake Macquarie City Council.

Mestan, K., & Scutella, R. (2007). *Intermediate Labour Markets as pathways to employment.* Melbourne: Brotherhood of St Laurence.

Net Balance Management Group Pty Ltd. (2009). *National Waste Data System Requirements Study.* Department of the Environment, Water, Heritage and the Arts.

Nolan-ITU Pty Ltd. (1999). *Review of recycled organic wastes in South Australia.* Adelaide: Environment Protection Agency (SA).

Nolan-ITU Pty Ltd. (2000). *Waste management committee - survey of paper and cardboard recycling in South Australia.*

NSW Government. (2009). *Waste Avoidance & Resouce Recovery Act 2001 No 58.*

NSW Government. (2010). *State Plan 2010: Chapter 5 Green State.*

NT Recycling Solutions. (2009). *Excuses are rubbish ... Recycle it!*

Office of the Queensland Parliamentary Counsel. (2009). *Environmental Protection (Waste Management) Policy 2000.* State of Queensland.

Pascoe, R. (2000). *Sorting of Waste Plastics for Recycling.* Rubber and Plastics Research Association.

Plastics and Chemicals Industries Association. (n.d.). *Plastics Identification Code*. Retrieved August 14, 2011, from Plastics and Chemicals Industries Association: http://www.pacia.org.au/Content/PIC.aspx

Plunkett Research. (2008). *Plunkett's Chemicals, Coatings and Plastics Industry Almanac 2009.* Houston: Plunkett Research Ltd.

Productivity Commission. (1990). *Industry commission: Interim report on paper recycling.* Canberra: Australian Government Publishing Service.

Productivity Commission. (1991). *Recycling: Volume 2. Recycling of products.* Commonwealth of Australia.

Productivity Commission. (2006). *Waste Management, Report No. 38.* Canberra: Australian Government.

Pulp & Paper Industry Strategy Group. (2010). *Final report: March 2010.*

Queensland Government Chief Procurement Office. (n.d.). Fact sheet 14: recycled paper.

Queensland Government.

Rawtec Pty Ltd. (2009). *South Australian recycling industry investment review.* Zero Waste South Australia.

Recycled Organics Unit. (2009). *Organics recycling in Australia: Industry Statistics 2009.* Compost Australia.

Recycled Organics Unit, The University of New South Wales. (2006). *Life cycle inventory and life cycle assessment for windrow composting systems.* Department of Environment, Climate Change and Water (NSW).

Recyle Iowa. (2001). *Economic Impacts of Recycling in Iowa.*

Research Solutions Pty Ltd. (2007). *Assessment of markets for recycled organics in Western Australia.* Perth: Department of Environment & Conservation (WA).

RISI. (2011, Vol 14, No. 22). PPI ASIA: Pulp and paper market news for Asia.

Schnaiberg, A., Weinberg, A., & Pellow, D. (2000). *Politicizing the Treadmill of Production: Reshaping Social Outcomes of 'Efficient' Recycling.* Illinois: Northwestern Univserity.

Scholl, P. (2010). *Evaluation of the social optimum for the landfill levy in Western Australia.* Perth: University of Western Australia.

Shire of Augusta Margeret River. (2010). *Glass reprocessing for local markets.* National Packaging Covenant.

Solomon, S. (2007). *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.* Cambridge University Press.

Spencer, M. (2009). *Paper and the Environment.* Fuji Xerox.

Steering Committee for the Review of the NSW Waste Strategy and Policy. (2010). *Review of Waste Strategy and Policy in New South Wales Report by the Steering Committee for the Review of NSW Waste Strategy and Policy (Richmond Review).* Department of Environment, Climate Change and Water (NSW).

Sustainability Victoria. (2010). *Annual survey of Victorian recycling industries 2008–2009.*

Sustainability Victoria. (2011). *Towards zero waste strategy 2009–10 progress report.* Melbourne: Sustainability Victoria.

The Roberts Enterprise Development Fund. (n.d.). *Rubicon Programs.* Retrieved September 1, 2011, from The Roberts Enterprise Development Fund: http://www.redf.org/learn-from-redf/publications/119

United Kingdom Cabinet Office . (2000). *Public Attitudes Towards Recycling and Waste Management Quantitative and Qualitative Review.* London: Government of the United

Kingdom.

