



Department of Environment and  
Conservation NSW

# Environmental Benefits of Recycling - Calculator

---

## Explanatory Notes

Thursday, 19 April 2007

Project No: NS03768

Report No: 1-2



Department of Environment and Conservation NSW

# Environmental Benefits of Recycling

## - Calculator

---

### Explanatory Notes

**Author:** Ingrid Cornander & Leanne Philpott

**Checker:** Ron Wainberg

**Approver:** Ron Wainberg

**Report No:** 1-2

**Report No:** NS03768

**Date:** Thursday, 19 April 2007

This report has been prepared for Department of Environment and Conservation NSW in accordance with the terms and conditions of appointment for Calculator dated March 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](http://www.hyderconsulting.com)





# Contents

<b>1</b>	<b>Background .....</b>	<b>1</b>
	1.1 Limitations .....	1
<b>2</b>	<b>Environmental Benefits .....</b>	<b>3</b>
	2.1 Conversion Factors .....	4
	Greenhouse Benefits .....	4
	Water and Energy Savings .....	5
	2.2 Sources .....	5
	2.2.1 Greenhouse Benefits (derived from AGO data) .....	5
	2.2.2 Hyder Conversion Factors .....	6
	Greenhouse Benefits .....	7
	Water Savings .....	9
	Energy Savings .....	12
<b>3</b>	<b>Benchmarking .....</b>	<b>15</b>
	Greenhouse Benefits .....	15
	Water Savings .....	22
	Energy Savings .....	23

# 1 Background

---

Hyder Consulting was commissioned by the Department of Environment and Conservation NSW (DEC) to develop a spreadsheet calculator to enable DEC to readily determine greenhouse gas, energy and water savings resulting from the recycling of various materials.

This Environmental Benefits of Recycling Calculator is a tool to calculate and demonstrate the environmental benefits resulting from recycling. The tool references published and publicly available performance data as “Conversion Factors” on a per tonne basis. Conversion Factors are used by the model to derive the net benefit for a nominated tonnage of material.

Conversion Factors are derived from assessment calculations that have used the method of Life Cycle Assessment. This ensures that all aspects of a system are comprehensively included in the assessment from raw materials extraction, through to collection, transport and processing of recovered materials and associated end-of-life management.

For recycling systems, the dominant impacts include materials sorting, reprocessing and transportation while the dominant benefits arise from the avoided product credits and avoided landfill. Avoided product credits arise when recovered materials are used in another application and thereby replace the need to produce from virgin materials. Avoided product credits include the avoidance of impacts associated with resource extraction, materials production and manufacturing process. These processes have a high energy and materials intensity and typically dominate the assessment.

## 1.1 Limitations

When applying the Conversion Factors, it is important to give regard to the limitations of the study and the impact these have on the final results. The limitations relate to original data reliability and accuracy and any assumptions made during calculations.

The scope of this study has required that best available published data on the recycling benefits of nominated materials and products be provided for decision support. Because the environmental Performance “Conversion Factors” have been *referenced* rather than modelled and derived by the Hyder project team, the data reliability cannot be guaranteed. It is therefore recommended that use of the model is restricted to internal decision making whereby the assessment tools limitations can be understood and factored into the decision making process.

Data accuracy limitations arise from:

**a** Factors are derived from secondary data

The study has not involved data collection on process performance or validation against primary data from industry and as such the data accuracy cannot be guaranteed. While the data have been

benchmarked against alternate data sources to assess for consistency, there has been no primary validation of the published figures. Further, for this study there is no attempt to include a confidence range for the Conversion Factor.

**b** Data Gaps and inconsistencies in the original data

Conversion factors may be based on data sets that have data gaps or different geographical and spatial validity ranges that are not obvious from the final results.

**c** Assumes linear relationship between per tonne benefit and the recycled quantity

It is important to recognise that the “per tonne” benefit of recycling does not correlate strictly with the quantity recycled. For some materials, this “per tonne” benefit diminishes as the rate increases for others, economies of scale result in the per tonne benefit increasing. The “per tonne” benefit is highly variable for most materials at different recovery rates. Further, the benefit will shift in accordance with a large number of variables including processing yield (influenced by contamination and process control issues etc), collection demographics, transfer distances etc.

