Australian Recycling Values

- A net benefits assessment

Final Report

Report No: F001-NS03923-NSR-03

Project No: NS03923

ACOR

Australian Recycling Values

- A net benefits assessment

Final Report

Authors: Ingrid Cornander, Leanne Philpott, Russ Martin, Jane Murray & Sally Asker

Checker: Ron Wainberg, Ingrid Cornander, Leanne Philpott

Approver: Ron Wainberg

Report No: F001-NS03923-NSR-03 Project No: NS03923 Date: Friday, 23 January 2008

This report has been prepared for ACOR in accordance with the terms and conditions dated 22 May 2007. Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

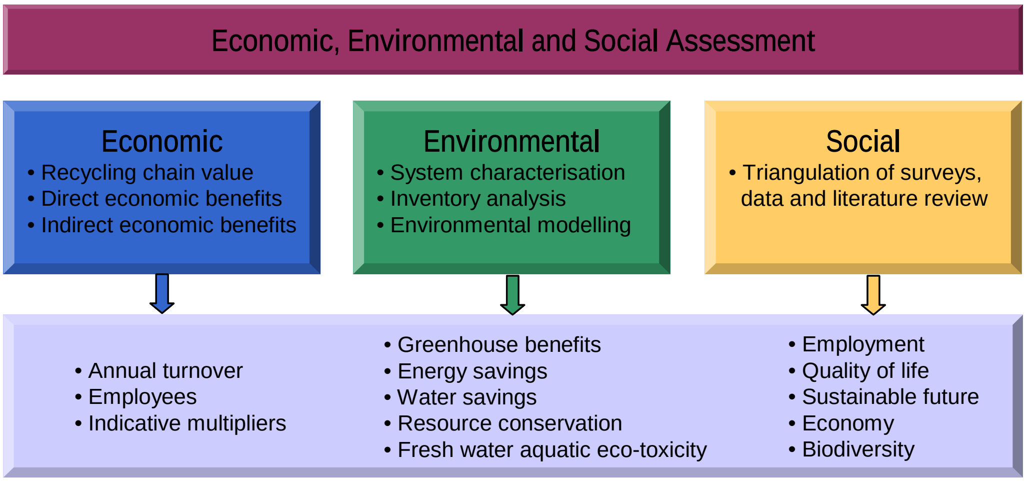
Hyder Consulting Pty Ltd
ABN 76 104 485 289
Level 5, 141 Walker Street, North Sydney NSW 2060, Australia
Tel: +61 2 8907 9000 Fax: +61 2 8907 9001 www.hyderconsulting.com

Executive Summary

Background

Current recycling practices exist because of the intrinsic "value" embedded in products and material at the end of their lives. The analysis presented in this report suggests that there are significant net benefits of recycling. Additional net benefits that are not translated into transaction costs are:

- Environmental benefits
  (including greenhouse gas abatement savings, water and resource use, aquatic eco-toxicity and energy savings);
- Economic benefits
  (including annual turnover, employment and indicative multipliers); and
- Social benefits
  (including employment, quality of life, sustainable future, economy and biodiversity).



Hyder Consulting was commissioned by the Australian Council of Recyclers to prepare a background paper to measure and report on the costs and benefits associated with current recycling activities in Australia and further to communicate a more complete picture of the real value of contributions that recycling makes to economic, social and environmental parameters of modern society.

This national economic assessment looks at the combination these benefits of recycling across the three major streams of solid waste: Commercial and Industrial (C&I), Construction and Demolition (C&D) as well as the Domestic waste stream.

The Current Situation

ACOR and its members have reported on a total member recovery of 9 million tonnes of material. This indicates an overall recovery of more than 12 million tonnes across Australia in 2006.

Total annual recovery by ACOR members and extrapolations for Australia (tonnes/yr)

Material Type	ACOR Performance	Net Australian Performance
Paper/cardboard	2,275,000	2,645,349
Glass	500,000	581,395
Ferrous	3,000,000	3,488,372
Non Ferrous	300,000	348,837
PET	23,949	27,848
HDPE	35,745	41,564
Concrete	3,100,000	5,000,000
Mixed C & D	205,000	unknown
Total	**9,439,694**	**12,133,365**

Economic Aspects

In 2006, the Australian recycling industry had a turnover of $11.5 billion, contributing 1.2% of Australia's GDP, and a capital investment of over $6 billion. In this same year, the industry directly employed around 10,900 people and indirectly employed another 27,700. This investment and employment has a number of direct and indirect benefits conservatively estimated at $55 billion.

Direct economic benefit results from collection of recovered materials but even greater benefit results from processing of recovered materials and manufacture into new products as the potentially 'wasted' value is, instead, recovered and the value retained within the economy. Reprocessing jobs in particular require higher skill and training than jobs in comparable industries, thereby resulting in higher salaries (NRC, 2001).

The Australian recycling industry provides both direct and indirect economic benefits. Direct economic benefits include direct employment, infrastructure investment and value-adding to recovered materials. Indirect economic benefits include use of accounting, legal and other services; industry and employee spending on other consumer goods and services; and payment of taxes, rates and fees.

The continued diminution of economic returns experienced by much of the resource recovery sector underscores the importance of regulatory, market-based and other influential variables. The potential drivers for recycling include: International Commodity Markets which dictate the price paid for recovered materials; technology capacity and performance to ensure utilisation of recovered materials; maintenance of product quality, domestic policy and regulation and procurement practices towards recycled content in products and services.

Environmental Aspects

Method Overview

The collection and utilisation of recycled materials results in significant environmental benefits. These benefits are for this study determined by the method of Life Cycle Assessment (LCA) which allows for the environmental characteristics and impacts of complete systems to be assessed from “cradle to grave”. When a recovered material is utilised, it avoids the need to produce from an alternative material. This avoided material/product is credited to the recycling system along with avoided landfill benefits. The high energy and materials intensity of virgin resource extraction and refining processes result in a relatively high benefit from this avoided product stage and this is dominant for all of the materials studied.

System Characterisation

Before the assessment could be conducted, existing collection and reprocessing systems had to be fully characterised. This task was undertaken on a national basis and required an update of data from previous studies and verification of underlying assumptions. Recycling systems were defined by waste stream and state. Each material was further modelled by reprocessing destination giving regard to contamination, material losses (i.e. net processing yields) and end product application as well as transportation.

The impacts associated with collection, sorting and reprocessing activities are modelled using life cycle inventory (LCI) databases. The material and energy balance recorded in the LCI is then expressed in terms of greenhouse benefits and energy, resource and water savings.

Greenhouse Benefits

Recycling commodity materials in Australia results in a total greenhouse benefit of over 8.8 million tonnes of CO_2eq. As an emissions reduction activity, it provides a significant contribution to the stabilisation of emissions and is greater than the average annual emission abatement achievements across all sectors throughout Australia reported from the base year of 1990 to 2005 (AGO, 2006) or equivalent to taking 1.8 million cars off the road[1].

---

[1] Assumes 8km/l petrol and 15,000km/yr

Greenhouse benefits by stream.

Material type	Total greenhouse gas savings ($t\ CO_2eq/yr$)	Average cars taken off the road
Paper/ Cardboard	1,215,448	249,323
Glass	524,064	107,500
Ferrous	2,107,031	432,211
Aluminium	4,933,503	1,011,967
PET	40,808	8,371
HDPE	22,164	4,547
Total	**8,843,019**	**1,813,919**

Energy Savings Indicators

Energy savings resulting from recycling are characterised and quantified using the four categories of delivered electricity, process heat, transport and miscellaneous energy inputs. The energy saving benefits associated with the Australian recycling performance amounts to over 202 TJ. Assuming an average household electricity usage of 20 GJ and transmission losses of 78.8 percent, the recycling in Australia results in energy savings equivalent to 2.1 million households.

Energy savings by stream

Material type	Total energy savings (TJ)	Average annual household electricity consumption offset
Paper/ Cardboard	37,474,585	396,505
Glass	1,209,115	12,793
Ferrous	104,958,763	1,110,529
Aluminium	54,971,726	581,616
PET	1,454,170	15,386
HDPE	1,980,677	20,957
Total	**202,049,035**	**2,137,786**

Water Savings Indicators

Unlike energy and greenhouse results which are linked to process thermodynamics and are therefore relatively constant between different plants, companies and countries, water usage can vary dramatically from plant to plant depending upon the technology being used and the availability of water. The water savings associated with the recycling activities in Australia are estimated to be about 134 GL. There is not a high degree of confidence in this data and it may vary by more than 20%. Based on a volume of 2.5 million litres to fill an Olympic swimming pool, the recycling in Australia results in water savings equivalent to about 54,000 pools each year.

Water savings by stream

Material type	Total Water savings (Ml)	Number of Olympic swimming pools filled with water offset
Paper/ Cardboard	33,223	13,289
Glass	1,078	431
Ferrous	28,751	11,500
Aluminium	73,018	29,207
PET	-845	-338
HDPE	-1,126	-450
Total	**134,100**	**53,640**

Resource Conservation

The use of recycled materials gives considerable savings in terms of virgin materials. The performance indicator for this impact category is the dominant resource input – only one resource is reported for each material collected although there are numerous resource inputs for each material produced.

The resource saving as a result of the reprocessing of Australian post consumer paper/cardboard is equivalent to three million trees (this is the theoretical fibre mass equivalent assuming 100 percent of the tree is used). In the order of 365,000 tonnes of sand, over four million tonnes of iron ore and 1.6 million tonnes of bauxite is being saved through these reprocessing activities. For plastics, the resource savings are measured as tonne of Oil equivalent (toe). The 60,000 and 90,000 toe savings of PET and HDPE equate to 430,000 and 650,000 barrel of oil equivalents (boe's).

Resource conservation – mass of resource (tonne equivalents)

State	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	938,466	158,413	1,312,665	547,500	18,914	28,467
Vic	1,003,010	70,752	1,183,618	467,545	21,584	32,486
Qld	522,529	57,890	709,772	190,920	10,789	16,238
SA	164,750	40,232	414,637	136,752	4,511	6,789
WA	224,924	17,401	325,947	130,688	2,038	3,067
Tas	58,242	9,480	97,968	38,945	1,264	1,902
NT	25,896	2,080	41,929	16,453	495	744
ACT	54,394	8,423	67,413	26,331	953	1,435
Australia	**2,992,212**	**364,670**	**4,153,948**	**1,555,134**	**60,548**	**91,129**

Social Aspects

The upstream and downstream social aspects of recycling in Australia are quantified looking at the capacity for communities to be able to contribute to a more sustainable future through recycling and reprocessing services which will have long term implications for employment, quality of life, a sustainable future, a stronger economy and improved biodiversity.

Employment

One of the major social costs of recycling across Australia is the apparent loss of employment in the areas of; natural resource extraction and packaging industries, within product development as well as within product construction and distribution. Through recycling there is a shift away from manufacturing toward a services and knowledge economy. This ultimately affects the long term employment structure.

As an offset from the shift in employment from the manufacturing industries there is creation of employment in the waste management and services related industries associated with recycling.

Quality of Life

There are various social costs which have major impacts on our social amenity and quality of life day to day. These include traffic, congestion, noise, pollution and odours from recycling collection scheme centres, reprocessing facilities and transportation of recycled materials.

The social benefits affecting the quality of life of residents and our broader community also provide benefits including social cohesion between recycling participants; a strong sense of civic pride within community areas; convenience, acceptance and satisfaction in participation of the recycling scheme due to ease of the program; and environmental improvements that link strongly with social wellbeing.

Sustainable Future

As part of the evolution towards a sustainable future there are social costs that limit recycling uptake and thus can affect sustainability on a wide level. These costs surround the financial implications for collection of recycling materials payable by public and private entities. Other costs involved with sustainable futures and recycling programs include costs to set up recycling infrastructure and education materials for new areas; the pressure for companies to become increasingly socially and environmentally responsible; and distance to waste facilities dictating recycling service costs.