US EPA. (2006). *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Edition.*

Vrijheid, M. (2000). Health Effects of Residence Near Hazardous Waste Landfill Sites: A Review of Epidemiologic Literature. *Environ Health Perspective 1 08 (suppl 1)*, pp 101-112.

Waste Management & Environment and Hyder Consulting. (2011). *Inside Waste: Industry Report 2011–12.* Waste Management & Environment.

Waste Management Association of Australia. (2008). *Resource recovery industry survey for the financial year ending 30 June 2007: Construction and Demolition sector.*

Waste Management Association of Australia. (2009a). *WMAA response to the National Waste Policy consultation paper.* WMAA.

Waste Management Association of Australia. (2009b). *WMRR data collection survey analysis.* WMAA.

Waste Management Association of Australia: National Technical Committee for Organics Recycling. (2004). *Best practice guideline series: composting.* Organics Recycling.

WCS. (2008). *The blue book: Australia waste industry 2007–08 - Industry and market report.*

Western Australian Waste Authority . (2010). *Draft waste strategy for Western Australia March 2010.* Perth: Western Australian Waste Authority.

White, K. M., Smith, J. R., Terry, D. J., Greenslade, J. H., & McKimmie, B. M. (2009). Social influence in the theory of planned behaviour: The role of descriptive, injunctive, and in-group norms. *British Journal of Social Psychology, 48*, 135–158.

World Health Organisation. (2011). *Fact Sheet No 313: Air Quality and Health.* World Health Organisation.

Wright Corporate Strategy Pty Limited in collaboration with Rawtec Pty Limited. (2010). *A Study of Australia's Current and Future E-Waste Recycling Infrastructure Capacity and Needs.* Department of Sustainability, Environment, Water, Population and Communities.

Zero Waste SA. (2010). *South Australia's waste strategy 2010–2015 Consultation draft.* Adelaide: Zero Waste SA.

Appendix B Organisations consulted in the development of this study

The following organisations were consulted in the development of this report:

- ACT NoWaste
- Amcor
- Australian Bureau of Statistics
- Australian Council of Recycling
- Compost Australia
- Department of Environment and Conservation, Western Australia
- Department of Environment and Resource Management, Queensland
- Department of Natural Resources, Environment, the Arts and Sport, Northern Territory
- Department of Primary Industries, Parks, Water and Environment, Tasmania
- Department of Sustainability and Environment, Victoria
- Department of Sustainability, Environment, Water, Population and Communities, Australian Government
- Office of Environment and Heritage, New South Wales
- Environment Protection Authority Victoria
- Plastics and Chemicals Industries Association
- Product Stewardship Australia
- Sustainability Victoria
- Veolia Environmental Services
- Transpacific
- Zero Waste SA

Appendix C Quantities of materials recycled in Australia, 2008–09

Table 42 Recycling quantities by material type in Australia, 2008–09 (Hyder Consulting Pty Ltd, 2011b)

CATEGORY	MATERIAL	RECYCLING (TONNES)								
		NSW[#]	VIC	QLD[#]	SA	WA	TAS[#]	ACT	NT[#]	TOTAL
Masonry materials	Asphalt	558,186	166,832	145,634	101,480	166,887	0	36,029	0	***1,175,049***
Masonry materials	Bricks	278,671	180,119	72,707	113,989	15,683	0	17,987	0	***679,157***
Masonry materials	Concrete	2,651,744	1,277,813	691,855	984,700	344,016	0	171,163	0	***6,121,291***
Masonry materials	Clay, fines, sand and rubble	838,517	676,923	218,774	19,830	196,914	0	54,124	0	***2,005,082***
Masonry materials	Plasterboard	16,982	27,313	4,431	0	0	0	1,096	0	***49,822***
Metals	Steel	1,765,600	965,000	623,430	271,306	345,160	1,067	8,683	712	***3,980,957***
Metals	Aluminium	97,069	33,000	34,275	21,897	17,419	59	18,549	39	***222,307***
Metals	Other non-ferrous	122,331	101,000	43,195	18,497	12,622	74	11,568	49	***309,336***
Organics	Food organics	21,355	18,265	21,216	4,821	5,896	504	0	0	***72,058***
Organics	Garden organics	594,645	289,036	590,776	203,615	249,053	14,037	197,011	0	***2,138,173***
Organics	Timber	171,358	158,025	170,243	35,061	42,885	4,045	31,389	0	***613,006***
Organics	Other organics	266,083	66,602	264,352	110,933	135,688	6,281	0	0	***849,939***
Organics	Biosolids	22,559	31,072	22,413	1,371	1,677	533	0	0	***79,625***