**d** A lack of completeness in regard to the impact categories

In addition, a lack of completeness in regard to the impact categories studies can bias the final results when the impact categories that are excluded (for example: human toxicity, photochemical oxidation potential etc) do not correlate with the categories that are reported. An attempt should be made to give regard to the broad suit of impacts categories when using the conversion factors for greenhouse and water and energy use.



## 2 Environmental Benefits

---

The conversion factors used in the calculator are summarised in the section below. Factors are presented on a per tonne basis except for televisions and computers which are presented per unit recycled. The factors are referenced from existing studies and are considered to be the best publicly available data. These are denoted in the table column header as “Conversion Factors – as referenced by Hyder”. No benefits could be established for mobile phones.

At the request of the client, additional conversion factors for Greenhouse benefits have been provided based on landfill savings reported by the Australian Greenhouse Office. Factors represented in the table column marked “Conversion Factors - AGO Derived” are based on mixed waste methane conversion factors (AGO Landfill Factors). For simplicity, the avoided landfill emissions from Hyder calculations have been substituted with the AGO data. The column marked “Conversion Factors - AGO Modified” is based on the figures in the previous column but with changed landfill gas collection assumptions in accordance with Section 2.2.1.

## 2.1 Conversion Factors

### Greenhouse Benefits

Material	As referenced by Hyder Consulting (tCO <sub>2</sub> eq / t or unit)	AGO Derived <sup>1</sup> (tCO <sub>2</sub> eq / t or unit)	AGO Modified (tCO <sub>2</sub> eq / t or unit)
Office Paper	1.54	2.40	1.15
Newsprint	0.57		
Cardboard	1.29	3.73	2.48
Paper/ Cardboard	1.13	3.62	2.40
Liquid Paperboard	-0.26		
Glass (bottles)	0.33		
Glass (plate)	0.92		
HDPE	0.49		
PET	1.43		
Steel (cans)	0.81		
Steel	0.58		
Aluminium (cans)	15.18		
Non-Ferrous Metals	17.07		
Garden Organics	0.40	1.21	0.66
Food Organics	0.45	1.05	0.60
Timber	0.15	3.63	2.03
Concrete	0.01		
Brick & Tiles	0.01		
Asphalt	0.06		
Natural Aggregate	-		
Soil	-		
Plasterboard	0.27		
Televisions (per unit)	0.20		
Computers (per unit)	0.04		

<sup>1</sup> Calculated based on avoided landfill Conversion Factors, Australian Government, Department of the Environment and Heritage Australian Greenhouse Office. (2006). AGO Factors and Methods Workbook. December 2006.

## Water and Energy Savings

Material	Water Savings (Kilolitres / t or unit)	Energy Savings (GJ / t or unit)
Office Paper	15.58	21.23
Newsprint	21.08	15.09
Cardboard	30.66	27.39
Paper/ Cardboard	29.74	26.57
Liquid Paperboard	9.60	7.20
Glass (bottles)	2.00	3.80
Glass (plate)	16.14	11.94
HDPE	-10.40	46.80
PET	-12.10	49.50
Steel (cans)	1.10	32.90
Steel	2.26	28.40
Aluminium (cans)	233.20	171.00
Non-Ferrous Metals	192.67	184.98
Garden Organics	0.48	1.17
Food Organics	0.70	1.61
Timber	0.07	7.34
Concrete	1.88	0.01
Brick & Tiles	1.88	0.01
Asphalt	1.68	4.39
Natural Aggregate	-	-
Soil	-	-
Plasterboard	2.34	3.83
Televisions (per unit)	0.46	0.35
Computers (per unit)	0.28	0.40

## 2.2 Sources

### 2.2.1 Greenhouse Benefits (derived from AGO data)

The data has been calculated by the AGO using the formula provided for MSW in landfill as described in this section and is based on carbon accounting principles in a landfill. Assumptions adopted to calculated the

AGO figure which may not reflect actual landfill practice include: recovered methane is zero, dissimilation of degradable Organic Carbon is 50 percent, oxidation of methane at the landfill surface is 10 percent, the fraction of carbon converting to methane is 50 percent.

