

FINAL REPORT

Costs and benefits of banning exports of waste



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Executive summary

The Council of Australia Governments' (COAG) announcement on 9 August 2019 stated two key related objectives: implementing a ban on waste plastic, paper, glass and tyre exports; and building Australia's capacity to generate high value recycled commodities. COAG's agreement reflects increasing concern in Australia and around the world about plastic pollution of our oceans and the need to ensure that exports of waste do not cause harm to human health and the environment.

This study evaluates the costs and benefits of four alternative options for implementing a waste export ban. It also considers the risks and initial risk mitigation activities that could be considered. The study scope does not consider other options for achieving the objectives outside of the waste export ban options.

The modelling in this report assesses four alternative scenarios, relative to the base case.

- The base case includes the existing domestic policy settings such as existing national/state targets, as well the assumptions regarding the overseas policy settings. It does not include the introduction of export bans. A number of variations to the base case are modelled with different material volumes and values.
- Scenario 1 introduces the export ban as defined by COAG's announcement (in terms of the coverage of the material and timing of the bans).
- Scenario 2 is a variant on Scenario 1, with an exemption for clean paper and cardboard. Clean paper and cardboard is currently not well defined. For the modelling we have assumed that any commercial and industrial (C&I) and construction and demolition (C&D) paper and cardboard will be clean and any municipal will not be clean.
- Scenario 3 is a variant on Scenario 1, with an exemption for whole tyres for retreading.
- Scenario 4 is a variant on Scenario 1, with an exemption for whole tyres for retreading and for clean paper and cardboard.

For the presentation of results, we show the costs and benefits under 'central case' assumptions. These assumptions are based on our view of the most likely values for key assumptions, such as the amount exported in the base case, prices for commodities and costs. However, there are a wide range of risks around these. To highlight these we have conducted sensitivity analysis of how the costs and benefits differ if the assumptions differ.

For each material and material stream, we have developed a view of the next best option if export markets are not available. These assumptions are shown in table 1. For mixed paper from municipal sources (MSW) we have assumed this is processed into a pulp, which would then be exported. For commercial paper and cardboard, this would be used to produce recovered paper liner and corrugating medium, which would then be exported. For plastics, material would be sorted into individual polymer types (if it is not already) and then pelletised. This may then be exported or used domestically. For tyres, we assume this is shredded and then exported.

The assumptions about where material goes for the next best option are based on the costs and revenues expected for different options, and knowledge of the markets available and industry interest in different options. If private market participants do not react in this way, particularly in respect of the risks related to these options, then costs and benefits will be different.

	MSW	C&I and C&D
Paper	Used to produce recovered paper pulp, which is then exported	Used to produce recovered paper liner and corrugating medium, which is then exported
Plastics	Used to produce single resin pellets, which are then used domestically or exported	Used to produce single resin pellets or film, which are then used domestically or exported
Tyres	Shredded and then exported	Shredded and then exported
Glass	Used to produce construction aggregate (sand), used domestically	Used to produce construction aggregate (sand), used domestically

1 Assumed next best option for each material and stream

Source: The CIE.

Material volumes impacted by the export ban

The modelled impact of the different export ban options evaluated in this study are shown in table 2, for 2019. There is uncertainty about the amount of material subject to an export ban, depending on the specific definitions used for scenarios and different data about current material flows. This is particularly the case for tyres. For this modelling, we have used analysis by Blue Environment indicating about 60 000 tonnes of whole tyre exports per year. The Tyre Stewardship Association estimates about twice this amount are exported whole.¹ Note that while there have recently been a small amount of exports of glass, we have assumed that this does not continue for our central case assumptions.

There may be some plastics within these volumes that could be exempt. This will depend on more detailed definitions than available at the time of the study.

¹ Tyre Stewardship Australia,2018-19 Australian Tyre consumption & recovery.

Item	Scenario 1 (full export ban)	Scenario 2 (exempt clean paper)	Scenario 3 (exempt whole tyres for retreading)	Scenario 4 (exemption for tyres for retreading and clean paper)
Paper				
Volume (kT)	1 118	436	1 118	436
Value (\$m)	235	22	235	22
Plastic				
Volume (kT)	187	187	187	187
Value (\$m)	43	43	43	43
Tyres				
Volume (kT)	61	61	53	53
Value (\$m)	12	12	3	3
Glass				
Volume (kT)	0	0	0	0
Value (\$m)	0	0	0	0
Total				
Volume (kT)	1 367	685	1 358	677
Value (\$m)	291	77	282	68

2 Material volume and value impacted by the export ban

Source: The CIE, based on analysis of export data and key inputs from Blue Environment.

Costs and benefits of the options

The overall net benefits of the scenarios are shown in table 3.

- A full export ban (Scenario 1) would impose a net cost of \$902 million in present value terms.
- Exempting clean paper and cardboard reduces the net cost to \$48 million in present value terms (Scenario 2).
- Exempting whole tyres for retreading reduces the net cost to \$826 million in present value terms (Scenario 3).
- Exempting both clean paper and whole tyres for retreading leads to a net benefit of \$28 million (Scenario 4). Note that the risks to this are largely downside, if additional capacity is not in place for domestic processing rapidly or costs are higher than expected.

The costs and benefits presented in this report do not consider the impact of supporting measures that may be taken by governments (i.e. industry support for new infrastructure or government procurement polices). Some of these supporting measures would redistribute the costs and benefits, while others could change the costs and benefits. Many government actions would likely be focused on reducing the risk of particular

negative scenarios that could occur, such as those considered in the sensitivity analysis undertaken in this report.

3 Summary of cost benefit analysis results

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Excludes clean paper	Excludes tyres for retread	Excludes clean paper and tyres for retread
Net benefit (\$m, present value)	-902	-48	-826	28
Change in problem exports (tonnes, present value)	-90 614	-73 046	-89 279	-71 711
Net cost per tonne	9 949	656	9 251	- 387

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent.

Source: The CIE.

In the absence of a damage cost curve for mismanaged plastic waste incorporating direct and indirect damage costs, a cost effectiveness measure is considered to assess the benefits of the proposed policy interventions. The measure used is the cost to the Australian community per tonne of avoided mismanaged material. Mismanaged material is approximated by material entering the marine environment. This applies a rate of 7 per cent of material that is residual to a recycling process entering the marine environment. This is applied to plastics and the residual material from paper recycling, which will largely consist of plastic contamination. There is enormous uncertainty about these rates and how these rates differ by waste type, country and even region within a country, as there is currently little information on what actually happens to residual material from waste sent overseas, or from Australia. For tyres, the tonnes mismanaged is measured as tonnes used in open burning.

The estimated change in problem exports — i.e. plastics in paper and plastic exports that end up in the marine environment and tyres burnt in open burning — would be a reduction of 90 614 tonnes of material. This means the net cost per tonne avoided is \sim \$10 000.

The Ocean Conservancy (2015) examined 33 potential solutions to the problem of plastic waste leaking into the ocean and identified five options that achieved maximum impact. The five options focusing on collection, mitigation and conversion options: The average expected cost of the five options selected was \$550 per tonne of plastic-waste leakage prevented. This is based on total annualised cost between \$4.9 billion and \$5.4 billion achieving a reduction in plastic waste leakage of 65 per cent.

This suggests that the cost effectiveness of a complete export ban is likely to be substantially higher than for other options to reduce waste. A ban with an exemption for both cleaner material (paper) and whole tyres for retreading has no cost per tonne (as this has a net benefit).