CATEGORY	MATERIAL	RECYCLING (TONNES)								
		NSW[#]	VIC	QLD[#]	SA	WA	TAS[#]	ACT	NT[#]	TOTAL
Paper/cardboard	Cardboard & waxed cardboard	966,956	878,000	324,837	104,147	121,772	24,355	34,387	6,708	***2,461,162***
Paper/cardboard	Liquid paperboard (LPB)	5,586	0	1,877	1,475	750	141	199	39	***10,066***
Paper/cardboard	Magazines	283,288	161,000	95,167	7,314	81,566	7,135	10,074	1,965	***647,511***
Paper/cardboard	Newsprint	105,115	0	35,312	40,226	0	2,648	3,738	729	***187,769***
Paper/cardboard	Phonebooks	13,201	0	4,435	5,052	0	333	469	92	***23,581***
Paper/cardboard	Printing & writing papers	225,853	93,000	75,873	45,885	26,912	5,689	8,032	1,567	***482,810***
Plastics	PET	20,969	41,082	9,158	5,208	3,748	799	537	257	***81,757***
Plastics	HDPE	19,842	38,874	8,666	2,689	6,694	756	563	243	***78,327***
Plastics	PVC	2,322	4,550	1,014	409	651	88	0	28	***9,063***
Plastics	LDPE	14,853	29,100	6,487	2,959	3,682	566	0	182	***57,829***
Plastics	PP	9,724	19,051	4,247	1,531	2,980	370	0	119	***38,023***
Plastics	PS	3,119	6,111	1,362	541	886	119	0	38	***12,176***
Plastics	Other plastics	2,671	5,232	1,166	463	759	102	0	33	***10,426***
Glass	Glass	500,700	185,000	192,800	61,600	26,700	7,100	16,000	4,000	***993,900***
Other	Leather & textiles	50,200	4,000	0	3,100	51,400	0	6,700	0	***115,300***
Other	Tyres & other rubber	0	35,000	0	10,100	2,000	0	4,000	0	***51,200***
Hazardous	Quarantine	0	0	0	0	0	0	0	0	***0***
Hazardous	Contaminated soil	0	0	176,400	0	0	6,000	0	0	***182,400***
Hazardous	Industrial waste	0	0	221,500	0	0	0	0	0	***221,500***

CATEGORY	MATERIAL	RECYCLING (TONNES)								
		NSW[#]	VIC	QLD[#]	SA	WA	TAS[#]	ACT	NT[#]	TOTAL
Hazardous	Asbestos	0	0	0	0	0	0	0	0	***0***
Fly Ash	Fly ash	705,800	399,200	929,600	223,000	139,200	0	0	0	***2,396,700***
Total		***10,335,300***	***5,890,100***	***4,993,200***	***2,403,000***	***2,003,600***	***82,900***	***632,300***	***16,700***	***26,357,300***

Note:

Recycling data for some states/territories (NSW, Qld, Tas and NT) and materials was only available at the aggregated "category" level (Hyder Consulting Pty Ltd, 2011b) Other states/territories (Vic, SA, WA and ACT) had data available at the more detailed "material" level. Individual recycling quantities for each material were estimated in the table above based on the average material proportions within each category for Victoria, SA and WA , the three major states with disaggregated data available (Hyder Consulting Pty Ltd, 2011b). Any discrepancies in totals are due to rounding.

Appendix D LCA references used for materials

Note: materials were often referred to under slightly different names and categories within the different LCA studies reviewed. All reasonable efforts were made to allow accurate comparisons between similar materials in different studies. Table 43 shows the references selected for use in this report. A comparison of multiple LCA results for each material is presented from Table 44 onwards.

Table 43 References used for the LCA assessment of energy, greenhouse, and water impacts