The social benefits associated with recycling in Australia have many links to other economic and environmental benefits affecting our sustainable future. Theses benefits include reduced need for waste management facilities; energy savings and decreased emissions may improves our social amenity and goals via lessened environmental impacts; reduced need for more landfill sites due to incineration and recycling; greater life cycle benefits linked from direct environmental benefits such as resource savings and greenhouse gas abatement; and the reduction in potentially useful materials could become hazards in landfill, rather than being retained as a resource through recycling.

Economy

One of the major social costs of recycling across Australia is apparent within the economy associated with recycling processes. Such economic costs are felt socially however the main impact is apparent for business and industries such as a lack of participation in resource recovery schemes; increased costs for development of non-domestic resource recovery programs; and costs associated with innovations and technologies likely to be passed to end consumers in product prices.

There are also many benefits to the economy including a reduction over all in the financial costs associated with manufacturing; reduced sorting costs for kerbside collected materials; the fostering of innovation and cooperation across products, sectors and industry groups; a greater opportunity to participate in non-domestic resource recovery programs; reduced collection and operating costs; reduced imports, increased exports and higher localised production; and overall the Net Social cost of recycling may be offset by some or all of the benefits.

Biodiversity

A major aspect of the recycling movement is to have a positive influence on our biodiversity. There are however some costs associated with the effect of recycling on biodiversity. With the greatest effect on natural resources arising as a benefit from the avoided use of virgin materials associated, it is expected that biodiversity impacts would correlated with resource extraction. There is still however some environmental degradation and perceived degradation from recycling facilities.

Contents

1 Background....1

2 The Current Situation....3

3 Methodology....4

4 Economic Aspects....5

4.1 Recycling Chain Value....5
4.2 Direct and Indirect Economic Benefits....5
4.3 Market Drivers....7

5 Environmental Aspects....9

5.1 Method Overview....9
5.2 System Characterisation and Boundary Definition....9
5.3 Sources and Assumptions....10
5.4 Inventory Analysis....14
5.5 Greenhouse Benefits....15
5.6 Energy Savings Indicators....19
5.7 Water Savings Indicators....24
5.8 Water Pollutant Load Savings....28
5.9 Resource Conservation....31

6 Social Aspects....34

6.1 Employment....34
6.2 Quality of Life....35
6.3 Sustainable Future....36
6.4 Economy....38
6.5 Biodiversity....39
6.6 Data Gaps....40

7 References....41

Appendix A

Reprocessing Destinations

Appendix B

Materials by state and stream

1 Background

Current recycling practices exist because of the intrinsic “value” embedded in products and material at the end of their lives (ACOR, 2005). However, the market value that can be realised fluctuates in accordance with international and local commodity prices and does not necessarily meet the costs of collection, dismantling and reprocessing of materials. The analysis presented in this report suggests that there are significant net benefits of recycling. Additional net benefits that are not translated into transaction costs are:

- Environmental benefits (including greenhouse gas abatement savings, water and resource use, aquatic eco-toxicity and energy savings);
- Economic benefits (including annual turnover, employment and indicative multipliers); and
- Social benefits (including employment, quality of life, sustainable future, economy and biodiversity).

If the net benefits of recycling as highlighted in this report were fully realised within the market for recovered resources, recycled materials could compete more equitably with virgin resources and this would result in significantly improved recovery rates. Conversely, the present economic drivers are unlikely to deliver the recycling rates and diversion from landfill that most State waste objectives are seeking, as even record high commodity prices increasingly will fail to off-set diminishing returns from complex and higher waste ratio consumer goods.

Incorporating the benefits of recycling into the market would therefore ensure that the optimum resource or whole value is obtained for materials at their end-of-life and not just the commodity value. This goal and the need for recognition of optimum resource value are compatible with national policy objectives for waste management as highlighted by a recent national industry review (Industry Commission, 2005).

Australia is now committed to the Kyoto Protocol and to a carbon trading scheme. The very intention of putting a cost on carbon is to alter the way in which resources are being processed and used and it can be expected that the re-use and recycling of commodities will be advantaged over virgin materials.

Accordingly, the economic benefits of recycling presented in this report will be significantly enhanced as the country moves toward a carbon based economy.

Hyder Consulting was commissioned by the Australian Council of Recyclers (ACOR) - Australia’s leading industry association representing companies involved in processing secondary, solid raw materials - to prepare a background paper to measure and report on the economic, environmental and social costs and benefits associated with the current recycling activities in Australia.

ACOR conducts a bi-annual survey of its members to ascertain the total tonnage of materials recovered for recycling by each member company. The most recent survey, conducted in May/June 2007 reports on an overall recovery of about 6 million tonnes of paper/cardboard, glass, ferrous, non ferrous, PET and HDPE materials in Australia. This directly generates in excess of 10,000 jobs and significant investments in facilities, equipment and technology. Recovery of construction and demolition waste whilst exceeding 5 million tonnes was beyond the scope of this study.

This report aims to measure and document the economic, environmental and social benefits derived from recycling activities conducted by ACOR members and other recyclers in Australia and seeks to communicate a more complete picture of the real value of contributions that recycling makes to economic, social and environmental parameters of industry stakeholders, society and the Government.

This report will underpin efforts to influence public policy and opinion towards improving conditions leading to higher recycling and recovery rates in a broader range of materials. The assessment incorporates upstream and downstream costs and benefits and examines the role of costs in regard to reprocessing, contamination, producer responsibility and management of particularly problematic products and materials.

2 The Current Situation

ACOR and its members have reported on a total member recovery of 9,439,694 tonnes of the materials listed in Table 2-1.

Table 2-1: Total recovery by ACOR members and extrapolations to show the total Australian situation (tonnes)

Material Type	ACOR Performance	Australian Performance
Paper/cardboard	2,275,000	2,645,349
Glass	500,000	581,395
Ferrous	3,000,000	3,488,372
Non Ferrous	300,000	348,837
PET	23,949	27,848
HDPE	35,745	41,564
Concrete	3,100,000	5,000,000
Mixed C & D	205,000	unknown
Total	**9,439,694**	**12,133,365**

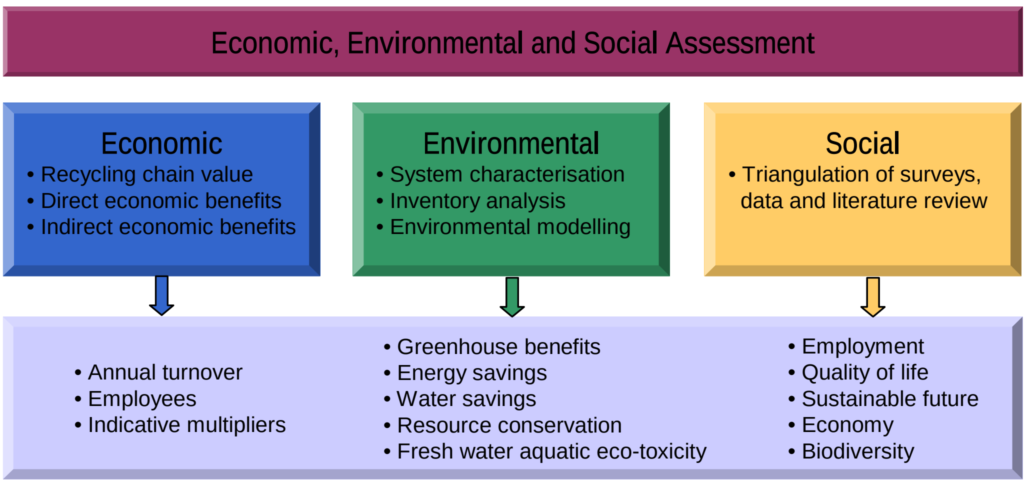
The environmental benefits of recycling concrete and mixed construction and demolition waste has not been modelled due to project scope limitations. It is recommended that the cost-benefit of recycling concrete and other masonry materials be assessed in the future because the contribution may be significant.

3 Methodology

This national economic assessment of recycling provides important new information for the analysis of recycling in Australia and looks at the combination of economic, environmental and social benefits of recycling the three major streams of solid waste: Commercial and Industrial (C&I), Construction and Demolition (C&D) as well as domestic recyclables. This is an update of the knowledge base for recycling which has focused on the domestic stream in recent years.

The cost benefit methodology adopted has required separate economic, environmental and social impact assessment followed by the interpretation and integration of results.

The integrated cost benefit methodology used in this study is represented in the following diagram. The economic, environmental and social analysis stages in the methodology are described in detail in sections 4, 5 and 0.



The assessment gives regard to direct benefits and impacts that are not incorporated in market prices. It is not intended to be a comprehensive list of benefits as for example environmental benefits such as avoided air pollution (non greenhouse) is not included.

4 Economic Aspects

In 2006, the Australian recycling industry had a turnover of $11.5 billion, contributing 1.2 percent of Australian GDP, and capital investment of over $6 billion. In this same time, the Australian recycling industry directly employed around 10,900 people and indirectly employed another 27,700. This investment and employment has a number of direct and indirect benefits.

4.1 Recycling Chain Value

Significantly more value is added to recovered materials as they move through the recycling chain. Whilst some direct benefit results from collection of recovered materials, even greater benefit results from processing of recovered materials and manufacture into new products as the potentially ‘wasted’ value is, instead, recovered and the value retained within the economy. Reprocessing jobs in particular require higher skill and training than jobs in comparable industries, thereby resulting in higher salaries (NRC, 2001).

While more detailed information was not available for this study to fully quantify Australian values, several factors can result in significant value adding for the recycling industry arising from the use of continuous production processes and economies of scale that provide improve production efficiencies (NRC, 2001). For example, various recycling and reprocessing facilities are limited in their operations by licence requirements on operating hours, government waste levies on recycling residuals and/or use of heavy equipment. In comparison, a variety of end users that benefit from use of continuous production and economies of scale, such as glass, aluminium and steel manufacturers, provide greater employment than comparable industries due to their need for three shifts per day instead of one.

Commercial drivers such as high capital equipment costs, high energy costs (and resulting need for energy conservation) and minimising start-up and shutdown inefficiencies, mean that many end users of recovered materials will continue to derive these economic benefits.

4.2 Direct and Indirect Economic Benefits

The Australian recycling industry provides both direct and indirect economic benefits. Direct economic benefits include direct employment, infrastructure investment and value-adding to recovered materials. Indirect economic benefits include use of accounting, legal and other services; industry and employee spending on other consumer goods and services; and payment of taxes, rates and fees.

Overseas studies indicate that local collection and processing represent around 20 percent of total recycling employment and receipts, while downstream manufacturing represents the remaining 80 percent.

This is known as having a multiplier effect of 4, as every $1 of direct investment in collection and processing provides $4 in downstream benefit in manufacturing. This is in addition to other indirect economic benefits. Applying these rates to industry turnover, the total direct and indirect economic benefits of recycling in Australia are estimated at $55 billion.

As a result, public policies that encourage recycling, and investment in collection and processing infrastructure (whether public or private) result in significant downstream economic activity.

Economic contribution can vary according to the total quantities of materials recycled and the underlying value of each material. For example, more jobs and economic activity can result from large quantities or high values of materials flowing through the economy as a result of recycling. A major investigation of recycling values in the US (NRC, 2001) assigned the following value scales:

Top end: plastics and non-ferrous metals

Middle: ferrous metals and paper

Low end: glass and compost

Recognising that actual values would be different in an Australian context, some indicative multipliers are available by material.

Table 4-1 shows indicative values for Type I multipliers. In this example, for every 100 jobs in aluminium recycling, an additional 62 jobs are created in other economic activities.

Table 4-1: Type I Job Multipliers (Recycle Iowa, 2001).

