Indufor ...forest intelligence

Australian Paper

Recycled paper:
A comparison of greenhouse gas emissions associated with locally made and imported paper products

Project report

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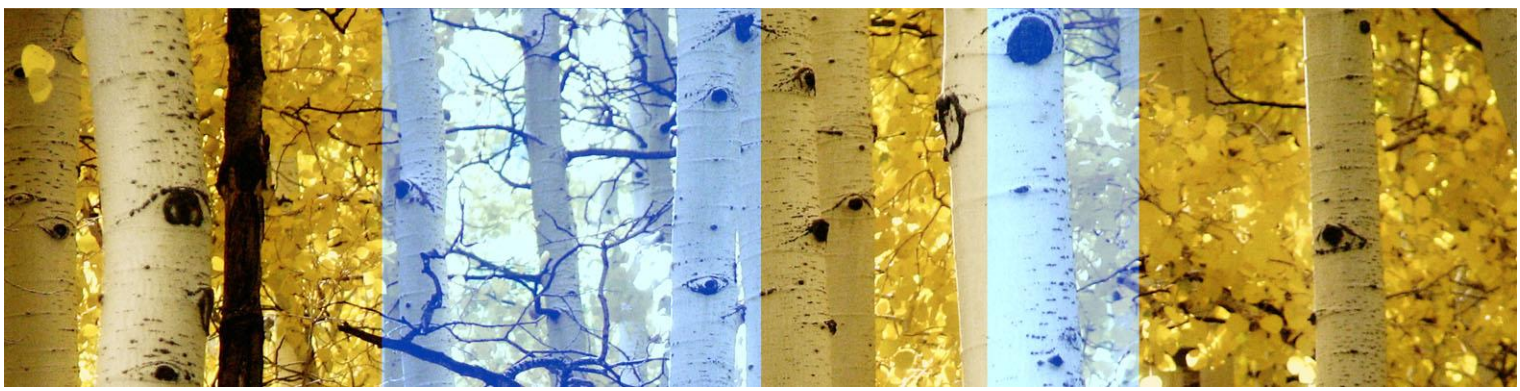

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Indufor makes its best effort to provide accurate and complete information while executing the assignment. Indufor assumes no liability or responsibility for any outcome of the assignment.

PREFACE

Indufor Asia Pacific (Australia) Pty Ltd (Indufor) was commissioned by Australian Paper (the Client) to prepare this report. The intended user of this report is the Client. No other third party shall have any right to use or rely upon the report for any purpose.

The project involved desktop analysis conducted in 2015, based on published information available at that time.

This report may only be used for the purpose for which it was prepared and its use is restricted to consideration of its entire contents. The conclusions presented are subject to the assumptions and limiting conditions noted within.

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EXECUTIVE SUMMARY

Australian Paper has opened a new paper recycling facility at its Maryvale mill in the Latrobe Valley in Victoria, with a capacity to recycle up to 80 000 tonnes of recovered paper. To address questions relating to the competitiveness of locally made recycled paper, Indufor was commissioned to compare the greenhouse gas (GHG) emissions associated with manufacturing these products with the use of imported recycled paper products, and also the production and use of locally made virgin fibre based paper.

This review was based on a differential analysis, comparing emissions along the supply chains of locally made recycled paper and imported recycled paper, as well as virgin fibre paper.

This review shows the GHG emissions associated with production of locally made recycled paper can be significantly lower than the emissions associated with imported paper (Table ES1). The key points of difference in these supply chains relate mainly to sea freight associated with imports of recycled paper, as well as exports of locally made paper displaced by imports; and also attribution of landfill emissions to that proportion of non-recovered paper that may be disposed to landfill if not recycled in Australia. On this basis, the aggregate differential is estimated to be in the order of 870 kg of CO_{2e} for each tonne of imported recycled paper.

Table ES1 Differential based comparison of GHG emissions from the production of Australian recycled paper and imported recycled paper

	Indicative GHG emissions from Australian made recycled paper *(kg CO_{2e} / tonne of paper)*	**Indicative GHG emissions from imported recycled papers** *(kg CO_{2e} / tonne of paper)*
Sea freight – imported paper	0	210
Sea freight – displaced paper export*	0	220
Landfill emissions associated with reduced demand for local recycled paper**	0	440
Total GHG emissions differential	**0**	**870**

Notes: * Assumption that imports displace local product ** Based on 2012 recycling rate estimate for landfill disposal

This review also compared supply chains for locally made recycled paper with virgin fibre based paper products, and concluded the emissions associated with production are broadly similar (Table ES2). While the pulping process for recovered paper consumes less energy than breaking down virgin fibre, the kraft pulping process produces black liquor as a by-product, which can be used for bioenergy to significantly lower the emissions associated with producing virgin fibre paper. On this basis, the differential in GHG emissions was found to be marginal.

Table ES2 Differential based comparison of GHG emissions from the production of Australian recycled paper and virgin fibre paper

	Indicative GHG emissions from Australian made recycled paper *(kg CO_{2e} / tonne of paper)*	**Indicative GHG emissions from Australian made virgin fibre paper** *(kg CO_{2e} / tonne of paper)*
Production of raw fibre materials	Assumed net neutral	Assumed nil
Collection of materials	40	70
Pulping and paper manufacturing – including emission reduction benefit from use of black liquor for bioenergy*	350	350*
Total GHG emissions differential	**390**	**420**

Notes: * Assumption that emission reduction benefits from the use of black liquor apply only to virgin fibre paper.

1. INTRODUCTION

Australian Paper has established a new paper recycling plant at the Maryvale mill in Victoria, and has estimated the new plant will triple its usage of recycled fibre to 80 000 tonnes of recovered paper[1]. This will enable the development of a range of new Australian made recycled paper products[2], including office, printing, publishing, envelope and stationery papers.

In this context, Australian Paper has engaged Indufor to compare the greenhouse gas (GHG) emissions[3] associated with locally made recycled paper with two alternative supply chains, being:

(i) imported recycled paper products; and

(ii) Australian made virgin fibre paper products.