Costs and benefits across materials

The costs and benefits of the scenarios across the different materials subject to a ban is shown in table 4.

- The largest net costs are from paper. Only applying the paper ban to MSW material substantially limits these costs – assuming that paper processing sets up and material is not landfilled beyond one year.
- Plastics has an estimated net benefit. The commercial proposition for plastic processing is relatively close currently, also evidenced by the flurry of investment in new sorting machinery and new processing facilities. This finding is highly sensitive to costs. Using cost estimates from EnvisageWorks (Appendix B) or a 20 per cent higher cost, this would be a net cost rather than a net benefit.
- Tyres has an estimated net cost under all scenarios, although a much lower net cost if whole tyres for retreading are exempted. This result is due to higher processing costs associated with shredding tyres compared to baling tyres and a lower value from the material produced. Also, the value for retreaded tyres is significantly higher than shredded tyres; in scenarios 1 and 2 tyres exported for retreading or reuse are assumed to be shredded leading to higher processing cost and a large reduction in value.

Scenario	Paper	Plastic	Tyres	Total
	\$m, PV	\$m, PV	\$m, PV	\$m, PV
Scenario 1	- 835	71	- 138	- 902
Scenario 2	19	71	- 138	- 48
Scenario 3	- 835	71	- 62	- 826
Scenario 4	19	71	- 62	28

4 Net benefits of alternative assumptions across commodities

Source: The CIE.

Costs and benefits across jurisdictions

The net benefits per person across the jurisdictions is shown in table 5. Note these are the present value welfare impacts rather than an impact per year. The largest per capita impacts are in states that are currently more export dependent and that would send material to other states (mainly for paper) in the event of an export ban, because of scale.

- Western Australia has the highest net costs per person, at \$119 per person for the full ban. Note that this is not an annual cost, but an equivalent once-off cost.
- Victoria and South Australia also have substantial negative impacts.
- NSW has smaller per person impacts because it is less export reliant than other states.

Impacts for some states are less reliable than others, such as Tasmania and potentially South Australia, because it is not possible to identify exports that originate in one state but are exported through a port in another state. This will tend to overstate the costs to Victoria and understate the costs to Tasmania and South Australia.

Scenario	NSW/ACT	VIC	QLD	SA	WA	TAS	NT
	\$/person						
Scenario 1	-10	-52	-11	-51	-119	-8	-28
Scenario 2	2	5	7	-10	-44	0	-13
Scenario 3	-7	-48	-10	-48	-116	-8	-28
Scenario 4	5	9	9	-7	-41	0	-13

5 Net benefits across jurisdictions (all scenarios)

Source: The CIE.

Distribution of costs and benefits

The net costs of a waste export ban will be distributed across households, businesses and government. The way that these costs are distributed will reflect the market structure and level of competition. The expected distribution of costs and benefits, for financial impacts, is shown in table 6. Households and businesses, as generators of waste, will face costs, as their recycling services become more expensive to reflect the lower price of recycled materials. For MSW waste, this would be reflected in higher waste charges from local councils. The recycling industry — meaning the processors of material rather than collectors and sorters — face large net financial gains. This is because they will have lower prices for their input materials. State governments receive a benefit in the form of additional landfill levies — this is also a part of the higher cost for households and businesses.

	Paper	Plastics	Tyres	Glass	Total
	\$m, pv	\$m, pv	\$m, pv	\$m, pv	\$m, pv
Households as waste generators	-2 451	- 157	- 151	0	-2 759
Businesses as waste generators	-5 158	0	- 168	0	-5 325
Recycling industry	6 681	197	174	0	7 053
Government (state)	147	35	7	0	189
Total	- 781	75	- 137	0	- 843

6 Distribution of financial impacts, central case Scenario 1

Source: The CIE.

The above estimates are based on all sectors being competitive in terms of purchase of materials, except for MSW paper. The impacts for paper with and without competition are shown in table 7. If there was competition to purchase MSW paper, the impacts would be substantially smaller, at ~\$14 per person (once-off) compared to almost \$100 otherwise. The impacts without competition are based on paper purchase charging the landfill gate fee less \$50 to take mixed paper. This may be somewhat low, if paper purchasers are considering the overall viability of the recycling system — at this level councils would financially be better off not having separate kerbside collections. However, financial impacts are only one aspect of councils' recycling decisions.

For C&I and C&D paper, the costs if markets are uncompetitive would be even larger. There are several purchasers of C&I paper currently. However, there may be less competition in some jurisdictions than in others.

	NSW	VIC	QLD	SA	WA	TAS	NT	Total
	\$/person							
MSW								
Uncompetitive	-102	-85	-90	-132	-106	-52	-2	-96
Competitive	-18	14	17	-48	-106	-2	-2	-14
C&I and C&D								
Uncompetitive	-219	-805	-290	-406	-184	-926	-2	-408
Competitive	-106	-369	-125	-241	-171	-600	-2	-203

7 Impacts on paper with and without competitive markets to purchase material

Source: The CIE.

Sensitivity analysis

There are a wide range of uncertainties that could impact on the results of the cost benefit analysis, ranging from costs being different to expected, differences in what happens to exports in the base case and timing for facilities to be operational. The net benefits under different assumptions are shown in table 8 for Scenario 1, and further explained below.

- Using central case assumptions, there is a net cost of \$902 million.
- If processing facilities do not set up, the net costs are substantially higher at \$3 297 million, as excess material is landfilled. This risk is particularly important for paper, where a range of complicated market and competition dynamics are at play. This assessment of the net cost assumes that there are no upstream changes to stop collecting materials given that they are landfilled — reducing collection costs would mitigate the cost, and be a sensible response if material was being landfilled anyway.
- Under the central case assumptions, exports were assumed to remain at 2018/19 levels. If exports grow in line with expected volumes of recycling, then the export ban would impose a larger net cost. If exports decline over the next ten years, such as reflecting other policies to increase domestic demand, then the net cost would be lower, at \$334 million.
- Under the central case assumptions, tyre and paper facilities would not be fully operational at the time of the policy being implemented, and there would be a year of landfilling. If facilities were operational, then the net costs are substantially lower at \$643 million, mainly from paper not being landfilled.
- If facilities took substantially longer to become operational than allowed for, then the net costs would be much larger, at \$1 727 million. This allows for paper facilities to be operational in six years and other material processing to be operational in four years. By far the largest risk is for paper in this regard, as plastic and tyre processing facilities

can be put together fairly simply, while paper facilities will require large sites and much more extensive environmental approvals.

- If costs are higher than expected by 20 per cent then this substantially increases the net costs, and vice versa. Higher costs would make plastic a net cost rather than a net benefit. A higher cost for plastic processing is consistent with other estimates, such as those of EnvisageWorks cited in Appendix B.
- A higher discount rate applied would increase the net cost, and a lower discount rate would reduce the net cost.
- If export prices fell to zero, then an export ban would have a net benefit. In this scenario, no value is being given up by not exporting any more. This could be representative of a dramatic decline in export markets without any domestic response.
- If higher tyre volume estimates are used, consistent with information reported by Tyre Stewardship Australia then the net cost for tyres increases from \$138 million to \$289 million.
- If the MSW paper is of lower quality than the central case, requiring 1.8 tonnes of input to achieve 1 tonne of output (instead of 1.5 in the central case), then the net cost for paper increases by \$186 million.
- Under the central case, we assume that glass exports do not continue, as CDS glass supplants kerbside glass once contracts end. If glass exports continue at a level of 30 000 tonnes per year, there would be a net cost of \$40 million.