Commodity	Jobs Type I
Aluminum	1.62
Plastics	1.43
All Other Metal	1.43
All Other Paper	1.41
Wood	1.36
Old Corrugated Containers	1.28
Glass	1.16

Table 4-2 shows comparable indicative values by material type for income for direct (Type I) activities and for indirect benefits of household spending (Type II).

Table 4-2: Type I Job Multipliers (Recycle Iowa, 2001).

Commodity	Type I	Type II
Aluminium	2.08	2.52
Plastics	1.73	2.15
Wood	1.69	2.09
All Other Metal	1.65	2.07
All Other Paper	1.55	1.96
Old Corrugated Containers	1.47	1.85
Glass	1.26	1.61

Applying the above figures, aluminium would represent the highest value material, as for every $1.00 of value created by recycling aluminium, there is an additional $1.08 in value created. When the impacts of household (Type II) spending are factored in, for every $1.00 of value created by recycling aluminium, there is an additional $1.52 in value created.

The most comprehensive study on recycling currently available (NRC 2001, p. ES-10) found that,

> *'Returning commodities to the stream of commerce is a value-adding, job-providing and economy-spurring activity. The recycling and reuse industry is a significant contributor to the …economy, providing large numbers of good jobs that pay well.'*

4.3 Market Drivers

The continued diminution of economic returns experienced by much of the resource recovery sector underscores the importance of regulatory, market-based and other drivers and the need to review the platform on which these operate. These drivers include:

International Commodity Markets

Commodity markets largely dictate the price paid for recovered materials as the recycled material competes with the virgin material for which it may substitute. Strong international commodity markets have not been sufficient to ensure the viability of recycling activities which remain marginally viable for many materials and have proved non-viable for some materials recently such as domestic steel recovery, some paper grades and many plastics.

Technology capacity and performance

Utilisation of recovered materials/resources is dependant on the technical capacity of material reprocessors. For some materials or material grades, additional processing capacity is needed or would be required in order to achieve increased recycling. Technological processing limitations span sorting processes such as automated separation and reprocessing activities such as de-inking and de-tinning. Limitations in regard to economies of scale in Australia can mean that the average age of technology imposes an international competitive disadvantage.

Infrastructure incentives and investment certainty is needed on a sector by sector basis if technology is to meet the requirements of recycling growth targets and projections.

Product quality

Market prices improve with product quality and refining or separation of materials. Formalised grading and adherence to quality specifications can assist in maximising the resource value and the economic return for materials. Source based initiatives can further assist by targeting waste generators with awareness raising and other practical strategies for quality preservation. Industry fragmentation and lack of coordination or information exchange can hinder quality improvements and restrict access to market information.

Domestic Policy

Government regulation in response to environmental awareness has had a driving effect on recycling including, notably, the National Packaging Covenant. The imminent Covenant mid-term review has applied pressure for a satisfactory performance review with attention on tonnages recycled. The threat of loosing control of the process remains a driver for relevant companies to foster strong recycling performance. Further NPC initiatives such as improved data collection and research into technologies and market application of products have also assisted the marketplace.

Procurement

Procurement of products with recycled content remains an important but under-utilised driver of recycling. The Buy Recycled Business Alliance is an industry led driver and government procurement initiatives remain a potentially powerful driver for some materials such as paper.

5 Environmental Aspects

5.1 Method Overview

The collection and utilisation of secondary materials for reprocessing results in significant environmental benefits. Benefits associated with recycling are determined for this study by the method of Life Cycle Assessment (LCA). This approach allows for the environmental characteristics of complete systems to be assessed including a range of environmental impacts from “cradle to grave”.

The method involved the following stages:

1. System Characterisation and Boundary Definition;
2. Inventory Analysis;
3. Impact Assessment; and
4. Results (interpretation and reporting).

5.2 System Characterisation and Boundary Definition.

Before the assessment could be conducted, existing collection and reprocessing systems had to be fully characterised. This task was undertaken on a national basis. It required an update of data from previous studies (NPC, 2001; DEC 2005 and 2006) and verification of underlying assumptions. Recycling systems were defined by waste stream and by state (including two regions, urban and regional).

Consultation with ACOR members and the waste industry helped to define the processing steps within the systems studied and was used to verify data and assumptions. Information was collected for the assessment from ACOR members through survey data, direct face-to-face and telephone discussions and email. Data on markets, materials, technologies, industry trends and waste management practices was collated from Hyder databases and ACOR members

The benefits and costs (impacts) of recycled material systems have been deducted from the distinct systems listed below in order to characterise the environmental performance of recycling:

- Waste and recycling collection,
- Transfer and reprocessing;
- The avoided virgin material systems.

For the recycling system, impacts arising from the material losses (i.e. net yields) as well as avoided landfill impacts have been considered, in addition to the impacts typically associated with collection, sorting and reprocessing activities, using life cycle inventory (LCI) databases and expressed in terms of greenhouse benefits, energy savings and water savings.

5.3 Sources and Assumptions

Origin of materials

Although the total quantity of materials recovered for reprocessing by the ACOR members was given, the split between state and stream was not provided. The split provided in 'Waste and Recycling in Australia' (DEH, 2006) was used to derive the split by stream and state. This is detailed in Appendix B.

The split between urban and regional areas is based on ABS Demographic Statistics and 2001 Census data (ABS, 2006; undated), see Table 5-1. Included in the category "Urban" are capital cities while "Regional" includes other *Major Urban Areas* and *Other Urban*, i.e. population centres with more than 1,000 people. *Bounded Locality* and *Rural Balance* (populations of up to 999 people) have been excluded based on an assumption of lack of kerbside collection in these areas.

Table 5-1: Split between urban and regional centres.

State	Urban	Regional	Bounded Locality and Rural Balance
NSW	55%	34%	11%
Victoria	68%	21%	11%
Queensland	42%	42%	17%
SA	68%	18%	14%
WA	64%	24%	12%
Tasmania	28%	45%	28%
NT	34%	39%	27%
ACT	99%	0%	1%

Collection and transport

The collection efficiency of recyclables varies depending on urban/regional conditions and also with type of material collected. Assumed collection and unloading times as well as transit distances per tonne material collected are presented in Table 5-2 for mixed recyclables and in Table 5-3 for paper.

Table 5-2: Recyclables collection, unloading and transit assumptions.

	Domestic	C&I	C&D
Urban areas			
Recyclables collection time (min)	8	6	3
Recyclables unloading time (min)	1	1	1
Recyclables transit (km)	1	1	1
Regional areas			
Recyclables collection time (min)	16	12	6
Recyclables unloading time (min)	1	1	1
Recyclables transit (km)	1	1	1

Table 5-3: Paper/cardboard collection, unloading and transit assumptions.

	Domestic	C&I	C&D
Urban areas			
Recyclables collection time (min)	10.5	7.5	n/a
Recyclables unloading time (min)	1.2	1.2	n/a
Recyclables transit (km)	1	1	n/a
Regional areas			
Recyclables collection time (min)	21	15	n/a
Recyclables unloading time (min)	1.2	1.2	n/a
Recyclables transit (km)	1	1	n/a

The transport of materials from MRF to local reprocessing facilities and also the transport of reject materials to landfill assume use of rigid trucks with an average payload of 7.5 tonne. The use of articulated trucks is assumed in modelling for long distance (interstate) haul. Interstate transport of ferrous metals is modelled using rigid trucks.

Reprocessing destinations and distances

The transit of materials for reprocessing involves a complex pattern of distances that varies by material and is highly specific to the state of origin. Materials collected may be transported locally, interstate or overseas for reprocessing. The reprocessing destinations, material flows and transport distances are summarised in Appendix A for each state and material type.

Reprocessed material products

The environmental benefits of material reprocessing are largely dependent on the "value" of the reprocessed product. The "avoided product credit" that is obtained when a secondary material is substituted for a virgin one is significant and includes all avoided resource extraction, refining and processing to the point of the commodity material substitution stage.

The assumptions regarding the end-use application of reprocessed material products are summarised in Table 5-4.

Table 5-4: Reprocessed material products.

Material Type	Products
Paper/cardboard	Packaging, cardboard products, newsprint, writing paper
Glass	Bottles
	Water filtration, air blasting abrasives, brick additives and landscaping applications
	Reflective beads in road paints
	Backfill in pipe and road bed construction
Ferrous	Local car parts, cans, rolled steel for export, corrugated iron etc
Aluminium	Aluminium cans, ingot to auto, valves, castings, ingot for export
PET	Soft drink bottles and other packaging applications, fibre applications such as geotextiles
HDPE	Pallets, agricultural pipe, bins and crates

It is assumed that 35 percent of the domestic paper/cardboard mix is recycled into newsprint and 65 percent into cardboard. For the C&I stream, 9.2 percent of mixed paper reprocessed within Australia is recycled into tissue and office paper and 90.8 percent into board. The split for exported C&I materials is assumed to be 50-50 percent.

Further, 42 percent of paper/cardboard collected is assumed to go through a commingled collection.

Contamination rates

Due to lack of information on contamination rates by state and collection system, state averages as reported by the jurisdictions (NEPM, undated) have been used for the domestic stream. Rates for Queensland, Tasmania and ACT are based on national averages.

Contamination rates for C&I materials is modelled at 5 percent for all material types. This assumes consistency between the states. Also for C&D materials a single rate of 20 percent, has been adopted for the non masonry material types. (Personal communications Morrissey T, 2007)

Table 5-5: Contamination rates assumed for environmental modelling.

State	NSW	Vic	Qld	SA	WA	Tas	NT	ACT
Domestic – Contamination rate at MRF								
All materials	8.4%[1]	11.4%[1]	16.8%[3]	12.8%[1]	20.0%[2]	16.8%[3]	31.4%[2]	16.8%[3]
C&I – Contamination rate at MRF								
All materials	5%[5]	5%[5]	5%[5]	5%[5]	5%[5]	5%[5]	5%[5]	5%[5]
C&D – Contamination rate at MRF								
Mixed C&D	20%[5]	20%[5]	20%[5]	20%[5]	20%[5]	20%[5]	20%[5]	20%[5]
Concrete	4-5%	4-5%	4-5%	4-5%	4-5%	4-5%	4-5%	4-5%
Contamination rate at reprocessor / Material degradation								
Paper/cardboard	25%[4]	25%[4]	25%[4]	25%[4]	25%[4]	25%[4]	25%[4]	25%[4]
Glass	2%[4]	2%[4]	2%[4]	2%[4]	2%[4]	2%[4]	2%[4]	2%[4]
Ferrous	4.2%[4]	4.2%[4]	4.2%[4]	4.2%[4]	4.2%[4]	4.2%[4]	4.2%[4]	4.2%[4]
Aluminium	5%[4]	5%[4]	5%[4]	5%[4]	5%[4]	5%[4]	5%[4]	5%[4]
PET	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]
HDPE	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]	10%[4]

[1] NEPM, undated, 2005/06 data.
[2] NEPM, undated a, 2004/05 data.
[3] Averaged based on NSW, Victoria, SA, WA and NT.
[4] NPCC, 2001.
[5] Personal communications Morrissey T, 2007.

5.4 Inventory Analysis

Inventory data used for the study included more than 150 air and water pollutant loads and raw material inputs. The assessment of pollutants for their environmental impact however was limited to greenhouse gases, a range of water pollutants with a toxicity factor and the energy value of fuels. Other inventory loads are ignored.