1.1 Paper recycling in an international context

The OECD has observed the pulp and paper industry is a key sector in the global economy with substantial opportunities to reduce GHG emissions along the supply chain and in end-of-life recycling options.[4]

International studies on the opportunities for the pulp and paper industry to reduce its environmental footprint have generally supported increasing production of recycled paper to achieve more responsible use of resources - not only through re-use of raw materials, but also through significant reductions in energy consumption and associated GHG emissions throughout the product life-cycle. [5]

The importance of recovered paper as a raw material in the paper industry has increased substantially over the past two decades. Recovered paper is already the most important source of fibre in the industry worldwide, as recovered paper provided approximately 51% of all fibre used in the paper industry in 2006[6]. There are clear signals this trend will continue with international forest and paper associations setting recovered fibre utilisation rate targets as high as 70%[7]: For example, these signals include:

- The American Forest & Paper Association has committed to increase the rate of paper recovery for recycling up to exceed 70% by 2020;
- The Japan Paper Association has committed to achieve a recovered fibre utilisation rate of 64% by 2015; and

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[1] For the purpose of this report, recovered paper is defined as paper that has been collected from households or offices, or otherwise diverted from disposal paths for recycling purposes. Recovered paper is generally used for material recycling, composting and energy use. Non-recovered paper refers to paper that has not been collected for reuse. Non-recovered paper refers to waste paper that has reached the end of its useful life and is directed to landfill.

[2] Recycled paper refers to paper products that are made with recycled fibre content from recovered paper.

[3] Greenhouse gasses, notably carbon dioxide (CO_{2e}) and methane; collectively measured and reported as CO_{2e} based on their respective Global Warming Potential.

[4] OECD, 2011 (The Organisation for Economic Co-operation and Development, Environmental Directorate, Environment Policy Committee), *A Sustainable Materials Management Case Study - Wood Fibres*. ENV/EPOC/WGWPR (2009)9/Final, p8.

[5] References include: OECD, ibid, p55; citing studies by ETC, 2004; and The Heinz Center, 2006; WRAP, 2010 (UK Waste & Resources Action Programme) *Environmental benefits of recycling – 2010 update*; and EEA, 2006, *Paper and cardboard — recovery or disposal? A review of life cycle assessment and cost-benefit analysis on the recovery and disposal of paper and cardboard.* Technical report No 5/2006.

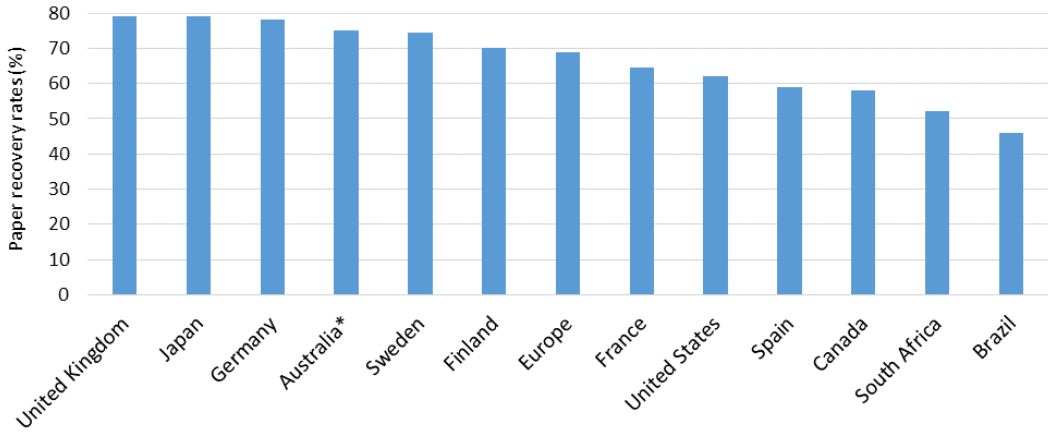
[6] COST (European Cooperation in Science and Technology), Action E48, 2010, *The Future of Paper Recycling in Europe: Opportunities and Limitations.*

[7] American Forest & Paper Association: 70% by 2020; Japan Paper Association 64% by 2015; European Recovered Paper Council plans to renew above 68%.

- The European Recovered Paper Council announced in 2014 that the paper recycling rate in Europe reached 71.7% in 2013. The total amount of paper collected and recycled in the European paper sector has remained relatively stable at just over 57 million tonnes, despite decreasing paper consumption in Europe. Paper recycling in Europe has increased by 45% since 1998, the base year for the first voluntary commitment set in the European Declaration on Paper Recycling.[8]

A snapshot of the level of paper recovery rates for selected countries is shown in Figure 1-1. This comparison for selected countries indicates that selected European countries along with Japan and Australia are leading the way on recovery rates.

Figure 1-1 Paper recovery rates for selected countries, 2011



*Australian rate based on 'paper recycling' rate, from the National Inventory Report 2012.
Source: World Business Council for Sustainable Development, 2011; and Commonwealth of Australia 2014

Australia's National Greenhouse Accounts for 2012 reported there has been a major shift in disposal of waste paper from landfill to recycling in this country since the 1980s. The amount of recovered paper as a share of paper products that had reached the end of its useful life increased from approximately 30% in 1990 to over 80% in 2012[9]. The 2012 National Accounts showed a sharp increase in recovery rates in 2006, which was considered to reflect the effectiveness of State Government waste management initiatives. On this basis, Australia can be considered one of the leading countries worldwide on paper recycling rates.

1.2 Methodology and scope

Indufor was commissioned by Australian Paper to undertake this sustainability comparison of the GHG emissions associated with Australian made recycled paper and the imports of recycled paper from other countries. Australian Paper also requested Indufor to compare the GHG emissions of its recycled paper with virgin fibre paper production within Australia.