	Paper	Plastic	Tyres	Total
	\$m, PV	\$m, PV	\$m, PV	\$m, PV
Central case assumptions	- 835	71	- 138	- 902
Material landfilled	-2 653	- 501	- 143	-3 297
Exports grow with recycling	- 996	98	- 647	-1 545
Exports decline over 10 years to zero	- 308	7	- 33	- 334
Facilities operational by the time of the ban	- 576	71	- 137	- 643
Facilities take twice time to set up	-1 502	- 85	- 139	-1 727
Costs 20 per cent higher than expected	-1 254	- 69	- 148	-1 471
Costs 20 per cent lower than expected	- 416	211	- 128	- 332
Discount rate of 10 per cent	- 881	- 1	- 106	- 988
Discount rate of 3 per cent	- 632	244	- 206	- 594
Base case export price falls to \$0	916	395	- 39	1 272
Higher tyre estimates	- 835	71	- 289	-1 053
Lower quality MSW paper	-1 021	71	- 138	-1 087
Glass exports continue				- 40 (glass only)

8 Net benefits of alternative assumptions (full export ban, Scenario 1)

Source: The CIE.

The above sensitivities highlight the key risks and ones that can be managed. In particular, an export ban will be more costly if additional paper processing facilities are not in place, as timing for these facilities can be long and uncertain, and there is not sufficient domestic capacity currently.

Costs of landfilling due to sudden and unpredictable changes in exports

For the purpose of estimating costs and benefits, under the central case assumptions we have assumed no further change in openness of export markets.²

However, this may not be the case. If export market conditions continue to change unpredictably and suddenly, then there are:

- costs of landfilling that would occur due to a sudden and unpredicted closure of export markets, and
- costs of renegotiating waste-related contracts, potentially multiple times if countries change their policies at different times and councils and recyclers do not arrive at more flexible contract arrangements.

A benefit of the export ban is that, by creating certainty about export markets, it would avoid such costs. We cannot quantify the probability of further export market restrictions and therefore cannot quantify these benefits for the CBA. Nonetheless, we can measure the magnitude of impacts from a sudden export market closure relative to a more certain timed closure as per the Australian export ban.

To model the costs of an unpredictable export closure situation we compare the costs and benefits of a sudden unannounced export ban in 2022, to a staged pre-announced ban as per Scenario 1.

- The unannounced ban would have net costs of \$1267 million in present value terms. The higher costs represent landfilling of material for 3 years for paper and two years for tyres and plastic, while facilities became operational to process material domestically.
- This is \$366 million higher than a structured ban, as per scenario 1. It would be even higher if the Australian Government's ban had longer timelines for implementation.

9 Impacts of an uncertain export shock versus proposed export ban

	Paper	Plastics	Tyres	Total
	\$m, pv	\$m, pv	\$m, pv	\$m, pv
Net benefit of export ban in 2022, no notice	-1 170	- 34	- 63	-1 267
Net benefit of proposed export ban	- 835	71	- 138	- 902
Net benefit of own ban relative to sudden ban	335	105	- 75	366

Source: The CIE.

² Note that under the base case we assume market prices (e.g. for sorted PET recyclates) remain at their current levels. These current levels do account for uncertainty about additional import restrictions or more stringent enforcement of restrictions by foreign governments.

Risks arising from a waste export ban

Table 10 reports risk ratings for the paper and cardboard, plastic and tyres sectors. Risks are scored as low, moderate or high. Green cells indicate a score is good/positive (i.e. low risk), red cells indicate a score is bad/negative, and yellow cells are in between. We have also considered whether risks are short run or long run risks in accordance with the timing of their impact.

We view paper and cardboard involving the greatest risks, primarily relating to the low commercial feasibility of domestic processing of this material, large scale required and lack of competition. Given high quality material is currently going to landfills, the additional material due to an export ban would also be at risk of going to landfill for some period of time.

Plastic, in particular PET and HDPE, are more likely to be commercially feasible to recycle which significantly reduces the downstream risks around material ending up in landfill or being stockpiled in the long run. However, under the central case for the costbenefit analysis polymer types 3-7 are landfilled because of insufficiently developed or no end-markets. This poses a risk to achievement of government policy objectives such as increasing recovery rates.

For tyres there is a high likelihood that more material will be stockpiled (or landfilled) as a result of an export ban.

Risks	Long run or Short run risk	Paper and cardboard	Plastic	Tyres
Commercial market consideration				
Lack of commercial feasibility currently (net benefit per tonne processed rather than exported, \$/t)	LR	-111	29	-287
Lack of commercial feasibility relative to landfill or stockpiling (net benefit per tonne processed versus landfilled, \$/t)	LR	+267	+449	+93
Commercial risks for operators	LR	High	Moderate	Moderate
Time to establish facility (years)	SR	2 - 6	1 - 3	1 - 7
Lack of competition	LR	High	Moderate	High
Amount of capital for a facility (\$million)		150	<20	Unknown
Market capacity and contracts				
Lack of capacity in existing facilities	SR	High	High	Not known
Rigidities in existing contracts	SR	High	Moderate	Low
Outcomes				
Increased material going to landfill	SR and LR	High	Moderate	Low

10 Risk ratings by material

Risks	Long run or Short run risk	Paper and cardboard	Plastic	Tyres
Increased material going to stockpiles	SR and LR	Moderate	Moderate	High
Downstream impacts				
Public confidence in recycling	LR	High	Moderate	Na
Increase in contamination of kerbside recycling	LR	Moderate	Low	Na
Challenge to viability of kerbside recycling	LR	High	Moderate	Na
Overall risk		High	Moderate	Moderate

Source: The CIE.

Risk mitigations

The types of risk mitigations that will be most important for further consideration include:

- Longer timeframes for implementation of the export ban than currently allowed, particularly for paper. This should have a long period to when a clearly defined policy comes into force. The net costs are highly sensitive to new facilities having time to be operational, because the costs of landfilling are high relative to the costs of new facilities for paper and plastic.
- The definitions and exemptions applied. Both the exemptions assessed in this report reduce the net cost of the export ban, and will not have much impact on the extent to which the ban meets its objectives. A more nuanced approach to exemptions based around accreditation of exporters could further reduce costs, while ensuring Australia is not contributing to problems from poor waste management in overseas countries.
- Government intervention to contract for capacity, in essence underwriting the market. For example, contracting for a new paper processing facility, where the Government pays a particular level of subsidy towards capital costs, or on an ongoing basis. This could be particularly necessary for paper, where commercial risks are high and commercial viability is lower. For processing of some plastics such as HDPE and PET, this would not likely be necessary, but to process lower value plastics this may be required. This type of intervention may also be used to ensure there is competition in the market for purchase of recycled materials, particularly paper.
- Information provision to reduce costs of renegotiations across councils and recyclers. There is a lack of information available and low levels of trust, which can mean that contract negotiations are protracted and expensive. Given that there are a total of 562 local government areas in Australia, based on estimates from negotiations following China National Sword, each significant change in export market conditions that warrants a renegotiation could cost between \$28-56 million. Providing guidance on how much contracts should vary by in response to the export ban could reduce these costs.

 Ensuring that materials that cannot be recycled are landfilled rather than stockpiled. Stockpiling will have substantially poorer outcomes than landfilling.