The inventory data used was existing data from the SimaPro proprietary software and the following sources:

- Department of Environment and Conservation. (2005; 2006; 2007). Waste and Recycling Calculator.
- Australian Greenhouse Office. (2006). Factors and Methods Workbook.
- RMIT & Nolan-ITU. (2003). Life Cycle Assessment of Waste Management Options in Victoria (including Energy from Waste).
- DEC. (2003). Alternative Waste Treatment Technologies Assessment Methodology and Handbook. Prepared by Nolan-ITU.
- Nolan-ITU. (2004). Decision Support System for the Assessment of Integrated Resource Recovery, Western Australian Local Government Association.
- Eriksson, O. & Björklund, A. (2002). Municipal Solid Waste Model.
- Finnveden *et al*. (2002). Energy from waste.
- Nolan-ITU and SKM. (2001). Independent Assessment of Kerbside Recycling in Australia.
- Grant *et al.* (2001). Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Stage 1 & 2 Report. Melbourne. For Eco Recycle Victoria.
- CRC WMPC. (1998). Life Cycle Inventories for Transport, Energy and Commodity Materials.
- White, P. (1999). IWM-2 An LCI computer model for solid waste management – model guide.

5.5 Greenhouse Benefits

Recycling results in the avoidance of environmental impacts associated with resource extraction and materials production and manufacturing processes. One impact area is global warming caused by the accumulation of greenhouse gases in the earth's atmosphere. Greenhouse gas savings are calculated in accordance with international and national protocols and expressed in terms of carbon dioxide equivalents (CO_2eq). In characterising the greenhouse benefits, savings in the following gases / aspects are quantified:

- Carbon Dioxide (CO_2);
- Methane (CH_4);
- Nitrous Oxide (N_2O); and
- Sequestration.

It should be noted that the equivalence factors applied are those to meet the 2012 international policy agreements including the Kyoto Protocol. It is assumed that methane has a global warming potential 21 times that of carbon dioxide while nitrous oxide has a global warming potential of 310 times that of carbon dioxide. From 2012 it is expected that the new equivalence factors for global warming are to change to 23 for methane and to 296 for nitrous oxide. It is assumed all materials except paper are inert in landfill.

The results of the modelling are presented in Table 5-6 to Table 5-13. Note that greenhouse gas avoidance is denoted by positive numbers while greenhouse gas generation is denoted by a negative number.

The recycling activities[2] in Australia results in a total greenhouse benefit of over 8.8 million tonnes of CO_2eq, see Table 5-6. The C&I sector stands for 61 percent of the benefit, followed by the C&D sector 25 percent and the domestic stream 14 percent.

The material with the highest per tonne benefit is aluminium due to the high avoided product credits resulting from the energy and materials intense refining stages. Although a relatively small part of the overall quantity of material collected for reprocessing, 5 percent, aluminium is still contributing 56 percent to the overall greenhouse benefit.

Ferrous metals stand for 24 percent of the total benefit. This is a result of the large quantity of material collected rather than a high per tonne benefit for recycling. Paper/cardboard recycling contributes 14 percent to the overall greenhouse benefit. PET is another material with relatively high per tonne benefits resulting from the recovery process. The low quantity collected however gives the material a modest 0.3 percent contribution to the overall performance.

---

[2] Recycling of paper/cardboard, glass, aluminium, steel, HDPE and PET.

Table 5-6: Greenhouse benefits by stream (t CO_2eq).

Material type	Total	Domestic	C&I	C&D
Paper/ Cardboard	1,215,448	320,407	895,042	-
Glass	524,064	338,136	138,631	47,297
Ferrous	2,107,031	120,676	1,495,286	491,069
Aluminium	4,933,503	420,763	2,797,578	1,715,162
PET	40,808	15,973	24,835	-
HDPE	22,164	7,377	14,787	-
Total	**8,843,019**	**1,223,333**	**5,366,158**	**2,253,528**

When looking at the greenhouse benefits by state, Table 5-7, it is clear that the larger states stand for the majority of the benefits due to the large quantities of recyclables generated and collected for reprocessing.

The only disbenefits arising from recycling in the states as apparent from Table 5-7 and also Table 5-9, is the collection and reprocessing of glass in the Northern Territory for greenhouse gas saving. This is a result of the great transport distances with glass being sent by truck for reprocessing in Gawler, South Australia.

Table 5-7: Greenhouse benefits by material type and state (t CO_2eq).

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	2,987,676	384,183	236,012	683,123	1,661,623	15,778	6,958
Vic	2,705,121	416,543	106,023	635,158	1,524,904	13,712	8,780
Qld	1,273,815	226,164	85,462	322,645	629,973	6,214	3,358
SA	769,134	59,874	62,394	202,571	440,068	2,532	1,695
WA	674,723	78,296	7,611	167,660	419,856	768	533
Tas	204,416	21,404	13,957	45,875	121,950	833	398
NT	72,348	5,881	-35	14,627	51,481	295	99
ACT	155,786	23,103	12,641	35,373	83,649	676	344
Australia	**8,843,019**	**1,215,448**	**524,064**	**2,107,031**	**4,933,503**	**40,808**	**22,164**

Table 5-8: Greenhouse benefits - Paper/cardboard recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	384,183	142,279	241,904	-
Vic	416,543	99,282	317,261	-
Qld	226,164	36,011	190,154	-
SA	59,874	18,290	41,584	-
WA	78,296	13,784	64,512	-
Tas	21,404	2,680	18,724	-
NT	5,881	596	5,284	-
ACT	23,103	7,485	15,619	-
Australia	**1,215,448**	**320,407**	**895,042**	**-**

Table 5-9: Greenhouse benefits - Glass recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	236,012	157,580	59,003	19,429
Vic	106,023	55,887	35,484	14,652
Qld	85,462	50,568	30,455	4,439
SA	62,394	50,937	6,821	4,635
WA	7,611	5,040	768	1,802
Tas	13,957	8,965	3,610	1,381
NT	-35	-21	-19	6
ACT	12,641	9,180	2,508	953
Australia	**524,064**	**338,136**	**138,631**	**47,297**

Table 5-10: Greenhouse benefits - Ferrous recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	683,123	9,045	367,683	306,394
Vic	635,158	91,619	504,540	38,999
Qld	322,645	1,708	271,299	49,637
SA	202,571	7,839	168,375	26,357
WA	167,660	9,472	113,713	44,474
Tas	45,875	441	33,282	12,152
NT	14,627	18	10,718	3,891
ACT	35,373	533	25,675	9,165
Australia	**2,107,031**	**120,676**	**1,495,286**	**491,069**

Table 5-11: Greenhouse benefits - Aluminium recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	1,661,623	27,583	344,596	1,289,444
Vic	1,524,904	252,189	1,180,515	92,200
Qld	629,973	24,904	553,101	51,968
SA	440,068	78,620	300,961	60,487
WA	419,856	29,847	278,989	111,019
Tas	121,950	4,091	65,848	52,010
NT	51,481	1,014	28,199	22,268
ACT	83,649	2,514	45,368	35,766
Australia	**4,933,503**	**420,763**	**2,797,578**	**1,715,162**

Table 5-12: Greenhouse benefits - PET recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	15,778	7,807	7,971	-
Vic	13,712	4,223	9,490	-
Qld	6,214	1,368	4,846	-
SA	2,532	1,786	746	-
WA	768	385	383	-
Tas	833	174	658	-
NT	295	37	258	-
ACT	676	193	483	-
Australia	**40,808**	**15,973**	**24,835**	**-**

Table 5-13: Greenhouse benefits - HDPE recycling (tonnes CO_2eq).

State	Total	Domestic	C&I	C&D
NSW	6,958	2,650	4,307	-
Vic	8,780	2,532	6,248	-
Qld	3,358	626	2,732	-
SA	1,695	1,162	533	-
WA	533	242	290	-
Tas	398	69	329	-
NT	99	6	93	-
ACT	344	90	253	-
Australia	**22,164**	**7,377**	**14,787**	**-**

Assuming an average 8km per litre of petrol and an annual average distance of 15,000km travelled by car and year, the recycling in Australia results in carbon dioxides savings equivalent to taking 1.8 million cars of the roads[3], refer Table 5-14.

Table 5-14: Average sized cars taken off the road by material type and state.

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	612,857	78,807	48,413	140,128	340,846	3,236	1,427
Vic	554,897	85,445	21,748	130,289	312,801	2,813	1,801
Qld	261,295	46,393	17,531	66,183	129,225	1,275	689
SA	157,771	12,282	12,799	41,553	90,270	519	348
WA	138,371	16,061	1,561	34,392	86,090	158	109
Tas	41,931	4,391	2,863	9,410	25,015	171	82
NT	14,841	1,206	-7	3,000	10,560	61	20
ACT	31,956	4,739	2,593	7,256	17,159	139	71
Australia	**1,813,919**	**249,323**	**107,500**	**432,211**	**1,011,967**	**8,371**	**4,547**

5.6 Energy Savings Indicators

Energy savings resulting from recycling are presented for each material. In characterising the energy savings, offsets in the following categories are quantified:

- Delivered Electricity;
- Process Heat;
- Transport; and
- Miscellaneous Energy Inputs.

In recent years, the association between energy consumption and the environment has become increasingly strong through the promotion of various energy efficiency programs, the increased uptake of renewable or "green electricity" and greater awareness of greenhouse issues. Whilst it is public knowledge that recycling results in environmental benefits, the degree to which recycling results in energy savings is not well understood. One of the main reasons for this is the comparatively high visibility of downstream collection and sorting processes (energy inputs) as compared

[3] 2.6 tonnes of CO_2-eq/kilolitres of petrol (AGO, 2006).

to the low visibility of upstream manufacturing and distribution (energy savings).

Much of the energy savings arise from paper / cardboard recovery, where the energy required for harvesting raw materials, subsequent pulping activities and process heat are avoided. It should be noted here that much of the energy required for paper / cardboard production is generated through the combustion of biomass and, because greenhouse gas emissions from the combustion of biomass are considered to be part of the natural carbon cycle, energy savings associated with the recycling of paper and cardboard are considerably higher than the corresponding greenhouse savings.

The results of the cumulative energy modelling is presented in Table 5-15 to Table 5-22 below. As with greenhouse gases, energy savings are denoted as positive numbers whilst energy consumption is denoted by negative numbers.

The energy savings associated with the recycling activities in Australia are in access of 202 million GJ, see Table 5-15. As for greenhouse benefits, the C&I sector stands for the majority of the benefit, 70 percent of the benefit, followed by the C&D sector 22 percent and domestic 8 percent.

The recovery of ferrous metals results in the greatest savings, contributing almost 52 percent of the total saving. This is however a result of the large quantity of ferrous metals collected for reprocessing rather than a high per tonne saving. The material with the highest per tonne benefit is again aluminium due to the electricity intensive production of virgin aluminium from bauxite. Aluminium contributes 27 percent and paper/ cardboard 19 percent to the overall energy saving.

Table 5-15: Energy savings by stream (GJ).

Material type	Total	Domestic	C&I	C&D
Paper/ Cardboard	37,474,585	3,470,572	34,004,013	-
Glass	1,209,115	770,268	345,337	93,510
Ferrous	104,958,763	6,568,303	73,913,844	24,476,616
Aluminium	54,971,726	4,683,882	31,164,151	19,123,693
PET	1,454,170	572,255	881,915	-
HDPE	1,980,677	711,668	1,269,009	-
Total	**202,049,035**	**16,776,947**	**141,578,269**	**43,693,818**

Energy saving by state is presented in Table 5-16. Again, the larger states stand for the majority of the saving due to the large quantities of recyclables generated and collected for reprocessing.

The reprocessing of glass from Northern Territory and Western Australia does not result in an energy saving due to the long transport distance to Gawler in South Australia.

Table 5-16: Energy savings by material type and state (TJ).