This study is based on a desktop review of published data, conducted in early 2015. It is a high level comparative assessment that focuses on the carbon dioxide equivalent (CO_{2e}) emissions associated with paper supply chains through to the products' end-of-life path.

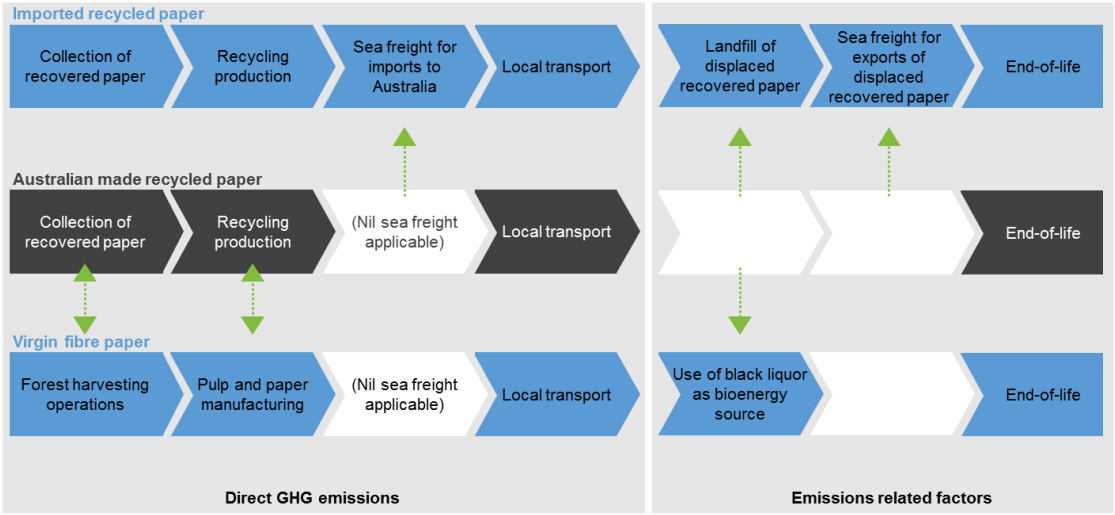
Indufor's approach to this study comprised a differential analysis of GHG emissions between the comparable components of the supply chains. This means the analysis does not address

[8] European Recovered Paper Council, 2014, Paper recycling in Europe at 71.7%. Press release, Brussels, 25 June 2014.
[9] Commonwealth of Australia (Department of the Environment) 2014*, National Inventory Report 2012 Volume 3,* April 2014.

supply chain components that are similar – for example, GHG emissions associated with the transport of paper products to distribution warehouses, and end-of-life disposal of paper products, were considered to be essentially the same for locally made recycled paper, virgin fibre based paper and imported paper.

Figure 1-2 illustrates the key points of difference between the supply chains that are addressed in the analysis.

Figure 1-2 Outline of the key components for the comparative analysis of supply chains



Source: Indufor. Notes: Arrows indicate segments compared in this differential analysis

Scope exclusions

The scope for this paper excluded a detailed analysis of different types of pulping systems, paper manufacturing processes and paper recycling facilities. This was considered to be a reasonable assumption for an analysis where the comparison of supply chains is high level and does not relate to specific facility comparisons. It is noted there can be significant differences between specific paper manufacturing and paper recycling facilities operating in Australia and in other countries; particularly given the range of leading exporters of paper products, such as China, Indonesia, Thailand, Germany and Austria; however, the study overlooks the detailed technical assessment of different manufacturing systems.

Furthermore, this analysis was based on the key premise that supply chain entities have access to the same level of technology as Australian Paper. Therefore, the analysis does not factor in that there can be considerable variation in emissions depending on machinery and methods, e.g. in terms of waste collection methods, or transport vehicles or ships.

The scope for this study also excluded a detailed assessment of the carbon stocks profile associated with alternative forest management regimes, and policy deliberations about the carbon balance associated with harvest and non-harvest regimes for natural forests. However, this study does incorporate a qualitative commentary on the management of carbon stocks within production forests, and the extent to which the sustainability of timber harvesting and temporal impacts on carbon stocks is addressed in leading forest management certification programs such as the Australian Forestry Standard (under the PEFC) and the Forest Stewardship Council (FSC).

2. INDUFOR ANALYSIS

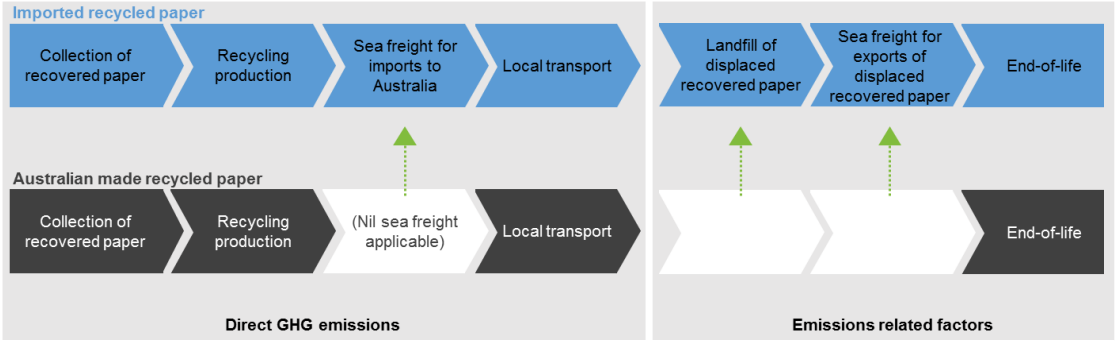
This analysis compares the supply chain GHG emissions associated with locally made recycled paper with the supply chain GHG emissions of imported recycled paper (section 2.1), and with those of virgin fibre paper (section 2.2).

2.1 Comparing Australian made recycled paper with imported paper

The relevant supply chain components to compare for GHG emissions associated with locally made recycled paper and imported recycled paper were identified as:

- The diversion of waste paper (recovered paper) from landfill in Australia; and
- Sea freight-based emissions for imported recycled paper; and also sea freight exports of locally made recycled paper displaced in the domestic market by imported paper.