Caveats

This report has been prepared over a four-week period and relies on the data available at the time and the experience of the team. Areas of uncertainty have sought to be addressed within the sensitivity analysis undertaken. Key areas include:

- data on the current and future level of export volumes and values. This study uses data from 2018/19 as the most recent financial year. Export volumes and values fluctuate over time for the different materials and from each jurisdiction
- the level of current tyre exports that would be subject to a ban there are very different estimates for tyre exports, and sensitivity has been conducted on this
- the extent to which private market participants will accept the risks for developing additional market capacity, which will determine if additional processing capacity is or is not developed, or whether there are other solutions found by businesses
- variation in costs depending on sites already available, ability to minimise logistics costs between facilities, commercial negotiations around equipment prices and efficiency of operation of facilities
- timing for approvals and construction of facilities.

Acknowledgements

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Glossary

Abbreviation	Meaning
MSW	Municipal solid waste. This refers to waste that comes from households.
C&I	Commercial and industrial. This refers to waste that comes from businesses, outside of construction and demolition.
C&D	Construction and demolition. This refers to waste that comes from the construction and demolition sector.
MRF	Material recovery facility. This is a facility that takes a mixed stream of waste and sorts it into different commodities. Sorting can be done at different levels.
СВА	Cost benefit analysis
TSA	Tyre Stewardship Australia

1 Introduction

Australia's waste exports

The Australian recycling system, and particularly the kerbside system, has been facing significant issues due to a lack of demand for what it produces.

- Plastic and paper from kerbside recycling have faced reduced demand because of restrictions on imported waste material under China's National Sword policy. A substantial share of recycled plastic and paper material is sent to overseas markets. China and Hong Kong were the major destinations for this material. China National Sword led to a significant decrease in the amount of material sent to China, due to changes in the quality specifications for materials which Australian MRFs could not achieve. In large part, the result was a shift to other destinations in South East Asia. Some of these destinations have also set conditions for import of waste materials.
- Glass from kerbside recycling is struggling to find buyers. Glass is nearly all sold domestically (rather than exported). The main markets are for use in glass bottle manufacturing by Owens-Illinois and Orora, as well as for use as a construction material in glass sand, often blended with quarried materials by groups such as Alex Fraser in Melbourne and formerly Benedict's in Sydney. A reduction in market pull and demand from established end markets has meant that some glass is being stockpiled or landfilled.
- Rising vehicle registrations and the subsequent increase in new tyre sales is underpinning the forecast increase in End of Life Tyre (EOLT) generation, estimated to exceed 506 000 tonnes by 2024-25. Historically, domestic recycling of EOLTs has been limited due to a lack of markets for tyre-derived products and strong international demand for tyre-derived fuel (TDF). REC et. al., 2017 estimate that 63 per cent of end-of-life tyres end up in landfill and 27 per cent are exported to serve as a cheap fuel alternative.³ The use of tyres in higher market applications is constrained by high competition from lower cost readily available substitutes and immature demand.

In total, of the 9.3 million tonnes of annual paper & cardboard, plastic, glass and tyre waste material generated, 5.2 million tonnes (56 per cent) ends up in landfill and a further 1.8 million tonnes (19 per cent) is exported (chart 1.1). The potential closure of export markets will, therefore, require dramatic increases in processing to create value-added materials and/or use of recycled materials within Australia to sustain existing recovery rates.

³ REC, et. al., 2017, National market development strategy for used tyres 2017-2022, p. ivvv, Melbourne: Report prepared by Randell Environmental Consulting, Reincarnate and Envisage Works on behalf of Sustainability Victoria



1.1 Annual waste material flows

Data sources: APCO 2019, Australian Packaging Consumption and Resource Recovery Data; Envisage Works 2019, Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy, October; Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report; ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports; IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, Geelong West, October 2019.

Not all of the exports are subject to a waste export ban.

Problems being addressed by government intervention

The Council of Australia Governments' (COAG) announcement on 9 August 2019 stated two key related objectives: implementing a ban on waste plastic, paper, glass and tyre exports; and building Australia's capacity to generate high value recycled commodities. COAG's agreement reflects increasing concern in Australia and around the world about plastic pollution of our oceans and the need to ensure that exports of waste do not cause harm to human health and the environment.

The consultation RIS indicates that the objectives are to:

- achieve better protection of the environment and human health through improved management of Australia's waste plastic, paper, glass and tyres
- ensure Australia actively manages the risk of countries imposing waste import restrictions so Australia's waste and recycling sector is well placed to manage any future disruption or closure of global waste markets without resulting in adverse environmental or human health impacts.

This project

This study evaluates the costs and benefits of different scenarios for implementing a waste export ban. It also considers the risks and initial risk mitigation activities that could be considered.

2 Cost benefit analysis

Key steps in undertaking cost benefit analysis

This study involves evaluating the costs, benefits and risks of a range of alternative policy options related to Australia's waste exports. In undertaking the CBA, we have used a structured approach based on the key steps in set out in box 2.1.

2.1 Key steps in a CBA

- Articulating the decision that the CBA is seeking to evaluate. For this analysis the CBA evaluates the various project options provided by the Department and determines which option is likely to result in the highest net benefit to society.
- Establishing the base case against which to assess the potential economic impacts of changes. The base case represents the amount of waste generated and recycled, as well as where this would be destinated under existing government policies.
- Quantifying the changes from the base case resulting from the possible scenarios being considered. This focuses on the incremental changes resulting from the decision, such as changes in the destination of material and prices paid for material.
- Placing values on the changes and aggregating these values in a consistent manner to assess the outcomes.
- Generating the Net Present Value (NPV) of the future net benefits stream, using an appropriate discount rate, and deciding on the Decision Rule on which to assess the different options. The best decision rule is to choose the scenario that has the highest net benefits.
- Undertaking sensitivity analysis on a key range of variables, given the uncertainties related to specific benefits and costs.

Types of costs and benefits

From an economic perspective, the ban on exports is a straightforward case of a reduction in demand. The consequences of this will be a reduction in price and a reduction in the quantity of recycled material used (chart 2.2). Note that there is no reason that the price has to be above zero in this market, unlike most markets — instead the price has to be above the cost of the alternative of landfilling. How the impacts play out in terms of quantity and price will reflect the nature of the supply curve of recyclable materials and demand for recyclable materials.

- If supply is inelastic, then the quantity of material sold will fall somewhat, but most of the adjustment will be in a much lower price
- If supply is relatively elastic, then the quantity of material sold will fall substantially and there will be less adjustment in the price
- If domestic demand is relatively elastic, then the reduction in price and quantity will be smaller. This will be the case if there are close domestic substitutes for the activities that occur overseas. For example, processing plants could be set-up in Australia with only a marginally higher cost than those currently accepting waste overseas.

The specific characteristics of the markets for each of the materials will determine the responsiveness of demand and supply. Of most importance is the extent to which there are domestic substitutes for demand at a similar willingness to pay — i.e. a relatively flat domestic demand curve around current prices.



2.2 The market for recycled commodities

Data source: The CIE.

The market for recycled commodities provides the mechanism through which the costs and benefits to private market participants would be measured. There will also be non-market costs and benefits, such as environmental impacts, that will have to be separately considered.



2.3 The market for recycled commodities with fixed supply

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Data source: The CIE.
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A summary of the likely trade-offs is shown in table 2.4.

2.4 Costs and benefits of a ban on exports

Costs	Benefits
 Resource costs of moving to next best option for materials exported in the base case. This can be measured by the: loss of export revenue, plus additional processing costs (capital and operating), less revenue from material post-processing. (This would be negative in the case of landfilling.) 	Reduced environmental costs from waste management practices in other countries of Australian material, to the extent valued by the Australian community. For example, impacts from waste entering the marine environment in South East Asia.
Any environmental impacts of the next best option outside of exports (which could be landfilling, stockpiling or processing within Australia), valued by the Australian community	

Source: The CIE.