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	63,689	9,984	638	33,395	18,528	525	619
Vic	61,944	13,082	293	30,369	16,990	492	718
Qld	32,089	6,832	224	17,437	7,014	237	345
SA	17,822	2,106	196	10,373	4,901	98	148
WA	16,549	3,678	-179	8,272	4,676	39	64
Tas	4,800	910	36	2,425	1,359	29	41
NT	1,814	280	-34	970	572	11	15
ACT	3,342	602	35	1,718	933	23	31
Australia	**202,049**	**37,475**	**1,209**	**104,959**	**54,972**	**1,454**	**1,981**

Table 5-17: Energy savings - Paper/cardboard recycling (GJ).

State	Total	Domestic	C&I	C&D
NSW	9,984,194	1,549,413	8,434,781	-
Vic	13,081,795	1,081,984	11,999,812	-
Qld	6,832,436	86,720	6,445,717	-
SA	2,105,878	94,066	1,911,812	-
WA	3,677,580	45,355	3,532,225	-
Tas	910,288	8,352	881,936	-
NT	280,019	3,110	276,910	-
ACT	602,393	1,572	520,821	-
Australia	**37,474,585**	**3,470,572**	**34,004,013**	**-**

Table 5-18: Energy savings - Glass recycling (GJ).

State	Total	Domestic	C&I	C&D
NSW	637,722	416,905	162,540	58,277
Vic	293,422	150,788	98,577	44,057
Qld	223,513	129,027	81,460	13,027
SA	195,839	158,482	21,660	15,697
WA	-178,813	-122,653	-18,044	-38,115
Tas	36,369	22,772	9,561	4,037

NT	-34,237	-10,494	-17,417	-6,326
ACT	35,300	25,441	7,002	2,857
Australia	**1,209,115**	**770,268**	**345,337**	**93,510**

Table 5-19: Energy savings - Ferrous recycling (GJ).

State	Total	Domestic	C&I	C&D
NSW	3,395,102	497,589	17,862,550	15,034,963
Vic	0,369,175	4,874,173	23,652,144	1,842,859
Qld	7,436,507	114,423	14,625,313	2,696,771
SA	0,373,107	464,142	8,549,233	1,359,732
WA	8,271,935	557,074	5,525,493	2,189,369
Tas	2,424,630	28,781	1,753,196	642,653
NT	970,391	2,136	708,695	259,560
ACT	1,717,915	29,987	,237,220	450,708
Australia	**104,958,763**	**6,568,303**	**3,913,844**	**24,476,616**

Table 5-20: Energy savings - Aluminium recycling (GJ).

State	Total	Domestic	C&I	C&D
NSW	8,527,651	307,179	3,840,683	14,379,789
Vic	6,990,035	2,807,894	13,154,254	1,027,887
Qld	7,013,855	276,957	6,157,942	578,957
SA	4,901,295	875,004	3,352,230	674,060
WA	4,675,743	332,115	3,106,674	1,236,954
Tas	1,358,704	45,489	733,473	579,742
NT	571,610	11,231	313,027	247,353
ACT	932,832	28,012	505,869	398,951
Australia	**54,971,726**	**4,683,882**	**31,164,151**	**19,123,693**

Table 5-21: Energy savings - PET recycling (GJ).

State	Total	Domesic	C&I	C&D
NSW	525,314	258,666	266,649	-
Vic	491,502	154,457	337,045	-
Qld	237,029	54,288	182,741	-
SA	98,176	69,947	28,230	-
WA	39,250	20,482	18,769	-

Tas	29,227	6,344	22,883	-
NT	11,011	1,486	9,525	-
ACT	22,660	6,586	16,074	-
Australia	**1,454,170**	**572,255**	**881,915**	**-**

Table 5-22: Energy savings - HDPE recycling (GJ).

State	Total	Domestic	C&I	C&D
NSW	619,057	249,954	369,102	-
Vic	717,755	224,763	492,992	-
Qld	345,209	78,587	266,622	-
SA	148,139	105,403	42,736	-
WA	63,795	33,221	30,574	-
Tas	40,516	8,725	31,791	-
NT	15,088	2,008	13,080	-
ACT	31,119	9,006	22,112	-
Australia	**1,980,677**	**711,668**	**1,269,009**	**-**

Assuming an average household electricity usage of 20 GJ and transmission losses of 78.8 percent (Hyder Consulting, 2007), the recycling in Australia results in energy savings equivalent to 2.1 million households, refer Table 5-23.

Table 5-23: Average annual household electricity consumption offset by material type and state.

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	673,870	105,639	6,747	353,341	196,034	5,558	6,550
Vic	655,403	138,414	3,105	321,325	179,765	5,200	7,594
Qld	339,517	72,291	2,365	184,489	74,211	2,508	3,653
SA	188,572	22,282	2,072	109,754	51,859	1,039	1,567
WA	175,085	38,911	-1,892	87,522	49,453	415	675
Tas	50,784	9,631	385	25,654	14,376	309	429
NT	19,192	2,963	-362	10,267	6,048	117	160
ACT	35,363	6,374	373	18,177	9,870	240	329
Australia	**2,137,786**	**396,505**	**12,793**	**1,110,529**	**581,616**	**15,386**	**20,957**

5.7 Water Savings Indicators

As with greenhouse gas and energy savings, the water savings resulting from recycling are presented on a per tonne basis for each material. Unlike energy and greenhouse results which are linked to process thermodynamics and are therefore relatively constant between different plants, companies and countries, water usage can vary dramatically from plant to plant depending upon the technology being used and the availability of water.

As a result, water usage can range from zero reticulated water consumption to very high usage, particularly in countries with few limitations on water supply, or those able to utilise saline waters for cooling, being situated near coastal areas.

Great water savings are available for the recovery of paper and cardboard, which is generally recognised as a water intensive process due to the wood pulping process for producing from virgin fibres. Another lesser known water intensive process is the production of aluminium. This is due to the refining of bauxite which is converted to alumina using a wet chemical process. As a result, high water savings (on a weight for weight basis) are also achieved when aluminium is recycled.

The recycling of HDPE and PET, while resulting in greenhouse and energy benefits, actually utilises more water than the virgin product system. This is due to the low density / high surface area nature of plastic containers and the sorting / washing process required during the reprocessing of these materials.

The water savings associated with the recycling activities in Australia are close to 134 GL, see Table 5-24. The C&I sector stands for the majority of the benefit, 69 percent of the benefit, followed by the C&D sector 24 percent and domestic 7 percent. The recovery of aluminium results in the greatest savingsfollowed by paper/cardboard. The material with the highest per tonne benefit is aluminium.

Table 5-24: Water savings by stream (ML).

Material type	Total	Domestic	C&I	C&D
Paper/ Cardboard	33,223	1,194	32,029	-
Glass	1,078	698	281	100
Ferrous	28,751	1,785	20,331	6,635
Aluminium	73,018	6,256	41,452	25,309
PET	-845	-334	-511	-
HDPE	-1,126	-410	-716	-
Total	**134,100**	**9,190**	**92,866**	**32,045**

Water savings by state are presented in Table 5-25. Again, the larger states stand for the majority of the saving due to the large quantities of recyclables generated and collected for reprocessing.

Table 5-25: Water savings by material type and state (ML).

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	28,386	8,388	469	9,074	24,522	-292	-352
Vic	29,775	11,592	209	8,182	22,582	-287	-401
Qld	12,989	6,134	171	4,929	9,356	-143	-201
SA	7,055	1,921	119	2,876	6,524	-60	-84
WA	8,618	3,490	51	2,253	6,223	-27	-38
Tas	2,338	865	28	679	1,808	-17	-23
NT	946	323	6	291	771	-7	-9
ACT	1,515	510	25	467	1,232	-13	-18
Australia	**134,100**	**33,223**	**1,078**	**28,751**	**73,018**	**-845**	**-1,126**

Table 5-26: Water savings - Paper/cardboard recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	8,387,718	512,500	7,875,218	-
Vic	11,592,494	362,424	11,230,070	-
Qld	6,134,422	141,114	5,993,307	-
SA	1,920,736	73,906	1,846,830	-
WA	3,489,664	59,169	3,430,495	-
Tas	865,217	11,517	853,700	-
NT	322,605	6,499	316,106	-
ACT	510,407	27,359	483,048	-
Australia	**33,223,263**	**1,194,489**	**32,028,774**	**-**

Table 5-27: Water savings - Glass recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	468,657	314,552	116,572	37,533
Vic	209,245	111,019	69,943	28,282
Qld	171,133	101,884	60,621	8,628
SA	118,945	97,365	12,953	8,628
WA	51,377	34,804	5,180	11,393
Tas	28,019	18,113	7,214	2,692
NT	6,142	1,860	3,118	1,164
ACT	24,890	18,113	4,935	1,842
Australia	**1,078,408**	**697,710**	**280,538**	**100,161**

Table 5-28: Water savings - Ferrous recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	9,074,490	136,559	4,884,454	4,053,477
Vic	8,182,278	1,316,428	6,376,293	489,557
Qld	4,928,590	32,691	4,143,510	752,390
SA	2,875,856	129,239	2,373,717	372,900
WA	2,252,511	152,748	1,509,438	590,325
Tas	679,051	8,173	493,094	177,784
NT	290,719	656	213,196	76,867
ACT	467,167	8,173	337,359	121,634
Australia	**28,750,662**	**1,784,666**	**20,331,061**	**6,634,935**

Table 5-29: Water savings - Aluminium recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	24,521,819	409,547	5,097,094	19,015,177
Vic	22,582,284	3,747,010	17,474,036	1,361,239
Qld	9,356,369	371,967	8,215,148	769,254
SA	6,523,659	1,169,585	4,459,945	894,128
WA	6,222,707	444,504	4,136,709	1,641,493
Tas	1,808,170	61,330	977,586	769,254
NT	770,626	15,333	422,686	332,607
ACT	1,232,313	37,197	668,824	526,292
Australia	**73,017,946**	**6,256,474**	**41,452,028**	**25,309,444**

Table 5-30: Water savings - PET recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	-292,037	-143,371	-148,666	-
Vic	-286,521	-91,148	-195,373	-
Qld	-143,224	-33,508	-109,716	-
SA	-59,898	-42,909	-16,989	-
WA	-27,172	-14,431	-12,742	-
Tas	-16,780	-3,723	-13,057	-
NT	-6,568	-922	-5,646	-
ACT	-12,657	-3,723	-8,933	-
Australia	**-844,856**	**-333,735**	**-511,121**	**-**

Table 5-31: Water savings - HDPE recycling (kL).

State	Total	Domestic	C&I	C&D
NSW	-351,574	-143,406	-208,168	-
Vic	-401,236	-127,643	-273,593	-
Qld	-200,573	-46,926	-153,648	-
SA	-83,880	-60,089	-23,791	-
WA	-37,961	-20,118	-17,843	-
Tas	-23,498	-5,214	-18,284	-
NT	-9,197	-1,292	-7,905	-
ACT	-17,723	-5,214	-12,509	-
Australia	**-1,125,642**	**-409,901**	**-715,741**	**-**

Based on a volume of 2.5 million litres to fill an Olympic swimming pool, the recycling in Australia results in water savings equivalent to almost 54,000 Olympic swimming pools, refer Table 5-32.

Table 5-32: Number of Olympic swimming pools filled with water offset by material type and state.

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	16,724	3,355	187	3,630	9,809	-117	-141
Vic	16,751	4,637	84	3,273	9,033	-115	-160
Qld	8,099	2,454	68	1,971	3,743	-57	-80
SA	4,518	768	48	1,150	2,609	-24	-34
WA	4,780	1,396	21	901	2,489	-11	-15
Tas	1,336	346	11	272	723	-7	-9
NT	550	129	2	116	308	-3	-4
ACT	882	204	10	187	493	-5	-7
Australia	**53,640**	**13,289**	**431**	**11,500**	**29,207**	**-338**	**-450**

5.8 Water Pollutant Load Savings

Pollutant loads from the inventory data are classified as Water Pollutant Loads if they have the potential to affect aquatic eco-toxicity. These are aggregated across the collection, reprocessing and avoided product systems by mass using a toxicity equivalence factor.