These supply chain components are illustrated below.



2.1.1 Diversion of recovered paper from landfill

A key premise of Australian Paper's new recycling plant at Maryvale is that it will utilise recovered paper that would otherwise have been directed to exports or landfill. The amount of recovered paper used will be up to 80 000 tonnes per year.

Australia's National Greenhouse Accounts Factors in 2013 incorporated 'waste mix methane conversion factors' to estimate the emissions profile for a range of products, including paper and cardboard. This guidance indicates that paper and cardboard products have a methane conversion factor of 2.5; that is, the amount of CO_{2e} emissions associated with decomposition of paper and cardboard is around 2.5 times the weight of these paper products.[10]

Therefore, every tonne of recovered paper that is utilised and not diverted to landfill avoids 2.5 tonnes of CO_{2e} emissions. Consequently, Australian Paper's Maryvale recycling plant has the potential to avoid up to 200 000 tonnes of CO_{2e} emissions altogether.

There is also a risk that imports of recycled paper could displace demand for Australian made recycled paper; and as a result, local production could be reduced, and non-recovered waste paper could be disposed in landfill and give rise to a significant amount of CO_{2e} emissions.

In the context of paper recycling processes, it should be noted the quantity relationship between recovered paper and recycled paper is generally not 1:1. In the case of Australian Paper's recycling plant at Maryvale, the relationship is closer to 1.1 tonnes of recovered paper being required for every tonne of recycled paper products.[11]

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[10] *Australian National Greenhouse Accounts - National Greenhouse Accounts Factors*, Commonwealth of Australia 2013, July 2013.

[11] Australian Paper has advised that recycled paper products comprise approximately 70% air dried pulp; and on this basis, 50 000 tonnes of pulp makes approximately 71 000 tonnes of recycled paper. Therefore,

This means that every tonne of imported recycled paper could potentially reduce the recovery and use of approximately 1.1 tonnes of waste paper.

However, there is a limit to the extent to which importing paper could result in increased landfill emissions. In Australia, there is an increasing trend towards paper recycling that has led to a decrease in the proportion of paper disposed to landfill.[12] The Australian Government has reported the proportion of paper disposed to landfill has dropped from around 67% in 1990 to 16% in 2012.[13]

It is beyond the scope of this assessment to determine the extent to which there is a direct causal linkage between the importation of recycled paper and the disposal of non-recovered paper in landfill in Australia; or the causal linkage between production of locally made virgin fibre and the disposal of non-recovered paper in landfill in Australia.

Noting this limitation, Indufor considers the extent to which importing recycled paper results in displacement of paper waste to landfills in Australia could be up to 16% of the total quantity imported, based on the Australian Government's most recent data on paper recycling levels. Therefore, Indufor has assumed the GHG emissions that may be attributed to importing paper rather than local recycling to be approximately 16% of the level of GHG emissions associated with paper disposed to landfill.

Therefore, landfill-based GHG emissions attributable to importing one tonne of paper are estimated to be approximately 16% of 2.5 tonnes of CO_{2e} for the equivalent quantity of waste paper *not* recovered from landfill; i.e. 440 kg of CO_{2e} for each tonne of paper imports.

On this basis, Indufor estimates:

- The emissions associated with imported paper that consequently reduces demand for locally produced recycled paper would indicatively be 440 kg of CO_{2e} per tonne of paper.

2.1.2 Sea freight impacts

Australia currently imports around 1.1 million tonnes of printing and writing paper per year, which has an import value of approximately $1.2 billion.[14] The largest suppliers of printing and writing products to Australia over the last decade have included China, Indonesia, Thailand, Germany and Austria.

GHG emission rates

Imported paper products are generally transported by sea freight[15].

In 2007, the Australian Greenhouse Office reported on trends and greenhouse gas indicators for the National Greenhouse Gas Inventory, including unit rates for emissions from different forms of freight transport. The emission rate specified for sea freight was 12.6 grams of CO_{2e} per tonne-km;[16] and this stands as the most recent estimate by the Australian Government for sea freight-based GHG emissions. This rate is comparable to reporting by the European Environment Agency (EEA), which assessed the emissions profile for different modes of transport in Europe between 1995 and 2011, and specified the rate for sea freight of 14 grams of CO_{2e} per tonne-km.[17]

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the conversion from 80 000 tonnes of recovered paper to 71 000 tonnes of recycled paper indicates 1.1 tonnes of recovered paper is required to make one tonne of recycled paper.

[12] *National Inventory Report 2012 Volume 3,* Commonwealth of Australia 2014.

[13] *Ibid.*

[14] ABARES, 2014, Forest and Wood Product Statistics, March and June quarters.

[15] Also referred to as 'maritime freight' and 'coastal shipping'.

[16] Australian Greenhouse Office, 2007, *National Greenhouse Gas Inventory - Analysis of Recent Trends And Greenhouse Indicators 1990 to 2005.*

[17] EEA, 2015, *Specific CO_2 emissions per passenger-km and per mode of transport in Europe, 1995-2011.*

While there is a wider range of published data on sea freight emission rates[18], the Australian Government data was selected for use in this review, as it is directly applicable to a study for Australian Paper, and there is consistent reporting by the EEA. On this basis, it is estimated the emissions associated with sea freight are approximately 12.6 grams of CO_{2e} per tonne-km.

Imports of recycled paper

The indicative emissions associated with importing a tonne of paper from leading producer countries of printing and writing papers into Australia are shown in Table 2-1.

Table 2-1 Indicative estimate of GHG emissions for sea freight of paper imports

Country of origin	Indicative freight distance (km)	Indicative grams CO_{2e}/tonne/km	Indicative total CO_{2e} (kg per tonne paper)
Finland	24 000	12.6	302
China	9 300	12.6	117
Germany	22 000	12.6	277
Belgium	22 000	12.6	277
Indonesia	6 300	12.6	79
Averages	~17 000	12.6	211

Source: Indicative freight distances from PortWorld (online portal); and Indicative CO_{2e} estimates based on unit rates published in AGO, 2007.