In an attempt to derive an AGO figure that more closely reflects actual landfill emissions, Hyder has changed the landfill gas collection assumption to be 50 percent. For the purpose of this report, all other assumptions are accepted. Methane collection is for flaring and there is no provision for cogeneration or associated electricity credit. Further, because this is not a life cycle based assessment, there is no allocation for fuel consumption or material use.

GHG Emissions =

$$(MSWt \times MSWf \times MCF \times DOC \times DOCf \times F \times 16/12) \times (1-R) \times (1-OX)$$

MSWt = Total MSW generated or material

MSWf = Fraction of MSW disposed to solid waste disposal site.

MCF = Methane correction factor (fraction)

DOC = degradable organic carbon (fraction)

DOCf = Fraction of DOC dissimilated

F = Fraction of carbon

R = Fraction of methane recovered %

OX = Oxidation factor

## 2.2.2 Hyder Conversion Factors

Where available, data for greenhouse benefits, water and energy savings have been drawn from a number of published reports. Otherwise, the recycling benefits are calculated and modelled using *SimaPro 7.0* software which incorporates various Australian and international data libraries such as:

- Australian Data Inventories - Data generated as part of the Australian LCA Data Inventory Project (1998 - 2002) by the CRC for Waste Management and Pollution Control in conjunction with the Centre for Design at RMIT.
- BUWAL - Inventory database developed for the Swiss Packaging Institute, prepared by the Swiss Federal Laboratories for Materials Testing and Research (EMPA).
- IDEMAT - This database has been developed at Delft University of Technology in Holland, department of industrial design engineering, under the IDEMAT project. The following table provides information on sources and relevant assumptions.



## Greenhouse Benefits

Material	Source	Comments
Office Paper	Duke University for the Paper Taskforce. (1995). White Paper No. 3, Lifecycle Environmental Comparison: Virgin Paper and Recycled Paper- Based Systems. Originally Published on December 19, 1995.	For office paper, the data referenced (US Paper Taskforce) compares recycled pulp and recycling with virgin pulp and landfill disposal. This is a theoretical estimate of the benefit of recycling. While transport data from overseas have not been modified to reflect the Australian situation, analysis of the relative significance of transport indicates that transport is only a few percent of the net system impact.
Newsprint	Hyder Consulting (2007).	Applies current market practice to define boundary conditions and assumptions. Calculated using the SimaPro 7.0 proprietary software.
Cardboard	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Applies current market practice to define boundary conditions and assumptions. Calculated using the SimaPro 7.0 proprietary software.
Paper/ Cardboard	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Cardboard figure chosen based on the application of recycled mixed paper. Figure adjusted for collection and processing inefficiencies.
Liquid Paperboard	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software. Recycling of LPB results in a net loss from a greenhouse gas perspective.
Glass (bottles)	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Glass (plate)	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
HDPE	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
PET	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.



Material	Source	Comments
Steel (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Steel	Hyder Consulting. (2007). Calculated using updated data from SimaPro 7.0 proprietary software.	Updated figures compared to previous publication (DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits)
Aluminium (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Non-Ferrous Metals	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Garden Organics	DEC NSW. (2005). Assessment of Garden Organics Collection Systems. Prepared by Nolan-ITU.	Calculated using the SimaPro 7.0 proprietary software. It is noted that the DEC study attempted to account for previously ignored impacts/benefits from compost. Some greenhouse benefits may not be captured (eg: N <sub>2</sub> O arising from synthetic fertiliser application).
Food Organics	Hyder Consulting. (2006). TBL Assessment of (Domestic) Food Organics Management. Prepared for DEC NSW.	Calculated using the SimaPro 7.0 proprietary software. As above, some greenhouse impacts/benefits may not be accounted for.
Timber	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	The timber recycling figure is based on 50% hardwood and 50% softwood. It assumes timber is reused not burnt for fuel or chipped. Previously obtained published data for timber (DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits) had contained significant data gaps including the complete absence of data for softwood water and energy usage. In light of these inadequacies, new data was sought and the final referenced data is from the LISA software developed by BHP Engineering.
Concrete	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Brick & Tiles	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.