CATEGORY	MATERIAL	LCA MATERIAL FACTOR USED (REFERENCE SOURCE)
Masonry materials	Asphalt	Asphalt (Department of Environment, Climate Change and Water (NSW), 2010b)
Masonry materials	Bricks	Brick (Department of Environment, Climate Change and Water (NSW), 2010b)
Masonry materials	Concrete	Concrete (Department of Environment, Climate Change and Water (NSW), 2010b)
Masonry materials	Clay, fines, sand and rubble	Soil and sand (Grant, 2005)
Masonry materials	Plasterboard	Plasterboard (Department of Environment, Climate Change and Water (NSW), 2010b)
Metals	Steel	Steel/ferrous (Hyder Consulting Pty Ltd, 2008)
	Two studies (Department of Environment, Climate Change and Water (NSW), 2010b; Grant, 2005) assumed that recycling steel reduced the availability of blast furnace slag created during virgin steel production. Blast furnace slag is commonly used in cement blends, and the studies assumed that a reduction of availability would lead to increased virgin cement requirements. The environmental impacts of the additional virgin cement were thus incorporated into the impact of steel recycling. This situation is potentially unique amongst the other materials because it involves a slag by-product which is already being used as a recycled material. Thus the benefits of recycling one material (steel) are assumed to compete with the benefits of another (slag). The inherent difficulties of this assumption were noted by one study (Department of Environment, Climate Change and Water (NSW), 2010b). This assumption is potentially inconsistent with the LCA of other materials reviewed, since the result is significantly impacted by systems only indirectly related to the material. It also implies that slag cannot be sourced elsewhere (such as improving slag collection rates), or substituted by an alternative material in cement blends (such as fly ash, which is also used in cement blends and is addressed in this study as a commonly recycled material). As a result, an alternative LCA factor for steel was used (Hyder Consulting Pty Ltd, 2008)	

CATEGORY	MATERIAL	LCA MATERIAL FACTOR USED (REFERENCE SOURCE)
	which did not appear to incorporate the secondary effects of slag.	
Metals	Aluminium	Aluminium scrap (Department of Environment, Climate Change and Water (NSW), 2010b) The study distinguishes between scrap aluminium and aluminium cans, with similar results.
Metals	Other non-ferrous	Copper (Department of Environment, Climate Change and Water (NSW), 2010b)
Organics	Food organics	Food and garden organics (Department of Environment, Climate Change and Water (NSW), 2010b)
Organics	Garden organics	Garden organics (Department of Environment, Climate Change and Water (NSW), 2010b)
Organics	Timber	Timber (Department of Environment, Climate Change and Water (NSW), 2010b)
Organics	Other organics	Food and garden organics (Department of Environment, Climate Change and Water (NSW), 2010b)
Organics	Biosolids	Food and garden organics (Department of Environment, Climate Change and Water (NSW), 2010b)
Paper/cardboard	Cardboard & waxed cardboard	Paper/cardboard (Department of Environment, Climate Change and Water (NSW), 2010b)
Paper/cardboard	Liquid paperboard (LPB)	Liquid paperboard (Department of Environment, Climate Change and Water (NSW), 2010b)
Paper/cardboard	Magazines	Newsprint/magazines (Department of Environment, Climate Change and Water (NSW), 2010b)
Paper/cardboard	Newsprint	Newsprint/magazines (Department of Environment, Climate Change and Water (NSW), 2010b)
Paper/cardboard	Phonebooks	Telephone books (Grant, 2005)
Paper/cardboard	Printing & writing papers	Office paper (Department of Environment, Climate Change and Water (NSW), 2010b)
Plastics	PET	PET (Department of Environment, Climate Change and Water (NSW), 2010b)
Plastics	HDPE	HDPE (Department of Environment, Climate Change and Water (NSW), 2010b)
Plastics	PVC	PVC (Department of Environment, Climate Change and Water (NSW), 2010b)
Plastics	LDPE	LDPE (US EPA, 2006)(GHG only) Only one LCA study specifically assessed LDPE and with no

CATEGORY	MATERIAL	LCA MATERIAL FACTOR USED (REFERENCE SOURCE)
		comparison studies available this value is potentially uncertain. However, LCA factors for other materials within this study were generally found to be consistent with the other studies. This provides reasonable confidence in the estimations made.
Plastics	PP	PP (Grant, 2005)
Plastics	PS	Mixed plastics (Department of Environment, Climate Change and Water (NSW), 2010b)
Plastics	Other plastics	Mixed plastics (Department of Environment, Climate Change and Water (NSW), 2010b)
Other	Glass	Glass (Department of Environment, Climate Change and Water (NSW), 2010b)
Other	Leather & textiles	LCA factor unavailable
Other	Tyres & other rubber	Rubber tyres (Department of Environment, Climate Change and Water (NSW), 2010b)
Hazardous	Quarantine	NA (no recycling reported) (Hyder Consulting Pty Ltd, 2011b)
Hazardous	Contaminated soil	LCA factor unavailable
Hazardous	Industrial waste	LCA factor unavailable
Hazardous	Asbestos	NA (no recycling reported) (Hyder Consulting Pty Ltd, 2011b)
Anomalies	Clean fill	NA (no recycling reported) (Hyder Consulting Pty Ltd, 2011b)
Anomalies	Fly ash	Fly ash (US EPA, 2006) (GHG-e only) As with LDPE, only one LCA study specifically assessed fly ash.