For the purposes of this comparison, if the average freight distance for imports is assumed to be approximately 17 000 km, the indicative estimate of emissions would be around 210 kg of CO_{2e} per tonne of paper.

Consequent exports of paper

As noted above, a further consequence of importing recycled paper is that it may displace domestic demand for locally made paper. In this case Australian Paper would need to look to export markets to be able to maintain production at levels that were set to meet domestic market demand.

As a result, if Australian Paper does export recycled paper, there would be additional GHG emissions associated with the sea freight to export markets. Australian Paper has identified the US and Western Europe as the primary markets for locally made paper products. Using rates published by the Australian Government, indicative emissions associated with exporting a tonne of paper from Australia to ports in the US and Western Europe are shown in Table 2-2.

Table 2-2 Indicative estimate of GHG emissions for sea freight of paper exports

Country of origin	Indicative freight distance (km)	Indicative grams CO_{2e} per tonne/km	Indicative total CO_{2e} (kg per tonne paper)
US – West Coast	13 000	12.6	164
US – East Coast	18 000	12.6	227
Western Europe	22 000	12.6	277
Averages	~18 000	12.6	223

Source: Indicative freight distances from PortWorld (online portal); and Indicative CO_{2e} estimates based on unit rates published in AGO, 2007.

[18] An OECD case study presents data on emissions includes a rate for waterborne freight of 30 grams of CO_{2e} per tonne-km. Source: OECD, 2011, (The Organisation for Economic Co-operation and Development, Environmental Directorate, Environment Policy Committee), *A Sustainable Materials Management Case Study - Wood Fibres*. ENV/EPOC/WGWPR (2009) 9/Final.

If the average freight distance for exports of Australian paper is assumed to be approximately 18 000 km, the indicative estimate of emissions would be around 220 kg of CO_{2e} per tonne of paper.

On this basis Indufor estimates:

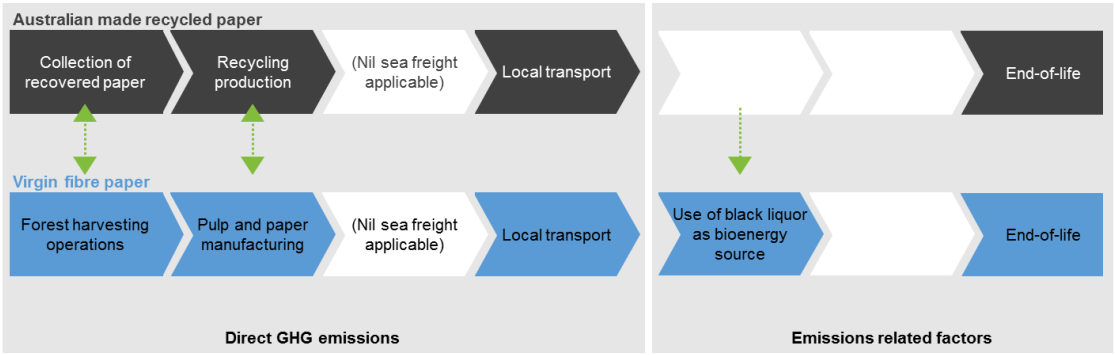
- The emissions associated with sea freight of imports of recycled paper would on average be around 210 kg of CO_{2e} per tonne of paper.
- Adding the sea freight emissions from exports of locally produced recycled paper (as a result of displacement from the market) imported recycled paper may account for up to 430 kg of CO_{2e} per tonne of paper in sea freight emissions.

2.2 Comparing Australian made recycled paper with virgin fibre paper

The relevant supply chain components to compare for GHG emissions associated Australian made recycled paper and virgin fibre paper were identified as:

- The harvesting of wood fibre from natural forests[19] or plantations to produce virgin fibre paper including loading activities; and
- Pulping and paper manufacturing from wood fibre, which differs from the process of recycling recovered paper.

These supply chain components are illustrated below.



2.2.1 Emissions associated with harvesting of virgin wood fibre

An assessment of GHG emissions associated with forest harvesting needs to recognise two distinct aspects of consideration, being:

- The impact of harvesting on the forest carbon balance associated with harvesting regimes over periods of time; and
- Emissions associated with operational harvesting activity including felling, loading and haulage.

Impact of harvesting on the forest carbon balance

The scope of this paper excludes a detailed assessment of the carbon stocks profile associated with alternative forest management regimes in Australia. However, Indufor notes there is extensive research and ongoing debate on the carbon balance associated with harvest and non-harvest regimes in Australia, for natural forests in particular.

Some researchers have argued there is considerable scope for reducing carbon emissions by reducing timber harvesting in natural forests, principally from avoiding the short-term release of CO_2 from mature trees constituting substantial carbon stocks.[20]

Others have argued a contrary view; specifically, that sustainable forest management can maintain or enhance carbon stocks over the long term, particularly if the carbon stored in harvested wood products is recognised.[21]

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[19] Note that 'natural forests' terminology is used in this report, in preference to 'native forests', to clearly delineate these native forests from plantations, which can be established with native species.

[20] See example - Keith, H., D. Lindenmayer, B. Mackey, D. Blair, L. Carter, L. McBurney, S. Okada, and T. Konishi-Nagano. 2014. Managing temperate forests for carbon storage: impacts of logging versus forest protection on carbon stocks. *Ecosphere* 5(6):75. http://dx.doi.org/10.1890/ES14-00051.1.

[21] See example – Ximenes, F.A.; George, B.H.; Cowie, A.; Williams, J.; Kelly, G. 2012. Greenhouse Gas Balance of Native Forests in New South Wales, Australia. *MDPI* - Forests 2012, 3, 653-683.