There is also a potential benefit if other countries were to introduce import bans, with little notice, while Australia can provide a better managed process with longer lead times. This is considered as a scenario, and the types of costs and benefits are discussed in chapter 10.

From a cost benefit analysis perspective for an Australian policy decision, the community of interest is typically defined as the Australian community. This means that impacts on overseas people are not accounted for. However, given that the focus of the policy is on reducing an overseas problem, we have identified cost effectiveness metrics, in terms of net cost to Australia per tonne of likely mismanaged waste entering the ocean in overseas countries.

A cost benefit analysis focuses on the direct impacts of a policy. Any policy will have flow-on impacts, both positive and negative. For example, a need for further domestic processing of waste at higher cost than overseas will:

- increase the amount of activity occurring in the waste processing industry itself
- require households and businesses to pay for these additional costs
- reduce income available to households and businesses on other expenditure
- re-allocate some resources, such as labour, from other industries to the waste industry.

The study provides an analysis of the potential distribution of costs and benefits but does not measure flow-on impacts.

Time period and discount rate

The study uses a social discount rate of 7 per cent and a time period of 20 years. The 20 years is sufficiently long to cover the period over which most processing plants operate. We include a residual value for any capital at the end of the 20 year period.

We also test sensitivities using a social discount rate of 3 per cent and 10 per cent.

3 The base case

The base case represents what would happen to the Australian recycling system in the absence of any of the proposed options (i.e. the waste export ban) which are the subject of this report.

The base case could change substantially from current outcomes, because the recycling system is already in a state of flux.

- Prices for lower quality commodities from the recycling system have fallen. This has already led to investment in further sorting and processing within Australia, and more would likely occur over time.
- There is constant pressure to increase recycling rates, which would lead to additional supply in the recycling system, adding to impacts from population growth. Policies by other governments (local and state) are often part of this, such as container deposit schemes and changes to kerbside recycling practices. Australian Packaging Covenant Organisation (APCO) also has targets for higher levels of recycling.
- Overseas governments may impose restrictions on imports in the base case. This will
 reduce the overseas markets available for Australian exports.

A summary of what the base case could entail is set out below. Given the uncertainties, we model a number of base case scenarios.

Amount of material generated by households and businesses

In total, of the 9.3 million tonnes of annual paper & cardboard, plastic, glass and tyre waste material generated, 5.2 million tonnes (56 per cent) ends up in landfill and a further 1.8 million tonnes (19 per cent) is exported (chart 3.1). The potential closure of export markets will therefore require dramatic increases in the use of recycled materials within Australia to sustain existing recovery rates or to increase recovery rates further.



3.1 Annual waste material flows

Data sources: APCO 2019, Australian Packaging Consumption and Resource Recovery Data; Envisage Works 2019, Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy, October; Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report; ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports; IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, Geelong West, October 2019

Paper and cardboard

An overview of the paper and cardboard waste industry is shown in chart 3.2.



3.2 Paper and cardboard waste industry overview

Sources: CIE; 2016-17 waste generation Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018; ABS 2019, *import-export database* supplied by Australian Treasury.

The 2018 National Waste Report estimates 5.6 million tonnes of paper and cardboard waste was generated in 2016-17.⁴ The associated landfill and recycling quantities are shown in table 3.3. Approximately 60 per cent of paper and cardboard waste was

⁴ Blue Environment 2018, National Waste Report 2018, p. 30, November

recycled and 40 per cent sent to landfill (including an unknown amount of domestic stockpiling).

3.3 2016-17 Paper and cardboard landfill, recycling and waste quantities by waste stream

Waste stream	Waste generated	Landfill	Recycled	
	Thousand tonnes	Thousand tonnes	Thousand tonnes	
Total	5 591	2 230	3 361	

Source: 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018

This implies the following source consumption amounts by applying IndustryEdge 2019 estimates of paper and paperboard source material⁵:

- 3 million tonnes of imported products, and
- 2.6 million tonnes of domestically sourced products.

Of the estimated 3.4 million tonnes of recycled paper and cardboard generated:

- ~1.3 million tonnes (~39 per cent) was exported from Australia⁶
- ~1.6 million tonnes (~46 per cent) was re-processed domestically (some of which was subsequently exported as a consumer product and some used domestically)⁷, and
- an unknown amount was stockpiled.

⁵ IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, p.4, Geelong West, October 2019

⁶ For commodities 47071000, 47072000, 47073000 and 47079000 sourced from ABS 2019, waste data import and export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-wastepolicy/waste-exports

⁷ IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, p.4, Geelong West, October 2019



3.4 Paper and cardboard material flows 2017/18

Data sources: ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-policy/waste-exports; IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, Geelong West, October 2019

There is data available on state waste generation and recycling from 2016/17. We have combined this with data on waste exports for 2017/18 by port to give an indicative view of the picture across states (chart 3.5). This is not perfect because of the different years and because of movement of material between states. For example, Victoria's exports include some material that originated in Tasmania and South Australia.



3.5 Annual paper & cardboard material flows by jurisdiction

Note: Exports include interstate waste transfers and may overstate jurisdictional proportions. Jurisdiction domestic recycled amounts apportioned based on 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018

Data source: ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-policy/waste-exports; IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, Geelong West, October 2019; Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-wastereports/national-waste-report-2018 Key conclusions from state-level analysis are:

- NSW is relatively less exposed to exports of paper and cardboard than other states
- Victoria and WA are particularly exposed to export markets
- The majority of paper and cardboard waste is generated in Victoria, NSW and Queensland.

On a per household basis (chart 3.6):

- Victoria has the highest annual recycled paper and cardboard exports (0.3 tonnes per household), and
- annual household paper and cardboard landfill is consistent across all jurisdictions (0.3 tonnes), except for South Australia (0.1 tonnes per household) and Victoria (0.2 tonnes per household)
- Tasmania has the highest domestic paper and cardboard recycling (0.5 tonnes per household). However, this is likely reflective of the data availability and inability to adjust for interstate exports. If Tasmania is exporting its waste paper to Victoria, then this is not measured and is instead allocated as domestic recycling.



3.6 Paper & cardboard material flows per household by jurisdiction

Note: Exports include interstate waste transfers and may overstate jurisdictional proportions. 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database,

https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018 Data source: ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-policy/waste-exports; IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, Geelong West, October 2019; Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-report-2018; ABS 2019, 3236.0 - Household and Family Projections, Australia, 2016 to 2041

Plastics

An overview of the plastic waste industry is shown in chart 3.7.



3.7 Plastic waste industry overview

Note: Mixed 1-7 is a mix of all plastic polymer types. Mixed 3-7 is a mix where HDPE and PET have been removed.

Sources: Envisage Works 2019, Plastics infrastructure analysis update, Final Report, 11 November 2019; Department of the Environment and Energy 2019, ABS 2019, import-export database supplied by Australian Treasury; National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018

Envisage Works 2019a estimate that consumption of plastics in Australia totalled 3.4 million tonnes in 2017–18. Of this consumption:

- 2 million tonnes (58 per cent) was sourced from imports of finished and semi-finished goods⁸
- 1.1 million tonnes (32 per cent) was sourced from locally manufactured products from imported virgin resin⁹
- 0.2 million tonnes (6 per cent) was sourced from locally manufactured products from domestic virgin resin, and
- 125 000 tonnes (4 per cent) was sourced from locally manufactured products made from processed recyclate.