Material	Source	Comments
Asphalt	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Natural Aggregate	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Soil	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Plasterboard	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software. No evidence of plasterboard recycling in Australia have been found, although recycling operations overseas deliver a recycling benefit as captured by the data.
Televisions	DEC NSW. (2006). Environmental Benefits of TV Recycling. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Computers	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.

## Water Savings

Material	Source	Comments
Office Paper	Duke University for the Paper Taskforce. (1995). White Paper No. 3, Lifecycle Environmental Comparison: Virgin Paper and Recycled Paper- Based Systems. Originally Published on December 19, 1995.	For office paper, the data referenced (US Paper Taskforce) compares recycled pulp and recycling with virgin pulp and landfill disposal. This is a theoretical estimate of the benefit of recycling. While transport data from overseas have not been modified to reflect the Australian situation, analysis of the relative significance of transport indicates that transport is only a few percent of the net system impact.
Newsprint	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Cardboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.

Material	Source	Comments
Paper/ Cardboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software. Cardboard figure chosen based on the application of recycled mixed paper. Figure adjusted for collection and processing inefficiencies.
Liquid Paperboard	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Glass (bottles)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Glass (plate)	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
HDPE	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
PET	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Steel (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Steel	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Aluminium (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Non-Ferrous Metals	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Garden Organics	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Calculated using the SimaPro 7.0 proprietary software.



Material	Source	Comments
Food Organics	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Calculated using the SimaPro 7.0 proprietary software.
Timber	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	The timber recycling figure is based on 50% hardwood and 50% softwood. It assumes timber is reused not burnt for fuel or chipped. Previously obtained published data for timber (DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits) had contained significant data gaps including the complete absence of data for softwood water and energy usage. In light of these inadequacies, new data was sought and the final referenced data is from the LISA software developed by BHP Engineering.
Concrete	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Brick & Tiles	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Asphalt	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Natural Aggregate	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Soil	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Plasterboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software. No evidence of plasterboard recycling in Australia have been found, although recycling operations overseas deliver a recycling benefit as captured by the data.
Televisions	DEC NSW. (2006). Environmental Benefits of TV Recycling. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Computers	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.

## Energy Savings

Material	Source	Comments
Office Paper	Duke University for the Paper Taskforce. (1995). White Paper No. 3, Lifecycle Environmental Comparison: Virgin Paper and Recycled Paper- Based Systems. Originally Published on December 19, 1995.	For office paper, the data referenced (US Paper Taskforce) compares recycled pulp and recycling with virgin pulp and landfill disposal. This is a theoretical estimate of the benefit of recycling. While transport data from overseas have not been modified to reflect the Australian situation, analysis of the relative significance of transport indicates that transport is only a few percent of the net system impact.
Newsprint	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Cardboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Paper/ Cardboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software. Cardboard figure chosen based on the application of recycled mixed paper. Figure adjusted for collection and processing inefficiencies.
Liquid Paperboard	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Glass (bottles)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Glass (plate)	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
HDPE	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
PET	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Steel (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Steel	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.



Material	Source	Comments
Aluminium (cans)	DEC NSW. (2006). Environmental Benefits of Recycling Calculator. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Non-Ferrous Metals	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Garden Organics	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Calculated using the SimaPro 7.0 proprietary software.
Food Organics	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Calculated using the SimaPro 7.0 proprietary software.
Timber	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	The timber recycling figure is based on 50% hardwood and 50% softwood. It assumes timber is reused not burnt for fuel or chipped. Previously obtained published data for timber (DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits) had contained significant data gaps including the complete absence of data for softwood water and energy usage. In light of these inadequacies, new data was sought and the final referenced data is from the LISA software developed by BHP Engineering.
Concrete	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Brick & Tiles	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Asphalt	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Natural Aggregate	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.
Soil	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.