Notes:

LCA results from (Department of Environment, Climate Change and Water (NSW), 2010b) were taken as the average of kerbside and C&I/C&D results

Eutrophication and photochemical oxidation results all taken from (Grant, 2005)

Recommended categories in previous DSEWPaC consultant study (Hyder Consulting Pty Ltd, 2011b)

Appendix E Summary of LCA environmental indicators

The tables presented in this appendix summarise all of the LCA data across the four reports that were reviewed in the development of the environmental benefits section of this report. In the tables presented in this appendix, a green cell is used to indicate those figures that have been used in the environmental impacts calculations, a dark grey cell indicates that data relating to the corresponding material was not included in the report and a light grey cell indicates that this data was not used in the environmental impacts calculations.

Table 44 Energy reduction achieved by recycling instead of landfill disposal

MATERIAL	ENERGY SAVINGS PER TONNE RECOVERED (GJ/T)			
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(Department of Environment, Climate Change and Water (NSW), 2006)
Aluminium		157.59	186.95	171
Aluminium cans	181.26		176.65	
Aluminium scrap	191.42			
Copper	36.09		35.43	
Packaging steel	7.31			
Steel/ferrous	7.94	30.09	39.77	32.9
Steel cans			36.67	
Car bodies			39.44	
Mixed metal				
Glass	6.46	2.08	6.42	3.8
Sheet/laminated glass	0.33		0.34	
Paper/cardboard	10.04	14.17	12.53	18
Office paper	3.38		12.99	
Mixed paper			11.52	
Telephone books			12.31	
Text books				
Newsprint/magazines	6.38		9.07	
Magazines				
Paper sludge			2.17	

MATERIAL	ENERGY SAVINGS PER TONNE RECOVERED (GJ/T)			
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(Department of Environment, Climate Change and Water (NSW), 2006)
Corrugated containers				
Liquid paperboard	-3.22		9.19	7.2
PET	51.97	52.22	53.12	49.5
HDPE	54.14	47.65	59.21	46.8
LDPE				
PVC	43.87		53.12	
PP			58.63	
Mixed plastics	60.62		50.94	
Rubber tyres	64.08		67.17	
Other rubber			74.41	
Asphalt	2.38		2.04	
Brick	0.28		0.12	
Concrete	0.35		0.55	
Plasterboard	0.55		0.23	
Rock			0.16	
Soil and sand			0.68	
Carpet				
Fly ash				
Timber pallets/packaging	10.73		6.50	
Timber (non-packaging)			1.34	
Food & garden organics	0.18		1.60	
Garden organics	0.47		1.18	
Sawdust- recycle to compost			1.34	
Sawdust- recycle to wood fibre			0.13	
MDF				

Note:

Negative values indicate an increased impact due by recycling.

Table 45 GHG-e reduction achieved by recycling instead of landfill disposal (figures in green used in environmental impacts section)

MATERIAL	GREENHOUSE SAVINGS PER TONNE RECOVERED (t CO_2–e/t recycled)				
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(US EPA, 2006)	(Department of Environment, Climate Change and Water (NSW), 2006)
Aluminium		14.14	17.49	13.61	15.2
Aluminium cans	16.79		16.53		
Aluminium scrap	17.72				
Copper	3.43		3.40	4.97	
Packaging steel	0.40				
Steel/ferrous	0.44	0.60	1.67		0.8
Steel cans			1.49	1.8	
Car bodies			2.05		
Mixed metal				5.4	
Glass	0.59	0.90	0.60	0.28	0.4
Sheet/laminated glass	0.02		0.03		
Paper/cardboard	0.62	0.46	0.30		0.4
Office paper	0.71		0.58	2.85	
Mixed paper			0.24	3.51	
Telephone books			0.24	2.65	
Text books				3.11	
Newsprint/magazines	1.02		0.46	2.8	
Magazines				3.07	
Paper sludge			0.48		
Corrugated containers				3.1	
Liquid paperboard	-0.30		0.64		-2
PET	1.07	1.47	1.04	1.52	1.5
HDPE	0.96	0.53	1.05	1.38	0.5
LDPE				1.67	