Of the 3.4 million tonnes of plastic consumed in 2017-18, an estimated 2.5 million tonnes entered the waste stream. Approximately 87 per cent of plastic waste was sent to landfill (including an unknown amount of domestic stockpiling) and 13 per cent recycled (table 3.8). These figures exclude plastics consumption into medium to longer term applications (greater than 12 months) and the use of plastics in applications that often do not enter waste streams at end-of-life (e.g. underground pipes).

Waste stream	Waste generated	Landfill	Recycled
	Thousand tonnes	Thousand tonnes	Thousand tonnes
Municipal Solid Waste	1 155 ^a	992	163
Commercial & Industrial	1 223 <mark>a</mark>	1072	151
Construction & Demolition	122 ^a	116	6
Total	2 500	2 180	320

3.8 Plastic landfill recycling and waste quantities by waste stream – 2017/18

^a Applying 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018 Note: Tables may not sum due to rounding.

Source: Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report

Of the estimated 320 000 tonnes of recycled plastic generated in 2017-18 (chart 3.9):

- ~160 000 tonnes (~50 per cent) was exported from Australia¹⁰
- ~30 000 tonnes (~13 per cent) was used in other applications
- ~130 000 tonnes (~41 per cent) was re-processed domestically, and
- an unknown amount was stockpiled.

- ⁹ For HS commodities 3901 -3909, sourced from ABS 2019, *import-export database* supplied by Australian Treasury.
- ¹⁰ For commodities 39151000, 39152000, 39153000 and 39159092, sourced from ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/wasteresource-recovery/national-waste-policy/waste-exports

⁸ Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report, Melbourne: Prepared by Envisage Works and Sustainable Resource Use on behalf of the Department of the Environment and Energy, as stated in Envisage Works 2019, Plastics infrastructure analysis update – Draft report, p. 5, October



3.9 Plastic material flows 2017/18

Data sources: Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report; ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports

High density polyethylene (HDPE) (2) and Polyethylene terephthalate (PET) (1) account for over half of annual recycled plastics (at 30 per cent and 25 per cent respectively). Most of these recycled plastic polymers are exported, 76 per cent for PET and 52 per cent for HDPE (chart 3.10).



3.10 Annual plastic recycling destination by polymer type

Data source: Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report, p. 26

There is data available on state waste generation and recycling from 2016/17. We have combined this with data on waste exports for 2017/18 by port to give an indicative view of the picture across states (chart 3.11). This is not perfect because of the different years and because of movement of material between states. For example, Victoria's exports include some material that originated in Tasmania and South Australia.
Key conclusions from state-level analysis are:

- South Australia has the largest amount of domestic recycling
- Victoria has the largest share of plastic exports (55 per cent)
- NSW/ACT accounts for the largest share of plastic landfill (35 per cent).





Note: Exports include interstate waste transfers and may overstate jurisdictional proportions. 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database,

https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018 Data source: ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-policy/waste-exports; Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report; Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018

On a per household basis (chart 3.12):

- South Australia accounts for the largest share of annual domestic plastic recycling (0.02 tonnes per household)
- Victoria has the highest annual recycled plastic exports (0.04 tonnes per household), and
- Queensland has the highest annual household plastic landfill (0.26 tonnes per household).



3.12 Plastic material flows per household by jurisdiction

Data source: ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resourcerecovery/national-waste-policy/waste-exports; Envisage Works 2019a, 2017–18 Australian Plastics Recycling Survey – National report; Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018; ABS 2019, 3236.0 - Household and Family Projections, Australia, 2016 to 2041

Glass

An overview of the glass waste industry is shown in chart 3.13.

3.13 Glass waste industry overview



Sources: APCO 2019, Australian Packaging Consumption and Resource Recovery Data, October; The CIE, APC; ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports; Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-report-2018

APCO estimate that 1.3 million tonnes of post-consumer glass packaging was generated in 2017-18. Approximately 55 per cent of glass waste was sent to landfill and 45 per cent recycled (table 3.14).

Waste stream	Waste generated	Landfill	Recycled
	Thousand tonnes	Thousand tonnes	Thousand tonnes
MSWa	983	525	443
C&Ia	317	171	145
Total	1 300	691	582

	3.14	Glass landfill	recycling and	l waste d	uantities b	y waste	stream -	2017	/18
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^a Applying 2016-17 waste proportions from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018 Note: Tables may not sum due to rounding.

Source: APCO 2019, Australian Packaging Consumption and Resource Recovery Data, October

There is a demand for recycled glass for post-consumer glass packaging. This is for larger pieces of glass, known as 'cullet', which can be used in remanufacturing of glass packaging after being beneficiated (cleaned and sorted). However, this source of demand has been falling because the domestic production of glass packaging has been falling, and imports of glass packaging increasing.

Glass fines, which are below the size required for glass remanufacturing, occurs because sorting crushes the glass. These glass fines are generally used in construction applications (such as road base) or landfilled.

Of the estimated 582 000 tonnes of recycled glass generated in 2017-18:

- ~18 000 tonnes (~3 per cent) was exported from Australia¹¹
- ~564 000 tonnes (~97 per cent) was re-processed domestically, and
- an unknown amount was stockpiled.





Data source: APCO 2019, Australian Packaging Consumption and Resource Recovery Data, October; ABS 2019, waste data export from Australia database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports..

¹¹ For commodity 700100 - Cullet and other waste and scrap of glass; glass in the mass sourced from ABS 2019, *waste data export from Australia database*,

https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/waste-exports

According to the National Waste database for 2016/17, NSW has the largest amount of glass waste generated, followed by Queensland and Victoria (chart 3.16).



3.16 Glass material flows by jurisdiction

Note: This will not add to 2017/18 data reported for Australia.

Data source: 2016-17 data from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018.

On a per household basis, glass generation is highest in the Northern Territory, Tasmania, WA and QLD (chart 3.17). South Australia has a noticeably higher recycling rate than other jurisdictions, possibly reflecting the glass processing facilities there and mature container deposit scheme. WA has a noticeably lower level of glass recycling, and has limited end demand for glass, with any glass that is recycled being used in construction.

3.17 Glass material flows per household by jurisdiction



Note: This will not add to 2017/18 data reported for Australia.

Data source: 2016-17 data from the Department of the Environment and Energy 2019, National Waste report 2018 database, https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018.

Tyres

An overview of the tyre waste industry is shown in chart 3.18.

3.18 Tyre waste industry overview



Source: Envisage Works 2019, Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy, October.

Envisage works 2019 estimate that 543 000 tonnes of new tyres were sold in Australia 2018-19, all of which were imported.¹² New tyre sales were supplemented by a small amount of domestically sourced casings and spares (~32 000 tonnes).

The 2018-19 end-of-life tyre waste generation, landfill and recycling quantities are shown in table 3.19. Approximately 69 per cent of end-of-life tyres were recycled and 30 per cent sent to landfill (including domestic stockpiling and onsite disposal).

¹² Envisage Works 2019, *Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy*, October

Waste stream	Waste generated	Landfill	Recycled
	Thousand tonnes	Thousand tonnes	Thousand tonnes
C&I	465	140	323
Total	465	140	323

3.19	2018-19 End-of-of-life ty	vre recycling and	1 waste quantities
		,	

Note: Tables may not sum due to rounding.