The Centre for Environmental Studies (CML), University of Leiden method was developed in 1992 and was latest updated in 2003. The fresh-water and marine aquatic eco-toxicity methods uses USES-LCA data to calculate Eco-toxicity Potential (FAETP) and takes into account fate, exposure and effects of toxic substances. Characterisation factors are expressed as 1,4-dichlorobenzene equivalents (1,4-DB eq).

The results of the fresh water aquatic eco-toxicity modelling are presented in Table 5-33-Table 5-40 below. As with previous impact categories savings are denoted as positive numbers whilst pollution is denoted by negative numbers.

The fresh water and marine aquatic eco-toxicity savings associated with the recycling activities in Australia amount to over 11 million kilo tonnes 1,4-DB eq, see Table 5-33. As for greenhouse benefits, the C&I sector stands for the majority of the benefit, 61.4 percent of the benefit, followed by the C&D sector 30.8 percent and domestic sector 7.8 percent.

The recovery of aluminium results in the greatest saving followed by ferrous metals. The reprocessing of PET and HDPE results in a net fresh water and marine aquatic eco-toxicity impact.

Table 5-33: Fresh water and marine aquatic eco-toxicity savings by stream (kt 1,4-DB eq).

Material type	Total	Domestic	C&I	C&D
Paper/ Cardboard	701,066	6,463	694,603	-
Glass	10,401	6,729	2,705	967
Ferrous	1,539,226	97,745	1,087,317	354,164
Aluminium	8,803,998	754,350	4,997,793	3,051,855
PET	-8	-3	-5	-
HDPE	-140	-51	-90	-
Total	**11,054,543**	**865,234**	**6,782,324**	**3,406,985**

Table 5-34: Fresh water and marine aquatic eco-toxicity savings by stream (kt 1,4-DB eq).

State	Total	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	3,687,412	197,897	4,521	528,272	2,956,761	0	-38
Vic	3,443,373	242,723	2,019	476,069	2,722,613	-4	-47
Qld	1,569,343	154,723	1,651	284,956	1,128,045	-2	-31
SA	985,131	30,926	1,148	166,540	786,528	-1	-11
WA	791,501	40,466	493	0	750,548	-1	-5
Tas	271,464	13,788	270	39,406	218,005	-1	-4
NT	117,521	7,701	59	16,849	92,915	-0	-1
ACT	188,798	12,843	240	27,135	148,583	0	-3
Australia	**11,054,543**	**701,066**	**10,401**	**1,539,226**	**8,803,998**	**-8**	**-140**

Table 5-35: Fresh water and marine aquatic eco-toxicity savings
- Paper/cardboard recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	197,897	2,872	195,025	-
Vic	242,723	1,939	240,785	-
Qld	154,723	765	153,958	-
SA	30,926	371	30,555	-
WA	40,466	280	40,186	-
Tas	13,788	56	13,732	-
NT	7,701	32	7,669	-
ACT	12,843	149	12,694	-

Australia	**701,066**	**6,463**	**694,603**	**-**

Table 5-36: Fresh water and marine aquatic eco-toxicity savings
- Glass recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	4,521	3,034	1,124	363
Vic	2,019	1,071	674	273
Qld	1,651	983	585	83
SA	1,148	940	125	83
WA	493	334	50	109
Tas	270	175	70	26
NT	59	18	30	11
ACT	240	175	48	18
Australia	**10,401**	**6,729**	**2,705**	**967**

Table 5-37: Fresh water aquatic eco-toxicity savings
- Ferrous recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	528,272	8,155	282,487	237,630
Vic	476,069	78,852	368,531	28,686
Qld	284,956	1,968	238,997	43,990
SA	166,540	7,743	136,984	21,813
WA	0.07	0.005	0.05	0.02
Tas	39,406	493	28,498	10,415
NT	16,849	41	12,309	4,499
ACT	27,135	493	19,511	7,131
Australia	**1,539,226**	**97,745**	**1,087,317**	**354,164**

Table 5-38: Fresh water aquatic eco-toxicity savings
- Aluminium recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	2,956,761	49,379	614,541	2,292,841
Vic	2,722,613	451,767	2,106,715	164,132
Qld	1,128,045	44,849	990,443	92,753
SA	786,528	141,015	537,703	107,810
WA	750,548	53,610	498,934	198,003
Tas	218,005	7,396	117,858	92,751
NT	92,915	1,849	50,961	40,105
ACT	148,583	4,485	80,638	63,460

Australia	8,803,998	754,350	4,997,793	3,051,855

Table 5-39: Fresh water aquatic eco-toxicity savings
- PET recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	0.4	0.1	0.3	-
Vic	-4.1	-1.4	-2.6	-
Qld	-1.5	-0.5	-1.1	-
SA	-0.8	-0.6	-0.2	-
WA	-0.6	-0.4	-0.2	-
Tas	-1.0	-0.2	-0.8	-
NT	-0.2	-0.04	-0.2	-
ACT	0.01	- 0.01	0.02	-
Australia	**-7.8**	**-3.1**	**-4.8**	**-**

Table 5-40: Fresh water aquatic eco-toxicity savings
- HDPE recycling (kt 1,4-DB eq).

State	Total	Domestic	C&I	C&D
NSW	-38.3	-15.8	-22.6	-
Vic	-47.4	-15.3	-32.1	-
Qld	-31.3	-7.5	- 23.8	-
SA	-10.5	-7.6	-2.9	-
WA	-4.7	-2.6	-2.2	-
Tas	-4.0	-0.9	-3.1	-
NT	-1.3	-0.2	-1.1	-
ACT	-2.9	-0.9	-2.0	-
Australia	**-140.4**	**-50.6**	**-89.7**	**-**

5.9 Resource Conservation

The use of recycled materials gives considerable savings in terms of the use of virgin materials. This section provides an indication of the resources saved as a result of Australia's recycling. The performance indicator for this impact category is the dominant resource input – only one resource is reported for each material collected although there are numerous resource inputs for each material produced. The indicator chosen may not either be the most relevant, valuable or environmentally significant resource.

5.9.1 Main assumptions

The following sections provide information on the main assumptions for calculation of resource conservation factors for the six material streams.

Paper/cardboard

The resource conservation factor chosen for paper/cardboard is the number of trees preserved from being cut down by the recycling of post consumer paper products.

Cardboard, tissue paper and office paper is assumed to be manufactured using 60 percent softwood and 40 percent hardwood while newsprint is manufactured from 85 percent softwood and 15 percent hardwood (NPCC, 2001). Further, an average softwood tree has, after 25 years, a volume of $5m^3$ and a density of 520 kg/m^3 compared to $8m^3$ and 720 kg/m^3 for a hardwood tree (Hayters, 2007 & NSW Forests, 2003). Calculations are further based on a 2:1 ratio between timber and pulp and a requirement of $4.3m^3$ of pulp per tonne paper in the sulphate process (to make cardboard, tissue paper and office paper) and $2.4m^3$ pulp per tonne paper in mechanical production of newsprint (SimaPro 7.1.3). The conservation figures calculated have also been adjusted for contamination and material degradation losses as of Table 5-5.

Note that calculations look at theoretical fibre mass equivalent assuming the whole tree is used for paper production while in reality about 50 percent, thinnings and residue offcuts, ends up in the paper industry, 25 percent in timber and 25 percent as waste (Hayters, 2007).

Glass

The resource conservation factor chosen for glass is the total tonnes of sand offset. In calculating this factor, a sand requirement of 720 kg per tonne of glass is used (SimaPro 7.1.3). This factor is then adjusted for contamination and material degradation losses as of Table 5-5 in deriving the results in Table 5-41.

Ferrous

The resource conservation factor chosen for ferrous metals is the total tonnes of iron ore offset. In calculating this factor, an iron ore requirement of 1.4 tonnes ore per tonne of metal is used. This includes iron ore, iron ore for sinter and pellet production as well as the iron ore behind the recycled material added to melting furnaces (SimaPro 7.1.3). This factor is then adjusted for contamination and material degradation losses as of Table 5-5 in deriving the results in Table 5-41.

Aluminium

The resource conservation factor chosen for aluminium is the total tonnes of bauxite offset. In calculating this factor, a bauxite requirement of

5.7 tonnes per tonne of aluminium is used (SimaPro 7.1.3). This factor is then adjusted for contamination and material degradation losses as of Table 5-5 in deriving the results in Table 5-41.

Results

As apparent from Table 5-41 the current recycling activities in Australia results in considerable savings of various resources. The equivalence to three million trees are saved from being cut down as a result of the reprocessing of Australian post consumer paper/cardboard. In the order of 365,000 tonnes of sand, over four million tonnes of iron ore and 1.6 million tonnes of bauxite is being saved through these reprocessing activities. For plastics, the resource savings are measured as tonne of oil equivalent (toe). The 60,000 and 90,000 toe savings of PET and HDPE equate to 430,000 and 650,000 barrel of oil equivalents (boe's).

Table 5-41: Resource conservation

State	Paper/ cardboard	Glass	Ferrous	Aluminium	PET	HDPE
NSW	938,466	158,413	1,312,665	547,500	18,914	28,467
Vic	1,003,010	70,752	1,183,618	467,545	21,584	32,486
Qld	522,529	57,890	709,772	190,920	10,789	16,238
SA	164,750	40,232	414,637	136,752	4,511	6,789
WA	224,924	17,401	325,947	130,688	2,038	3,067
Tas	58,242	9,480	97,968	38,945	1,264	1,902
NT	25,896	2,080	41,929	16,453	495	744
ACT	54,394	8,423	67,413	26,331	953	1,435
Australia	**2,992,212**	**364,670**	**4,153,948**	**1,555,134**	**60,548**	**91,129**

6 Social Aspects

This report demonstrates the upstream and downstream social aspects of recycling in Australia and quantifies the social costs and benefits related to activities undertaken by ACOR and its members. The proposed approach also seeks to provide a balanced overview of how potential costs and benefits can affect the state of recycling in Australia and the relative drivers for improvement.

The social component provides a brief qualitative summary of the social aspects, *costs and benefits,* of recycling Australia wide. These aspects include the capacity for communities to be able to contribute to a more sustainable future through recycling and reprocessing services which will have long term implications for:

- Employment;
- Quality of life;
- A sustainable future;
- A stronger economy; and
- Improved biodiversity.

These aspects listed above have a myriad of associated social costs and benefits related to activities undertaken by ACOR and its members and are discussed in greater detail below.

6.1 Employment

Costs

One of the major social costs of recycling across Australia is the apparent loss of employment in the areas of; natural resource extraction and packaging industries, within product development as well as within product construction and distribution. Through recycling there is an obvious shift away from manufacturing toward a services and knowledge economy in many major metropolitan areas. This ultimately affects the long term employment structure. (Nolan ITU Pty Ltd, 2005)

Benefits

As an offset from the shift in employment from the manufacturing industries there is creation of employment in the waste management and services related industries associated with recycling. Along with this employment shift comes a change in the dynamics in the way waste management is delivered which inturn has many consequential effects including:

- Improved procedures and practices in product/design, manufacture and distribution, including changes associated with cleaner production, recycled content usage, and/or greater source segregation of materials in workplaces;
- Increased volumes of recyclable materials at collection schemes and reprocessing facilities;
- Better quality of material in recycling collection schemes and reprocessing facilities;
- Reduced worker health and safety risks of employees via an increase in workplace standards; and
- 'Best practice' implementation of domestic kerbside recycling for Council staff and/or contractors.