MATERIAL	GREENHOUSE SAVINGS PER TONNE RECOVERED (t CO_2–e/t recycled)				
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(US EPA, 2006)	(Department of Environment, Climate Change and Water (NSW), 2006)
PVC	1.67		1.04		
PP			1.64		
Mixed plastics	1.56		1.37	1.5	
Rubber tyres	1.07		1.19	0.39	
Other rubber			1.20		
Asphalt	0.03		0.02	0.08	
Brick	0.02		0.01		
Concrete	0.02		0.03	0.01	
Plasterboard	0.03		0.05	-0.03	
Rock			0.01		
Soil and sand			0.09		
Carpet				7.22	
Fly ash				0.87	
Timber pallets/packaging	1.35		0.50		
Timber (non-packaging)			0.33	2.46	
Food & garden organics	0.25		0.52		
Garden organics	0.32		0.23		
Sawdust- recycle to compost			0.25		
Sawdust- recycle to wood fibre			0.09		
MDF				2.47	

Note:

Negative values indicate an increased impact due by recycling.

Table 46 Calculation of greenhouse emissions savings in terms of vehicle emissions in Australia

	VALUE	REFERENCE
Average annual distance per vehicle	14,600 km per vehicle	(Australian Bureau of Statistics, 2007)
Average fuel efficiency of vehicle	14L/100 km	(Australian Bureau of Statistics, 2007)
Average annual fuel usage per vehicle	2,044 L per vehicle	(distance x fuel efficiency)
Energy content of fuel	35.7 GJ/kL	(Department of Climate Change and Energy Efficiency, 2011)
Average energy consumed per vehicle	72.9 GJ per vehicle	(calculated from above)
Emissions factor for fuel combustion	69.8kg CO_2–e/GJ	(Department of Climate Change and Energy Efficiency, 2011)
Average emissions per vehicle	5.1 t CO_2–e per vehicle	(Average energy x emissions factor)
GHG-e savings from recycling	9,676,068 t CO_2–e	(determined in this report)
"Vehicles off the road"	1,902,271 vehicles	(GHG-e savings/emissions per vehicle)
Total vehicles in Australia, 2008–09	15,674,436 vehicles	(Australian Bureau of Statistics, 2009)
% of Australian vehicles	12.1%	(calculated from above)

Note:

Figures include all vehicle types (passenger, truck, motorcycle etc.). NGA factors used were based on weighted average of two-thirds petrol, one-third diesel (Australian Bureau of Statistics, 2007).

Table 47 Water savings achieved by recycling instead of landfill disposal (figures in green used in environmental impacts section)

MATERIAL	WATER SAVINGS PER TONNE RECOVERED (KL/T)			
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(Department of Environment, Climate Change and Water (NSW), 2006)
Aluminium		209.32	201.70	233.2
Aluminium cans	191.90		191.00	
Aluminium scrap	202.03			
Copper	5.97		5.90	
Packaging steel	-2.29			
Steel/ferrous	-2.36	8.24	-0.60	1.1
Steel cans			-0.70	
Car bodies			7.60	
Mixed metal				
Glass	2.37	1.85	2.40	2
Sheet/laminated glass	0.01		0.00	
Paper/cardboard	26.85	12.56	33.00	23.7
Office paper	1.64		31.10	
Mixed paper			30.80	
Telephone books			33.10	
Text books				
Newsprint/magazines	12.51		22.20	
Magazines				
Paper sludge			0.30	
Corrugated containers				
Liquid paperboard	8.66		16.20	9.6
PET	-21.47	-30.34	-22.20	-12.1
HDPE	-3.45	-27.09	-4.10	-10.4
LDPE				
PVC	67.64		-22.20	

MATERIAL	WATER SAVINGS PER TONNE RECOVERED (KL/T)			
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Hyder Consulting Pty Ltd, 2008)	(Grant, 2005)	(Department of Environment, Climate Change and Water (NSW), 2006)
PP			-13.00	
Mixed plastics	-11.31		-13.10	
Rubber tyres	52.25		52.40	
Other rubber			61.80	
Asphalt	0.88		1.10	
Brick	1.26		1.30	
Concrete	1.28		1.30	
Plasterboard	-0.03		-0.04	
Rock			1.30	
Soil and sand			0.40	
Carpet				
Fly ash				
Timber pallets/packaging	-0.04		2.10	
Timber (non-packaging)			0.10	
Food & garden organics	0.44		0.80	
Garden organics	0.48		0.50	
Sawdust- recycle to compost			0.60	
Sawdust- recycle to wood fibre			1.80	
MDF				

Note:

Negative values indicate an increased impact due by recycling.