Source: Envisage Works 2019, Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy, October

Of the estimated 323 000 tonnes of end-of-life tyres generated in 2018-19:

- 255 000 tonnes (~79 per cent) was exported from Australia.¹³ Note that export data we have used suggests a lower figure. This large discrepancy between export data and survey data has been noted by EnvisageWorks and is attributable to historically high levels of underreporting waste tyre exports, and
- 68 000 tonnes (~21 per cent) was re-processed domestically.

For the purposes of the waste ban, this would only apply to whole tyres. Blue Environment estimates there are ~61 000 tonnes of whole tyres expected, of which ~8000 tonnes are for retreading. This is what we have used for the central analysis. Tyre Stewardship Australia notes substantially higher estimates, of 128 000 tonnes of whole tyres exported. We have conducted a sensitivity analysis using this estimate.



3.20 End-of-life tyre material flows 2018-19

Data sources: Envisage Works 2019, Tyre flows and recycling analysis: Final Report – Prepared for the Department of the Environment and Energy, October.

¹³ As reported by local collectors and processes. Envisage Works 2019, p17 note a significant discrepancy between the customs export dataset and the exports as reported by local collectors and processors.

Domestic markets for materials

There are also big differences in the infrastructure available to manage waste, recycle materials and manufacture products containing recyclable material across Australia's states and territories and between metropolitan, rural, regional and remote areas.

The domestic and overseas markets for recycled material are set out in table 3.21.

Recycled item	Potential end markets
Glass	Reused by bottle manufacturers domestically Glass sand for use in construction/drainage Glass used in road base
Paper and cardboard	Reused in paper manufacturing domestically Reused in paper manufacturing overseas
HDPE, PP and PET	Plastic manufacturing domestically Plastic manufacturing overseas
Rigid plastics (outside of above)	Minimal markets currently, but potential to be used in chemical recovery and waste to energy facilities
Soft plastics	Recycling to make outdoor furniture, gardening stakes, bin liners, etc. Virgin-like quality polypropylene resin Blending with asphalt for roads and concrete footpaths Chemical degrading to make new plastics As an energy source (waste to energy)
Tyres	Tyre derived fuels Combined with crushed rock to make retaining walls Crumbed rubber asphalt for roads, pavements, synthetic sporting tracks/fields and soft fall children's play spaces Crumbed rubber combined with polyolefin plastic to manufacture commercial pipes Removed steel reinforced layer melted and reformed into steel billet for use as rods, bars and wires

3.21 Key domestic and overseas markets

Source: APCO Working Group 2018 reports for Soft Plastics, Expanded Polystyrene, Polymer Coated Paperboard, and Glass; Tyre Stewardship Australia, *Tyre-Derived Products Case Studies*, REC, et. al., 2017, *National market development strategy for used tyres 2017-2022*, Melbourne: Report prepared by Randell Environmental Consulting, Reincarnate and Envisage Works on behalf of Sustainability Victoria; the CIE.

Key domestic producers

Domestic material producers, who are major current or potential purchasers of recycled material, are shown in table 3.22. There are only a small number of producers domestically for many materials. Export markets have historically been important in constraining the market power of these businesses as buyers of recycled product.

Over time the domestic material producers and their production volumes will change. For instance, VISY's Albury site, recently purchased from Norske Skog, is not operational but may reopen in the future, and plastic processors are investing in processing which will also increase capacities. The central case analysis factors in an increase in domestic processing; this is because recycling increases while exports stay at levels similar to current.

3.22 Domestic material producers

Material	User	Description
Glass bottling	0-1	Annual tonnes produced of ~700,000, using ~260,000 tonnes of recycled glass ^a
	Orora	Annual tonnes produced of ~400 000, of which ~100 000 is from recycled glass.
Glass as a construction substitute	Frasers	100 000-150,000 tonnes
	Benedicts (previously)	150,000 tonnes, now zero
	Other	135 000 - 185 000 tonnes p.a.
Paper and cardboard	VISY	Produced 1.4 million tonnes of paper products and received 1.8 million tonnes of recycled paper and cardboard. Some of which it exports ^b
		In 2019 VISY purchased Norske Skog's Albury newsprint plant, which is now not in operation. This has an annual capacity for 265,000 tonnes of newsprint, but it is unclear whether it will reopen, or will be repurposed and have a different capacity.
	Orora	Received 700,000 tonnes of recycled paper and cardboard
Tyres	Global Distillation Technologies	Undertake tyre pyrolysis. At full capacity their commercial plant will be capable of processing 19,000 tonnes of end-of-life tyres per year. This represents approximately 3% of the end-of-life tyres that are generated in Australia every year. ^C
	Pearl Global	Undertake tyre pyrolysis. Currently in commissioning phase. 10,000 tonnes current capacity, 20,000 anticipated capacity. End markets are fuel oil, carbon char and steel recycling. d
	Tyre cycle	Undertake shredding, granulation and TDF production. Some of which it

Material	User	Description
Plastics	Qenos	Annual tonnes produced of $\sim\!\!375,\!000,$ none from recycled material. $^{\rm f}$
	LyondellBasell	Annual tonnes produced for the domestic market of ~200,000, none from recycled material. ^g
	Advanced Circular Polymers	Stated capacity of 70 000 tonnes per annum.
	Astron Sustainability	Not known
	Many other smaller operators	Undertaking expansion of plastics processing capacity.

a https://recycleglass.com.au/o-i-australia/history/ b https://www.visy.com.au/about/visy c https://www.gdtc6.com/tyre-recycling/ $^{\rm d} {\rm https://www.tyrestewardship.org.au/static/uploads/files/j13310-tsa-guide-tyre-pyrolosis-web-wfabwwkdtntp.pdf ^{\rm e}$ http://www.tyrecycle.com.au/sites/default/files/TyrecycleCorpBrochure.pdf

f http://www.qenos.com/internet/home.nsf/web/OurPlants g : Envisage Works 2019, Plastics infrastructure analysis update, Final Report, 11 November 2019.

Source: As noted above.

More recent work commissioned by the Department provides a picture of the range of reprocessing infrastructure facilities throughout Australia. Table 3.23 provides a summary of the number of reprocessing facilities in different parts of Australia. NSW and Victoria have the largest number of facilities and coverage across the different waste streams. Some of the other jurisdictions do not have any facilities or smaller facilities that have limited capacity. The impact of banning waste exports will tend to have a greater impact in these jurisdictions.

Jurisdiction	Paper	Plastics	Glass	Tyres
	no.	no.	no.	no.
NSW	4	14	2	7
VIC	4	25	3	3
QLD	3	9	1	7
WA	0	2	0	4
SA	1	6	1	1
NT	0	0	0	1
ACT	0	0	0	1
TAS	1	2	0	1

3.23 Number of existing reprocessing facilities

Note: Some companies may own and operate several facilities in a jurisdiction. Visy Recycling, for example, has three paper processing facilities in Victoria (Springvale, Heidelberg and Coolaroo). In regards to plastics reprocessing, there were 66 facilities identified of which there were 8 facilities where the location was not identified.

Source: Envisage Works (2019), Plastics Infrastructure Analysis update, Nov, Sustainable Resource Use (2019) Assessment of Australian recycling infrastructure - Glass packaging, October. IndustryEdge (2019), Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, October. Envisage Works (2019), Tyre flows and recycling, Oct.

Further information on individual facilities and their locations is set out in Appendix G.