While noting this range of views, it is clear that landmark intergovernmental agreements recognise that well managed forests represent a renewable resource of timber, wood fibre and other products. The principles of sustainable forest management, as described by the Montreal Process[22], include the maintenance of the productive capacity of forest ecosystems, and the maintenance of forests' contribution to the global carbon cycle.[23] In this context, the growth cycle of natural forests and plantations can support wood fibre production on a sustainable basis, and in broad terms the emissions profile is counter-balanced by carbon sequestration of growth and regrowth over time.

Further to this, the Intergovernmental Panel on Climate Change (IPCC) concluded in 2007 that, "*in the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit*."[24] Therefore, the principal consideration in relation to the management of forest carbon stocks is whether the forests producing wood fibre for paper are 'sustainably managed' or otherwise well managed.

Independent third party certification provides the most compelling basis for an assurance of sustainable forest management. The leading forest management programs globally, notably the Programme for Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC) certification program include specific principles and criteria that relate specifically to maintenance and enhancement of forest resources and their contribution to the global carbon cycle, as well as to practices that support socially beneficial and economically viable forest management.

On this basis, independent third party certification under internationally recognised programs such as the PEFC and FSC are considered to provide a level of assurance that forest carbon stocks are maintained or enhanced over the management period.

On this basis, Indufor concludes:

- The emissions profile for forests managed in accordance with internationally recognised certification programs such as the PEFC or FSC can be considered to be net neutral if not positive over the longer term.

Emissions associated with operational harvesting activity

Identifying and quantifying GHG emissions associated with the harvest operations for paper production can be complex. Most timber harvesting in public natural forests in Australia comprises integrated operations, and similarly, the final harvests for long rotation plantations (mainly softwoods) comprise sawlog and pulplog production. Integrated forest harvesting means harvesting for a range of products, such as sawlogs, poles and pulpwood, in the one operation; and attribution of costs and emissions cannot be easily delineated.

However, on the basis that sustainably managed forests represent a renewable resource of timber and wood fibre, the emissions associated with harvesting operations relate principally to machinery fuel usage during harvest and loading onto transport vehicles.

Average fuel-based emissions from harvest and haulage operations in Australia were estimated as part of a national life-cycle inventory for forestry and wood products in 2009.[25] The inventory was based on three native hardwood case studies and four plantation softwood studies, and it covered all aspects of forest management, burning and harvest, including transport of logs to saw mills. Considering the harvest component only, the study found the average emissions per

[22] The Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests ("Montréal Process") was formed in Geneva in June 1994.
[23] Montreal Process Criteria and Indicators, Third Edition, 2009.
[24] IPCC Fourth Assessment Report: Climate Change 2007. Working Group III.
[25] Tucker, S. N; Tharumarajah, A; May, B; England, J; Paul, K; Hall, M; Mitchell, P; Rouwette, R; Seo, S; and Syme, M, 2009, *Life Cycle Inventory of Australian Forestry and Wood Products.* Project No: PNA008-0708, Forest & Wood Products Australia Limited.

unit log harvested for softwood plantations were around 6 kg CO_{2e} per cubic metre (m^3); while for natural forests, emissions were 14 kg CO_{2e}/m^3. The conversion of green metric tonnes to cubic metres can be assumed to be in the order of 1:1 for key commercial species in Australia. Therefore, the emissions associated with harvesting one green metric tonne of pulpwood in Australia are estimated to be between 6-14 kg of CO_{2e} or in the order of 10 kg of CO_{2e}.

Following harvest operations, pulpwood fibre is transported to a pulp mill and paper manufacturing facility. The life cycle inventory report published in 2009 included estimates of fuel-based emissions from the transport of logs from Australian natural forests or plantations. The report concluded average emissions from haulage of logs to processing facilities were around 9 kg CO_{2e}/m^3 for softwood plantations and 15 kg CO_{2e}/m^3 for natural forests.[26] Therefore, the emissions associated with haulage of one tonne of pulpwood to processing facilities are estimated to be in the order of 12 kg of CO_{2e}.

In total, the average emissions from harvesting and haulage of pulpwood originating from both natural forests and plantations are estimated to be around 22 kg CO_{2e}/m^3. On the basis that around three tonnes of pulpwood fibre is required to produce one tonne of non-recycled paper[27], emissions associated with one tonne of non-recycled paper are in the order of 65-70 kg of CO_{2e}.

On this basis Indufor estimates:

- The GHG emissions associated with harvesting and haulage of pulpwood (virgin wood fibre) to be around 70 kg of CO_{2e} per tonne of non-recycled paper.

2.2.2 Collection of recovered paper

The first component of the supply chain for recycled paper is the collection of recovered paper, which happens either directly from offices or central collection points. The recovered paper is transported from metropolitan areas to recycling plants for processing. It is assumed this transportation within Australia will be primarily by road, and therefore by a combination of trucks. Fuel use is the main driver of emissions from road transport.

The Australian Government's analysis of trends and emissions indicators between 1990 and 2005 indicates the CO_{2e} emissions associated with loading, fuel consumption and emissions, across all road freight vehicles, was in the order of 0.14 kg CO_{2e} per tonne of paper per km.[28] This is broadly consistent with intergovernmental studies in Europe that have provided estimates in the order of 0.08 to 0.16 kg CO_{2e} per tonne-km.[29,30]

For the purpose of this review, with consideration of the location of the Maryvale mill, it is assumed the average cartage distance would be 250 km. On this basis, the indicative emissions associated with collecting and transporting one tonne of recovered paper to the recycling plant would be around 35 kg CO_{2e}.

Australian Paper has reported that it plans to collect approximately 80 000 tonnes of recovered paper of which it can produce around 50 000 tonnes of air dried pulp. Australian Paper has also advised the proportion of air dried pulp in recycled paper is approximately 70%. Therefore, approximately 1.1 tonnes of recovered paper are required to make one tonne of recycled paper.[31]

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[26] Tucker, et. al, ibid.