Material	Source	Comments
Plasterboard	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software. No evidence of plasterboard recycling in Australia have been found, although recycling operations overseas deliver a recycling benefit as captured by the data.
Televisions	DEC NSW. (2006). Environmental Benefits of TV Recycling. Prepared by Hyder Consulting.	Calculated using the SimaPro 7.0 proprietary software.
Computers	Hyder Consulting (2007).	Calculated using the SimaPro 7.0 proprietary software.

### 3 Benchmarking

Conversion factors, with a focus on those materials previously not modelled by Hyder Consulting, were benchmarked against best publicly available international data to highlight any anomalies. The results from the benchmarking are presented in the table below. The data available is very scarce, especially in the area of water savings.

#### Greenhouse Benefits

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Office Paper	1.5	0.4	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Previously published data contained significant data gaps. The Paper Taskforce data is more complete.
		0.58	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Source data was assessed and contained significant data gaps.
Newsprint	0.57	0.46	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	



Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Cardboard	1.29	0.30	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Paper/ Cardboard	1.13	0.24	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Liquid Paperboard	-0.26	0.64	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Recycling assumptions have changed since the RMIT data was developed.
Glass (bottles)	0.33	0.60	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Glass (plate)	0.9	1.0	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	In the same order of magnitude.
		0.03	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
HDPE	0.49	1.05	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
PET	1.43	1.04	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	



Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Steel (cans)	0.81	1.49	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Steel	0.6	0.58–0.83	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude.
		1.67	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Aluminium (cans)	15.2	12.3-13.1	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
		16.53	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Non-Ferrous Metals	17.07	17.49	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Garden Organics	0.40	0.23	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Food Organics	0.45	0.52	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Timber	0.15	0.043	DEC NSW. (2006). Review of WRAPP Incorporation of Greenhouse Gas Benefits. Prepared by Hyder Consulting.	Previously published data contained significant data gaps including the complete absence of data for softwood water and energy usage.
		0.33	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Concrete	0.01	0.03	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Brick & Tiles	0.01	0.01	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Asphalt	0.06	0.02	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Natural Aggregate	-	0.01	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	
Soil	0	2.3	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude. ERM is reporting the 2.3 to be a 'maximum recycling benefit'. Variations can be explained by the geographic system boundaries.
		0.09	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(tCO <sub>2</sub> eq / t or unit)	(tCO <sub>2</sub> eq / t or unit)	Source	
Plasterboard	0.27	0.05	RMIT University, Centre for Design. (2005). Life Cycle Impact Data for Resource Recovery from Commercial and Industrial and Construction and Demolition Waste in Victoria. Final Report – Version 3. Prepared by Tim Grant and Karli James for EcoRecycle Victoria.	Assumptions regarding the avoided product due to recycling differ.

## Water Savings

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(1,000 l / t or unit)	(1,000 l / t or unit)	Source	
HDPE	-10.4	-9.5	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
PET	-12.1	-14.87	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Timber	0.1	0.04-2.5	SimaPro 7.0 proprietary software. Pine, hardwood and European beech data from IDEMAT and Australian Data Inventory databases.	In the same order of magnitude.



## Energy Savings

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(GJ / t or unit)	(GJ / t or unit)	Source	
Newsprint	15.1	21.3	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Cardboard	27.4	17.8	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Glass (bottles)	3.8	1.9	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Glass (plate)	11.9	15.0	SAEFL, Swiss Agency for the Environment, Forests and Landscape. (1998). Life Cycle Inventories for Packaging. Volume I.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Steel	28.4	17.0	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	In the same order of magnitude.
Non-Ferrous Metals	185.0	132-143	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.
Timber	7.3	0.0020 - 1.38	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude. Variations can be explained by the geographic system boundaries.

Material	Conversion Factor	Alternative Conversion Factor		Comments
	(GJ / t or unit)	(GJ / t or unit)	Source	
Soil	0	-1.031-0.027	ERM. (2006). Carbon Balances and Energy Impacts of the Management of UK Wastes. DEFRA R&D Project.	In the same order of magnitude.
Plasterboard	3.8	2.7	BHP Engineering and Newcastle University. (1999/2000). Lisa Sustainable Design in Architecture.	In the same order of magnitude.