Drivers for Improvement

There are many key drivers for improvement within the recycling industry. In respect to employment as a major social component it can be identified that the higher the employment in the waste management sector, the higher community awareness. Community awareness is inclined to increase as an offset of employment via employees as they advise their peers, family and associates on best practice recycling procedures. Employees are also expected to act as behavioural leaders for recycling which can influence many and varied community members. Such knowledge sharing and observational learning is invaluable and cannot be substituted by any program.

Improved recycling initiatives can also affect the diverse range of suppliers of recyclable materials due to the niche employment market for individuals or small companies to act as catalysts for innovation and product demand between the recyclers and the suppliers (OECD, 2007).

Lastly, differing Government incentives for the advancement of alternative waste treatments and particularly for the creation of jobs related to recycling can in turn improving recycling rates.

6.2 Quality of Life

Costs

There are various social costs which have major impacts on our social amenity and quality of life day to day. Quality of life costs include:

- Transportation of recycled materials could cause traffic, congestion and noise problems;
- Pollution and accidents associated with the transport of recycled materials may have social and/or environmental impacts;
- Noise and air pollution may occur from recycling collection scheme centres and reprocessing facilities; and,

- Odours from recycling collection scheme centres and reprocessing facilities.

Benefits

The social benefits affecting the quality of life of residents and our broader community also provide benefits including:

- Social cohesion between recycling participants across communities toward a common interest;
- A strong sense of civic pride within community areas;
- Convenience, acceptance and satisfaction in participation of the recycling scheme due to ease of the program; and,
- Environmental improvements that link strongly with social wellbeing.

Drivers for Improvement

Various quality of life costs can provide strong drivers for improvement to communities across Australia. For example, those adversely affected by odours may consider adjusting their consumption habits in efforts to recycle and dispose of waste more thoughtfully or may plant natives to act as wind breaks as well as buffer zones for odour control.

It has also been evident through media and behavioural change patterns that increased public expectations regarding recycling services can drive the decision making process' of local authorities and place heightened pressure for improved recycling services levels and implementation. To accompany such service improvements most Council's have Waste Management or Sustainability related strategies outlining key objectives and targets to reduce, re-use, recycle and recover more waste; such strategies help guide decisions leading to cultural change in practices.

6.3 Sustainable Future

Costs

As part of the evolution towards a sustainable future there are social costs that limit recycling uptake and thus can affect sustainability on a wide level. These costs surround the financial implications for collection of recycling materials payable by public and private entities. Fees vary from Council area and contractor. In some cases these costs can be prohibitive for public and private entities and can be avoided based strictly on the associated fees. Other costs involved with sustainable futures and recycling programs include:

- Costs to set up recycling infrastructure and education materials for new areas;

- The pressure for companies to change their practices to become socially and environmentally responsible; and,
- Distance to waste facilities dictating recycling service costs, i.e. the further the landfill site is from the residents who produce the waste, the higher the cost of transport (Commission of the European Communities, 2003).

Benefits

The social benefits associated with recycling in Australia have many links to other economic and environmental benefits affecting our sustainable future. Theses benefits include:

- Improved natural resource base for future generations due to higher recycling uptake;
- Increased access to recycling in residential and non-residential settings;
- Improved information for behavioural change regarding purchasing and recycling; and the development of 'conserver' behaviours in areas outside of materials use;
- An easily accessible opportunity for participation in a simple activity with proven 'sustainability' outcomes;
- Greater awareness and improved understanding of environmental impacts associated with waste management systems;
- Value adding to existing recycling processes, from the materials produced from recycling;
- Reduced need for waste management facilities (landfill sites etc);
- Energy savings and decreased emissions may improves our social amenity and goals via lessened environmental impacts;
- Reduced need for more landfill sites due to incineration and recycling (Nolan ITU Pty Ltd, 2005);
- Greater life cycle benefits linked from direct environmental benefits such as resource savings and greenhouse gas abatement;
- Greater social and environmental responsibility within corporations so that consumers can have a wide choice of products from companies with such ethics. Assuming that there are strong parallels to Australian consumers, the UK Social Market Foundation think tank showed that 82% of consumers prefer to purchase goods and services from companies that are socially and environmentally responsible. (Nolan ITU Pty Ltd, 2005);
- Greater contribution to inter-generational equity (Nolan ITU Pty Ltd, 2005); and,
- Reduction in potentially useful materials could become hazards in landfill, rather than being retained as a resource through recycling (Bureau of International Recycling, 2007).

Drivers for Improvement

The very notion of sustainability and its meaning commonly held by the public can influence disposal and recycling behaviours. Some of the drivers for improvement towards a sustainable future include:

- Recent government media campaigns;
- The environmental impact of and scarcity of Landfill site creating incentives for government to explore alternative waste treatment methods that invariably include recycling; and,
- The increasing distance to waste disposal facilities resulting in an increase in the cost of disposal, pressuring Councils to improve recycling. For example glass and plastic recycling in New York City ceased in 2002 as it was not seen as economically viable. As landfills near the city closed down it became increasingly expensive to transport waste to the new landfills and recycling returned (NRDC, 2004).

6.4 Economy

Costs

One of the major social costs of recycling across Australia is apparent within the economy associated with recycling processes. Such economic costs are felt socially however the main impact is apparent for business and industries such as:

- A lack of participation in resource recovery schemes and their educational benefits due to costs associated with the schemes;
- Increased costs for development of non-domestic resource recovery programs, such as public place recycling; and,
- Costs associated with innovations and technologies likely to be passed to end consumers in product prices.

Benefits

Although there are costs associated with recycling programs Australia wide, there are also many benefits to the economy including:

- A reduction over all in the financial costs associated with manufacturing due to recycling technology advances;
- Reduced sorting costs for kerbside collected materials due to consumer knowledge and understanding as well as improved collection processes;
- The fostering of innovation and cooperation across products, sectors and industry groups;
- A greater opportunity to participate in non-domestic resource recovery programs;

- Reduced collection and operating costs as collection costs for recycling are not needed for land filling (Rich Bishop, Governor Task Force, 2006);
- Reduced imports, increased exports and higher localised production. Less products and raw materials manufactured from outside Australia will be imported as recycling mainly takes place locally. (Appendix A); and,
- Overall the Net Social cost of recycling may be offset by some or all of the benefits (Rich Bishop, Govenor Task Force, 2006).

Drivers for Improvement

By helping build consumer trust in products with recycled material there is potential for a significant boost to local economies (OECD, 2007). Local authorities can become the benchmark for behavioural change by leading by example to buy recycled products. This consumerism then demonstrates to the public that recycled products are of good quality.

In addition, by working with private sector partners and/or local authorities to deliver planning services competition can be increased for economically viability and therefore can facilitate better recycling rates (Communities and Local Government, 2007).

The increased public demand for higher corporate accountability has already resulted in some ‘greener’ product innovation and development. Such product innovation and development often cover full life cycle planning i.e. recycling schemes where companies collect and recycle their products when they reach end of life.

6.5 Biodiversity

Costs

A major aspect of the recycling movement is to have a positive influence on our biodiversity. There are however some costs associated with the effect of recycling on biodiversity. The costs to the social environment include:

- Environmental degradation from transportation and handling of recycling materials as well as the facilities where recycling products are processed; and,
- The transport, handling and processing of materials can affect biodiversity adversely via air, water, noise and odour pollution as well as resource depletion causing a greater social loss of biodiversity and the amenity associated with it.

Benefits

There are direct and indirect benefits of recycling on biodiversity Australia wide including:

- Habitat preservation through the utilisation of raw materials obtained through recycling, not via our natural resources;
- Improved systems reducing consequential biodiversity impacts from transport, handling and processing of recyclables;
- Improved resource efficiency use;
- Less landfill required, reducing the disturbance to habitat areas; and
- Improved residential amenity.

Drivers for Improvement

Due to increasing biodiversity loss as a result of climate change, recycling can be one of the major drivers for improvement used to reduce greenhouse gas emissions. In the UK current recycling saves between 10-15 million tonnes of CO_2 equivalents per year compared to applying the current mix of landfill and incineration with energy recovery to the same materials (WRAP, 2006). Linking education to change is vital to capture these improvements. Communities need to be exposure to information regarding the environmental benefits of recycling.

By reducing the use of virgin materials through recycling processes habitat loss can be minimised, especially in vulnerable ecosystems (for example Weipa in the Darling Range and Mitchell Plateau areas of Western Australia where bauxite is mined to produce aluminium).

6.6 Data Gaps

Whilst there is much information on how communities regard recycling activities Australia wide, the social impact assessment of recycling in comparison with alternatives is severely constrained due to lack of community survey information as well as social impact information.

The combining of financial and environmental costs and benefits in this study is an important step in providing the necessary information to the community to enable a more comprehensive community surveying program from which a detailed social impact assessment can be undertaken. This need has also been noted by *Nolan-ITU Pty Ltd & Sinclair Knight Merz, 2001.*

7 References

ABS, Australian Bureau of Statistics. (2006). 3101.0 - Australian Demographic Statistics, Dec 2006.

ABS, Australian Bureau of Statistics. (Undated). 2001 Census Data by Location.

ACOR, Australian Council of Recyclers. (2005). Rewarding Recycling: Eco-Services from the Resource Recovery Industry - A Market Based Approach. Discussion Paper. Prepared by Nolan-ITU.

AGO, Australian Greenhouse Office. (2006). AGO Factors and Methods Workbook.

AGO, Australian Greenhouse Office. (2006). Tracking to the Kyoto Target.

Bishop, Rich, Governor Task Force. (2006). Economics of Waste Recovery and Disposal. URL: http://wasteresources.wisconsin.gov/docview.asp?docid=6275&locid=83. (17.09.2007).

Bureau of International Recycling. (2007). URL: http://bir.org/aboutrecycling. (19.09.2007).

Chandler, Mark. (2007). General Manager of the Alex Fraser Group. Personal communication. (2.10.2007).

Commission of the European Communities. (2003). 'Recycling – Good for Business'. URL: www.zerowaste.sa.gov.au/pdf/fact_sheets/good_for_business.doc. (17.09.2007).

Communities and Local Government. (2007). 'Planning for a Sustainable Future White Paper'. Presented to Parliament by The Secretary of State for Communities and Local Government, UK. URL: www.communities.gov.uk/documents/planningandbuilding/doc/319907.doc. (21.09.2007).

DEC, Department of Environment and Conservation. (2006). NSW Reprocessing Industries Survey 2003-2004.

DEH, Department of Environment and Heritage. (2006). Waste and Recycling in Australia. Prepared by Hyder Consulting.

Derksen, Linda & Gartrell, John. (1993). The Social Context of Recycling. *American Sociological Review*, Vol. 58, No. 3 (June, 1993).

Hassan Warwick, O-I Glass. (2007). Personal communication. (2.10.2007).

Hayters, Kim of Hayters Sawmill, Orangeville. (2007). Personal Communication. (22.01.2008).

Hyder Consulting. (2007). Life Cycle Assessment on Returnable Plastic Crates. Prepared for Coles Group Ltd.

Hyder Consulting. (2005). Rewarding Recycling: Eco-Services from the Resource Recovery Industry - A Market Based Approach, Discussion Paper.

Jenkins, Gary, General Manager of Amcor Recycling. (2007). Personal communication. (9.10.2007).

NEPM, National Environment Protection Council. (undated). Reports from jurisdictions on the implementation of the Used Packaging materials NEPM 2005/06.

NEPM, National Environment Protection Council. (undated a). Reports from jurisdictions on the implementation of the Used Packaging materials NEPM 2004/05.

Morrissey, Tony. (2007). Business Development Manager of Veolia. Personal communication. (2.10.2007).

National Recycling Coalition. (2001). U.S. Recycling Economic Information Study. Prepared by R.W. Beck.

Nolan ITU. (2005). Consultation Regulatory Impact Statement on the Revised National Packaging Covenant.

NPCC, National Packaging Covenant Council. (2001). Independent Assessment of Kerbside Recycling. Prepared by Nolan-ITU & SKM Economics.