[27] References include Australian Bluegum Plantations, 2013, *From Tree to Paper*. Online resource; and Finnish Forest Industries, 2013, *How much wood do you need to make paper?* Online resource.

[28] Australian Greenhouse Office 2007, ibid.

[29] EEA, 2015.

[30] OECD, 2011 (The Organisation for Economic Co-operation and Development, Environmental Directorate, Environment Policy Committee), *A Sustainable Materials Management Case Study - Wood Fibres*. ENV/EPOC/WGWPR (2009)9/Final.

[31] Australian Paper has advised that recycled paper products comprise approximately 70% air dried pulp; and on this basis, 50 000 tonnes of pulp makes approximately 71 000 tonnes of recycled paper. Therefore,

On this basis Indufor estimates:

- The GHG emissions associated with the collection of recovered paper, to be in order of 40 kg of CO_{2e} per tonne of recycled paper.

The indicative GHG emissions associated with the harvesting and haulage of virgin wood fibre are therefore higher than the collection of recovered paper.

2.2.3 Pulping and paper manufacturing

The paper recycling processes for Australian made recycled paper will be different to the production processes for manufacturing of paper from virgin fibre material. The analysis presented in this paper is based on the assumption that leading examples of modern pulping, paper manufacturing and paper recycling will have generally similar levels of energy use and associated emissions on a per unit production basis.

Emissions from manufacturing virgin fibre based paper

Paper production from virgin wood fibre comprises two distinct processes – pulping and papermaking.

In relation to the *pulping process*, the energy use, GHG emissions and water use depends on a number of complex factors. An OCED case study in 2011 noted these factors include:[32]

- *The nature of the pulping process:* There are large differences in both the amount and the mix of energy consumed from chemical, mechanical and paper pulping;
- *The type of paper produced:* Energy use, CO_{2e} emissions and water use will depend upon factors that include: whether pulp is bleached or non-bleached; paper characteristics such as strength, freeness, brightness and texture; and the processes involved in papermaking, such as sizing, coating, calendering and drying;
- *Plant-specific characteristics:* Facility parameters that can have an effect are numerous and include the age of the equipment used in the facility, the operating point of the facility and how equipment is operated and maintained; and
- *Regional factors;* The location of the plant can influence the mix of fuels used to produce the electricity supply to the plant and market dynamics including the distances to markets for paper, which can impact on opportunities for integrating pulp and paper mills.

The pulping processes that consume the largest share of energy in chemical pulping generally comprise wood preparation, cooking, evaporation, chemical preparation, bleaching and oxygen delignification, as well as pulp drying for transport if the pulp mill is not integrated with a papermaking facility.[33] Published data on European pulp mills indicate that energy use in non-integrated mills can be in the order of 50% higher than integrated mills;[34] therefore, non-integrated mills can be expected to have significantly higher energy use and GHG emissions than modern integrated mills.

In relation to *papermaking*, the processes that consume the most energy are stock preparation and drying. Stock preparation includes refining the pulp to improve its strength and suitability for papermaking. In the drying stage, the paper sheets are typically passed under a set of heaters to remove most of the water. Office copy paper also involve other optional processes such as sizing, coating, or calendering, which are used to improve paper characteristics such as surface strength and smoothness.

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the conversion from 80 000 tonnes of recovered paper to 71 000 tonnes of recycled paper indicates 1.1 tonnes of recovered paper is required to make one tonne of recycled paper.

[32] OECD, ibid.

[33] OECD, ibid.

[34] OECD, ibid.

The OECD case study in 2011 presented summary data on GHG emission estimates for paper manufacturing, including harvesting, pulping and papermaking. Excluding the emissions associated with harvesting activity (already addressed above), the summary data showed that emissions for paper manufacturing (i.e. pulping and papermaking) from virgin fibre ranged from around 700 kg of CO_{2e} per tonne of paper for coated graphic paper (without recovered paper de-inking) up to around 1 tonne of CO_{2e} per tonne of paper for unbleached paper from kraft pulping processes.[35]

These estimates were derived from older studies (circa 1998), and there has been substantial technological and systems advances since then. The OECD also noted the average level of GHG emissions from Swedish pulp and paper operations between 2001 and 2008 was considerably lower – between 100-200 kg of CO_{2e} per tonne of paper; although this data did not distinguish between virgin fibre and recovered paper pulps. Further to this, the pulp and paper industry in Sweden utilises a large proportion of renewable energy, which may be factored into the average level of GHG emissions.

Indufor notes that Australian Paper is using a kraft pulping process at the Maryvale mill, and also observes the advances in technological improvement over the past 15 years, which in broad terms would have reduced GHG emissions on a per unit basis. Therefore, the GHG emission rate for paper manufacturing from virgin fibre would now be lower.

On this basis Indufor estimates:

- The total GHG emissions for paper manufacturing (comprising pulping and paper making) are in the order of 600 kg of CO_{2e} per tonne of virgin fibre (non-recycled) paper without a bioenergy emissions reduction component.

The role of bioenergy

GHG emissions associated with pulp and paper production are closely tied to energy use[36]. In this context, the scope to use bioenergy, which is "essentially renewable and carbon neutral"[37], can significantly reduce emissions associated with production.

Kraft pulping processes, which the Maryvale mill uses, generate black liquor[38] from the removal of lignin from virgin wood fibre. Black liquor can be used as a biofuel feedstock to provide a valuable form of onsite bioenergy.

Australian Paper has advised the use of black liquor at Maryvale accounts for indicatively 50% of its energy requirements for onsite production processes;[39] thus constituting a significant reduction in reliance on fossil fuel-based energy and potentially a significant reduction in net GHG emissions. Therefore, the impact of using black liquor for energy needs at the mill should be recognised in the GHG emissions associated with producing virgin fibre based paper in particular, as it arises from the delignification of virgin wood fibre.

Indufor estimates the total external energy requirements could be reduced by 30-50% by using black liquor. Therefore, taking into consideration the usage of bioenergy in the production process, emissions are estimated to be around 300-400 kg of CO_{2e} per tonne of paper.