Table 48 Landfill savings achieved by recycling instead of landfill disposal (figures in green used in environmental impacts section)

MATERIAL	LANDFILL SAVINGS PER TONNE RECOVERED (TONNE SAVED/TONNE RECOVERED)	
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Grant, 2005)
Aluminium		1.55
Aluminium cans	1.48	1.52
Aluminium scrap	1.56	
Copper	1.10	1.10
Packaging steel	0.95	
Steel/ferrous	1.00	0.96
Steel cans		0.86
Car bodies		0.84
Mixed metal		
Glass	0.97	0.99
Sheet/laminated glass	1.04	1.04
Paper/cardboard	0.69	0.441
Office paper	0.95	0.504
Mixed paper		0.327
Telephone books		0.375
Text books		
Newsprint/magazines	0.71	0.438
Magazines		
Paper sludge		0.445
Corrugated containers		
Liquid paperboard	0.31	0.259
PET	0.78	0.823
HDPE	2.70	0.815
LDPE		
PVC	0.79	0.702

MATERIAL	LANDFILL SAVINGS PER TONNE RECOVERED (TONNE SAVED/TONNE RECOVERED)	
	(Department of Environment, Climate Change and Water (NSW), 2010b)	(Grant, 2005)
PP		0.786
Mixed plastics	0.83	0.832
Rubber tyres	1.07	0.925
Other rubber		0.742
Asphalt	1.06	1.075
Brick	1.07	1.072
Concrete	1.09	1.078
Plasterboard	0.98	0.945
Rock		1.069
Soil and sand		1.056
Carpet		
Fly ash		
Timber pallets/packaging	0.80	0.400
Timber (non-packaging)		0.445
Food & garden organics	0.35	0.227
Garden organics	0.61	0.447
Sawdust- recycle to compost		0.448
Sawdust- recycle to wood fibre		-0.534
MDF		

Note:

Negative values indicate an increased impact due by recycling.

Table 49 Other environmental benefits achieved by recycling (figures in green used in environmental impacts section)

MATERIAL	REDUCTION OFFERED PER TONNE RECYCLED (Grant, 2005)	
	EUTROPHICATION (KG PO_4^{-3} eq./TONNE)	PHOTOCHEMICAL OXIDATION(KG C_2H_2/TONNE)
Aluminium	6.879	6.910
Aluminium cans	6.492	6.533
Aluminium scrap		
Copper	1.035	0.240
Packaging steel		
Steel/ferrous	0.954	2.712
Steel cans	0.870	2.553
Car bodies	1.041	2.446
Mixed metal		
Glass	0.305	0.161
Sheet/laminated glass	0.012	0.013
Paper/cardboard	0.293	0.750
Office paper	0.428	0.799
Mixed paper	0.260	0.658
Telephone books	0.276	0.681
Text books		
Newsprint/magazines	0.347	0.773
Magazines		
Paper sludge	0.142	0.509
Corrugated containers		
Liquid paperboard	0.228	0.684
PET	1.088	2.296
HDPE	0.719	12.408
LDPE		
PVC	1.144	0.296

MATERIAL	REDUCTION OFFERED PER TONNE RECYCLED (Grant, 2005)	
	EUTROPHICATION (KG PO_4^{-3} eq./TONNE)	PHOTOCHEMICAL OXIDATION(KG C_2H_2/TONNE)
PP	0.974	2.216
Mixed plastics	0.712	1.922
Rubber tyres	1.223	0.513
Other rubber	1.329	0.287
Asphalt	0.300	0.013
Brick	0.006	0.007
Concrete	0.019	0.036
Plasterboard	0.022	0.058
Rock	0.010	0.009
Soil and sand	0.056	0.225
Carpet		
Fly ash		
Timber pallets/packaging	0.256	1.460
Timber (non-packaging)	0.093	0.345
Food & garden organics	0.099	0.276
Garden organics	0.078	0.225
Sawdust- recycle to compost	0.081	0.224
Sawdust- recycle to wood fibre	0.196	0.380
MDF		

Note:

Negative values indicate an increased impact due by recycling.