NRDC, Natural Resources Defence Council. (2004). 'Recycling Returns, Ten Reforms for Making New York City's Recycling Program More Cost-Effective'. URL: www.nrdc.org/cities/recycling/returns/contents.asp. (20.09.2007).

NSW Forests, NSW Department of Primary Industries | Forests. (2003). 'About Wood'. URL: http://www.forest.nsw.gov.au/publication/forest_facts/aboutwood/default.asp. (22.01.2008).

OECD. (2007). 'Policy Brief: Improving Recycling Markets'. URL: www.oecd.org/publications/Policybriefs. (25.09.2007).

RDC-Environment & Pira International. (2003). Evaluation of costs and benefits for the achievement of reuse and recycling targets for the different packaging materials in the frame of the packaging and packaging waste directive 94/62/EC – European Union.

Recycle Iowa. (2001). U.S. Economic Impacts of Recycling in Iowa. Prepared by R.W. Beck.

PACIA, Plastics and Chemicals Industries Association. (2006). 2006 National Plastics Recycling Survey (2005 calendar year). Prepared by Hyder Consulting.

PACIA, Plastics and Chemicals Industries Association. (2007). 2007 National Plastics Recycling Survey (2006 calendar year). Prepared by Hyder Consulting.Sustainability Victoria. (Undated). Annual Survey of Victorian Recycling Industries.

Sales, David, CEO Southern Waste Strategy Authority Tasmania. (2007). Personal communication. (19.09.2007).

SimaPro 7.1.3 Proprietary Software.

UTS Institute for Sustainable Futures. (2004). Beyond Recycling: Opportunities and strategies for Local Government to share the responsibility and maximise efficiency.

WA DEC, Western Australia Department of Environment and Conservation. (2007). Review of Total Recycling Activity in Western Australia 2005/06. Prepared by Cardno BSD.

WRAP, Waste & Resources Action Programme. (2006). Environmental Benefits of Recycling, An international review of life cycle comparisons for key materials in the UK recycling sector, UK. URL: www.wrap.org.uk/wrap_corporate/about_wrap/environmental.html. (17.09.2007).

ZWSA, Zero Waste South Australia. (2007). Recycling Activity in South Australia 2005-06. Prepared by Hyder Consulting.

Appendix A

Reprocessing Destinations

Table A - 1. Paper/Cardboard – Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Botany/Smithfield/Albury, NSW	Coolaroo /Fairfield, Vic	Malaysia / China
Victoria	Coolaroo/Fairfield/ Maryvale, Vic	Albury, NSW	Malaysia / China
Queensland	Gibson Island, Qld	Sydney/Albury, NSW	Malaysia / China
SA	Dry Creek, SA	Sydney, NSW / Victoria	Malaysia / China
WA		Coolaroo, Vic or Fairfield, Vic	Malaysia / China
Tasmania		Coolaroo/Fairfield/ Mary-vale, Vic/Albury, NSW	Malaysia / China
NT		Brisbane, Qld	Malaysia / China
ACT		Sydney, NSW	

Table A - 2. Paper/Cardboard – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	88.2%	4.7%	7.0%
Victoria	68.0%	8.2%	23.9%
Queensland	93.0%	4.3%	2.7%
SA	3.0%	44.2%	52.8%
WA		12.3%	87.7%
Tasmania		44.2%	55.8%
NT		90.5%	9.5%
ACT		100.0%	

Table A - 3. Paper/Cardboard – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	56	872		16	8,428	213
Victoria	64	325		5	8,523	157
Queensland	14	1,007		25	7,668	510
SA	14	1,068		15	8,339	398
WA		3,448		19	5,950	275
Tasmania		60	1,026	1	8,691	287
NT		3,429		10	4,498	1,500
ACT		309				5

Table A - 4. Glass – Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Botany/Penrith, NSW	Laverton, Vic	
Victoria	Laverton, Vic	Port Adelaide, SA	
Queensland	Wacol, Qld		
SA	Gillman, SA	Laverton, Vic	
WA		Gilman, SA	
Tasmania		Melbourne, Vic	
NT		Gillman, SA	
ACT		Botany/Penrith, NSW	

Table A - 5. Glass – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	83.7%	16.3%	
Victoria	73.3%	26.7%	
Queensland	100.0%		
SA	99.7%	0.3%	
WA		100.0%	
Tasmania		100.0%	
NT		100.0%	
ACT		100.0%	

Table A - 6. Glass – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	34	891				213
Victoria	22	744				157
Queensland	21					510
SA	15	716				398
WA		2,694				275
Tasmania		22	870			287
NT		3,031				1,500
ACT		274				5

Table A - 7. Ferrous – Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Port Kembla/ Newcastle, NSW	Laverton, VIC	Malaysia / China
Victoria	Brooklyn/ Laverton North, Vic	Port Kembla, NSW	Malaysia / China
Queensland		Port Kembla, NSW	Malaysia / China
SA	Whyalla, SA	Port Kembla, NSW	Malaysia / China
WA	Forrestfield/Kwinana, WA		Malaysia / China
Tasmania		Port Kembla, NSW/ Laverton, VIC	Malaysia / China
NT		Port Kembla, NSW/ Whyalla, SA	Malaysia / China
ACT		Port Kembla/Newcastle NSW/ Laverton, VIC	

Table A - 8. Ferrous – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	99.9%		0.1%
Victoria	78.0%	0.6%	21.4%
Queensland		3.7%	96.3%
SA	23.8%	3.7%	72.5%
WA	4.9%		95.1%
Tasmania		78.6%	21.4%
NT		0.4%	99.6%
ACT		100.0%	

Table A - 9. Ferrous – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	127			16	8,428	213
Victoria	17	823		5	8,523	157
Queensland		938		25	7,668	510
SA	384	1,348		15	8,339	398
WA	31			19	5,950	275
Tasmania		57	1,182	1	8,691	287
NT		3,434		10	4,498	1,500
ACT		447				5

Table A - 10. Aluminium – Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Yennora, NSW		Malaysia / China
Victoria		Yennora, NSW	Malaysia / China
Queensland		Yennora, NSW	Malaysia / China
SA		Yennora, NSW	Malaysia / China
WA		Yennora, NSW	Malaysia / China
Tasmania			Malaysia / China
NT		Yennora, NSW	Malaysia / China
ACT		Yennora, NSW	

Table A - 11. Aluminium – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	99.9%		0.1%
Victoria		32.7%	67.3%
Queensland		32.7%	67.3%
SA		32.7%	67.3%
WA		14.0%	86.0%
Tasmania			100.0%
NT		32.7%	67.3%
ACT		100.0%	

Table A - 12. Aluminium – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	29			16	8,428	213
Victoria		856		5	8,523	157
Queensland		940		25	7,668	510
SA		1,381		15	8,339	398
WA		3,949		19	5,950	275
Tasmania				1	8,691	287
NT		3,981		10	4,498	1,500
ACT		261				5

Table A - 13. PET– Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Prestons, NSW		
Victoria		Prestons, NSW	China
Queensland		Prestons, NSW	China
SA		Prestons, NSW	China
WA		Prestons, NSW	China
Tasmania			China
NT			China
ACT		Prestons, NSW	

Table A - 14. PET – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	100.0%		
Victoria		76.0%	24.0%
Queensland		80.0%	20.0%
SA		80.3%	19.7%
WA		63.5%	36.5%
Tasmania			100.0%
NT			100.0%
ACT		100.0%	

Table A - 15. PET – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	44					213
Victoria	13	842		5	9,617	157
Queensland		968		25	7,836	510
SA	11	1,368		15	9,875	398
WA	10	3,951		19	7,477	275
Tasmania				1	9,721	287
NT		3,983		10	5,121	1,500
ACT		248				5

Table A - 16. HDPE – Assumed Destinations

State of Origin	Local	Interstate	Overseas
NSW	Enfield/Smithfield/ Moama, NSW	Kilburn, SA / Maribyrong, Vic	China
Victoria	Maribyrnong/ Camp-bellfield/ Braeside/ Lilydale/ Laverton North/ Mildura, Vic	Moama, NSW	China
Queensland			China
SA	Kilburn/Port Pirie, SA		China
WA	Wangara/Fremantle/ Perth, WA	Kilburn, SA	China
Tasmania			China
NT			China
ACT			China

Table A - 17. HDPE – Assumed Percentages

State of Origin	Local	Interstate	Overseas
NSW	81.0%	9.0%	10.0%
Victoria	69.4%	6.6%	24.0%
Queensland			100.0%
SA	68.2%		31.8%
WA	45.0%	18.5%	36.5%
Tasmania			100.0%
NT			100.0%
ACT			100.0%

Table A - 18. HDPE – Assumed Kilometres

State of Origin	Local	Interstate		Overseas		Distance regional to urban centres
	Trucking	Trucking	Shipping	Trucking	Shipping	
NSW	14	1,208		16	8,578	213
Victoria	34	251		5	9,617	157
Queensland				25	7,836	510
SA	40			15	9,875	398
WA	23	2,691		19	7,477	275
Tasmania				1	9,721	287
NT				10	5,121	1,500
ACT				309	8,578	5

Appendix B

Materials by state and stream

Table 7-1: Split between states and streams – Paper/Cardboard.

State	Domestic	C&I	C&D
NSW	13.8%	17.5%	-
Victoria	9.9%	23.5%	-
Queensland	4.0%	13.5%	-
SA	2.0%	3.5%	-
WA	1.7%	5.9%	-
Tasmania	0.3%	1.6%	-
NT	0.2%	0.7%	-
ACT	0.8%	1.1%	-

Table 7-2: Split between states and streams – Glass.

State	Domestic	C&I	C&D
NSW	28.3%	10.1%	3.9%
Victoria	10.3%	6.1%	2.9%
Queensland	10.1%	5.3%	0.9%
SA	9.2%	1.1%	0.9%
WA	3.6%	0.4%	1.2%
Tasmania	1.8%	0.6%	0.3%
NT	0.2%	0.3%	0.1%
ACT	1.8%	0.4%	0.2%

Table 7-3: Split between states and streams – Ferrous.

State	Domestic	C&I	C&D
NSW	0.5%	16.1%	16.1%
Victoria	4.8%	21.0%	1.9%
Queensland	0.1%	13.7%	3.0%
SA	0.5%	7.8%	1.5%
WA	0.6%	5.0%	2.3%
Tasmania	0.0%	1.6%	0.7%
NT	0.0%	0.7%	0.3%
ACT	0.0%	1.1%	0.5%

Table 7-4: Split between states and streams – Aluminium.

State	Domestic	C&I	C&D
NSW	0.5%	6.5%	28.8%
Victoria	5.1%	22.3%	2.1%
Queensland	0.5%	10.5%	1.2%
SA	1.6%	5.7%	1.4%
WA	0.7%	5.3%	2.5%
Tasmania	0.1%	1.2%	1.2%
NT	0.0%	0.5%	0.5%
ACT	0.1%	0.9%	0.8%

Table 7-5: Split between states and streams – PET.

State	Domestic	C&I	C&D
NSW	12.8%	18.0%	-
Victoria	11.8%	23.6%	-
Queensland	4.6%	13.3%	-
SA	5.7%	2.1%	-
WA	2.1%	1.5%	-
Tasmania	0.5%	1.6%	-
NT	0.2%	0.7%	-
ACT	0.5%	1.1%	-

Table 7-6: Split between states and streams – HDPE.

State	Domestic	C&I	C&D
NSW	12.8%	18.0%	-
Victoria	11.8%	23.6%	-
Queensland	4.6%	13.3%	-
SA	5.7%	2.1%	-
WA	2.1%	1.5%	-
Tasmania	0.5%	1.6%	-
NT	0.2%	0.7%	-
ACT	0.5%	1.1%	-