[35] OECD, ibid.
[36] OECD, ibid, p35.
[37] Stucley, C., Schuck, S., Sims, R., Bland, J., Marino, B., Borowitzka, M., Abadi, A., Bartle, J., Giles, R. and Thomas, Q, 2012, *Bioenergy in Australia: Status and Opportunities*. Report for Bioenergy Australia.
[38] Black liquor is the waste product from the kraft process when digesting pulpwood into paper pulp, removing lignin, hemicelluloses and other extractives from the wood to free the cellulose fibres.
[39] Australian Paper, pers. comm., February 2015.

On this basis Indufor estimates:

- The GHG emissions rate for paper manufacturing from virgin fibre is estimated to be in the order of 350 kg of CO_{2e} per tonne of paper taking into consideration usage of bioenergy in the production.

Emissions from recycled paper production

The new recycling plant at Maryvale mill is expected to incorporate best available technologies[40] and systems to optimise energy and transport efficiencies. The technologies for recycled paper production continue to evolve, and the emissions associated with the recycling process will vary with the specific configuration of the production process, the nature of the recovered paper and other factors.

As an indicative guide, the OECD case study referred to above presented a range of summary data (from circa 1998) on GHG emissions associated with the manufacturing of different paper types from recovered fibre. These estimates ranged around 600 kg of CO_{2e} per tonne of recycled paper, based on studies for uncoated graphic paper (with recovered paper de-inking), and similar reported levels for unbleached paper from kraft pulping processes.[41]

Acknowledging the advances in technological improvement over the past 15 years (since 1998), it is assumed the emissions associated with recycling production process would now be lower; indicatively, between 300-400 kg CO_{2e} per tonne of recycled paper.

On this basis Indufor estimates:

- The GHG emissions associated with the paper recycling processes for recovered paper to be in order of 350 kg of CO_{2e} per tonne of paper.

This is broadly the same level of emissions as expected from the production of virgin fibre based paper, noting the assumption that there is an emission reduction benefit attributable to virgin fibre paper production for use of black liquor as bioenergy.

[40] OECD, 2011, ibid.
[41] OECD, ibid.

3. CONCLUSIONS

The use of recovered paper as a raw material has become increasingly important to the paper industry globally over the past two decades. In Australia, the amount of recovered paper as a proportion of total paper consumed and disposed has increased significantly. As a result, Australia can now be considered one of the leading countries on paper recycling rates.

Australian Paper's investment in domestic production of recycled paper products can be considered to be contributing to this global trend.

This report has provided a comparison of the supply chain GHG emissions of locally made recycled paper with two alternative supply chains, being:

(i) imported recycled paper products; and

(ii) Australian made virgin fibre paper products.

3.1 Comparing locally made recycled paper with imported paper

The high level comparison of key differences in GHG emissions associated with Australian made recycled paper and imported recycled paper is set out in Table 3-1.

Table 3-1 Comparing GHG emissions of Australian made recycled paper with imported recycled paper

	Indicative GHG emissions from Australian made recycled paper *(kg CO_{2e} / tonne of paper)*	**Indicative GHG emissions from imported recycled papers** *(kg CO_{2e} / tonne of paper)*
Sea freight – imported paper	0	210
Sea freight – displaced paper export*	0	220
Landfill emissions associated with reduced demand for local recycled paper**	0	440
Total GHG emissions differential	**0**	**870**

Notes: * Assumption that imports displace local product ** Based on 2012 recycling rate estimate for landfill disposal

The key points of difference in these supply chains relate mainly to:

- attribution of sea freight emissions associated with imports of recycled paper, as well as exports of locally made paper displaced by imports; and
- attribution of landfill emissions to that proportion of non-recovered paper that may be disposed to landfill if not recycled in Australia. These emissions are estimated to be up to 440 kg of CO_{2e} per tonne of imported paper, considering around 16% of all paper is disposed of in landfill in Australia.

This comparison shows GHG emissions associated with the supply chain of locally made recycled paper can be significantly lower than those associated with imported paper. The potential total differential is in the order of 870 kg of CO_{2e} per tonne of paper.

3.2 Comparing locally made recycled paper with virgin fibre paper

A high level comparison of the differences in GHG emissions associated with Australian made recycled paper and virgin fibre based paper is set out in Table 3-2. The overall energy use and GHG emissions associated with virgin fibre based paper products tends to be higher than Australian made recycled paper products. However, this review has assumed the black liquor generated by the production of virgin fibre based paper can be used as a bioenergy feedstock, which serves to reduce the use of fossil fuel based energy and associated GHG emissions.

On this basis, the net GHG emissions from virgin fibre paper products were found to be broadly similar to the emissions associated with Australian made recycled paper.

Table 3-2 Comparing GHG emissions from production of Australian recycled paper with virgin fibre paper

	Indicative GHG emissions from Australian made recycled paper *(kg CO_{2e} / tonne of paper)*	**Indicative GHG emissions from Australian made virgin fibre paper** *(kg CO_{2e} / tonne of paper)*
Production of raw fibre materials	Assumed net neutral	Assumed nil
Collection of materials	40	70
Pulping and paper manufacturing – including emission reduction benefit from use of black liquor for bioenergy*	350	350*
Total GHG emissions differential	**390**	**420**

Notes: * Assumption that emission reduction benefits from the use of black liquor apply only to virgin fibre paper.

3.3 Summary of key findings

In summary, the key findings from this review are:

1. Australia can be considered one of the leading countries globally on paper recycling rates, ranking alongside a number of European countries and Japan.
2. The GHG emissions associated with the production and use of locally-made recycled paper can be significantly lower than those associated with importing paper products into Australia, when sea freight and product displacement factors are taken into account.
3. The net GHG emissions associated with the production and use of locally-made recycled paper and virgin-fibre paper products in Australia are considered to be broadly similar, when the use of black liquor for bioenergy is taken into account.

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