The gaps in processing infrastructure relative to that required to process Australia's currently exported materials are substantial:

- spatially, there is a substantial gap in Western Australia, particularly for paper and cardboard processing. There are also gaps in smaller jurisdictions, but Western Australia is the largest state that has the most limited re-processing facilities
- in paper and cardboard, there is one currently not operational facility owned by VISY at Albury that could be viewed as spare capacity. Other paper processing facilities are largely operating at capacity
- in plastic, there has been investment in a number of new facilities in the past two years, and some of these facilities do not appear to be operating at their stated capacity yet. The export volumes for plastic would likely require about 10 new reasonable scaled facilities (20 000 tonnes per year) or more if the facilities are smaller. The scale of a processing line for HDPE and PET is fairly small, (around 7000 tonnes a year for a facility with one HDPE and one PET line operating at 12 hours per day).

Policies of Australian governments

There are a range of policies that have been adopted by the Australian Government and state counterparts over the past few years to improve the management of waste. The actions introduced by the jurisdictions are summarised below.

National policies

The National Waste Policy developed by the Australian Government in 2018 embodies a circular economy, shifting away from 'take, make, use and dispose' to a more circular approach where we maintain the value of resources for as long as possible. The Policy presents broad principles to guide the developments. In 2019 a National Action Plan was developed identifying actions and presenting targets to implement the 2018 National Waste Policy. These targets and actions will guide investment and national efforts to 2030 and beyond.

Specific actions/targets identified in the National Waste Policy Action Plan include:

- Target 1. Ban the export of waste plastic, paper, glass and tyres, commencing in the second half of 2020. The analysis conducted in this report is intended to guide the further development of specific aspects of this target.
- **Target 2**. Reduce total waste generated in Australia by 10 per cent per person by 2030.
- **Target 3**. 80 per cent average resource recovery rate from all waste streams following the waste hierarchy by 2030.
- **Target 4**. Significantly increase the use of recycled content by governments and industry.
- **Target 5**. Phase out problematic and unnecessary plastics by 2025.
- **Target 6**. Halve the amount of organic waste sent to landfill by 2030.

Target 7. Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions.

The National Waste Policy Action Plan 2019 also provides a range of actions designed to support each of the seven targets. These actions include a range of general actions such as:

- improve waste definitions, data collection and reporting
- conducting further investigations to understand infrastructure capacity
- supporting further research to understand consumer behaviour, investigate scope for funding R&D into waste recovery technology
- supporting education campaigns.

The actions include target timeframes for completion and also identifies partner organisations for each actions.

Other actions by the Australian Government include the introduction of product stewardship schemes. The *Commonwealth Product Stewardship Act 2011* provided the first national approach to voluntary and regulated product stewardship schemes, involved industry taking greater responsibility for the environmental impacts of their products, particularly where they become waste. Each year the Minister for the Environment publishes a product list of problematic wastes that may be considered under the Product Stewardship Act.

The *National Television and Computer Recycling Scheme* was the first co-regulatory scheme under the *Commonwealth Product Stewardship Act 2011*. The scheme aims to boost recycling of televisions and computers and divert them from landfill disposal. The target is to achieve an 80% recycling rate by 2021.

The *National Tyre Product Stewardship Scheme* was introduced in January 2014. The scheme helps tackle the significant environmental challenges arising from used tyres. The scheme aims to increase domestic tyre recycling, expand the market for tyre-derived products and reduce the number of Australian end-of-life tyres that are sent to landfill, exported as baled tyres or illegally dumped. Tyre Stewardship Australia conducts education, compliance and market development activities to achieve its objectives.

The Australian Packaging Covenant is an agreement between the Australian, state and territory governments and the packaging industry that aims to reduce the environmental impacts of consumer packaging in Australia. Its focus is on sustainable packaging design, recycling of used packaging and reduction of litter from packaging. APCO is an independent body established to administer the Covenant. The *National Environmental Protection* Measure (*Used Packaging Materials*) 2011 requires all states and territories to provide and enforce regulations to underpin the Covenant and create a level playing field for businesses. The four targets identified in the *Australian Packaging Covenant Strategic Plan 2017–2022*, to be achieved by 2025, are:

- 100% of packaging to be reusable, recyclable or compostable
- 70% of plastic packaging recycled or composted
- 30% average recycled content across all packaging

Phase out problematic and unnecessary single-use plastic packaging through redesign, innovation or alternative delivery methods.¹⁴

Industry will continue to innovate, and conduct research and development activities supported by Government programs. Examples include the Australian Government's:

- \$100 million Australian Recycling Investment Fund to support the manufacturing of products containing recycled materials such as plastics and paper
- \$20 million Cooperative Research Centres Projects grants to find new and innovative solutions to plastic recycling and waste.¹⁵

State policies

State and territory governments have primary responsibility for managing waste through legislation, policy, regulation, strategy and planning, as well as permitting and licensing of waste transport, storage, treatment and disposal operations. Over the past decade there has been an increasing focus by the state and territory governments on waste management in the respective jurisdictions.

Broadly speaking the objectives involve reducing waste generated per person, increasing diversion of resources from landfill and a continued emphasis on recirculating material in the economy. The range of policies and mechanisms to achieve these goals differ between the different jurisdictions. These include:¹⁶

- Waste disposal levy. Most jurisdictions require landfills to pay some amount to the state for each tonne of waste deposited in landfill. The additional fee pushes up the cost of landfill, increasing the attractiveness of recycling. The levy rates differ between the jurisdictions which has also led to incentives for interstate movement of waste to the cheapest destinations.
- Waste targets. Many jurisdictions have action plans which specify targets, such as
 resource recovery rates for different waste streams. The target rates and timing for
 achieving the targets differ between jurisdictions.
- **Product Bans**. Some jurisdictions have implemented a ban on single-use plastics.
- **Grant funding**. The revenue collected from the waste levies are commonly used to fund recycling infrastructure, programs or governance organisations. These actions typically focus on reducing the amount of waste generated, increasing recycling and developing new markets for waste products. The NSW Waste Less Recycle More program, for example, allocates \$800m investment program. It began in 2012 with funding allocated to actions and programs to reduce waste, increase recycling, invest in infrastructure, reduce litter and tackle illegal dumping.¹⁷

¹⁴ https://www.environment.gov.au/system/files/resources/e2f0f12e-fa6e-4a4b-94e3-1268d9cd1360/files/australian-packaging-covenant-strategic-plan-2017-2022.pdf

¹⁵ Department of Environment and Energy (2019), *Consultation RIS, Phasing out certain waste exports*, Dec, p.13,

¹⁶ Appendix F includes further details of the different jurisdictions.

¹⁷ The following link provides further details of the specific actions already funded or to be funded over the period 2017-2021 https://www.epa.nsw.gov.au/-/media/epa/corporate-

- Container Deposit Scheme. This scheme pays a refund (e.g. ten cents) to consumers who return an eligible drink container, with the payments funded by a levy on suppliers of containers. The aim is to encourage the community to recycle while reducing litter and the number of containers going to landfill. Currently NSW, South Australia, the ACT, the NT and Queensland all have a CDS operating. Western Australia will commence a container deposit scheme in June 2020, while Victoria and Tasmania have signalled, they may also implement schemes in the future.
- Licensing arrangements. Waste facilities and waste transporters are required to be licenced. The Government may specify the conditions of operation for individual licences. This includes regulating stockpile limits on resource recovery facilities to ensure waste is managed appropriately and efficiently.
- Other actions.
 - Government procurement. Most jurisdictions have a strategy that guides government organisations and industries in improving waste management over the strategy period. In many cases, strategies set targets for resource recovery or other waste performance indicators
 - Landfill bans. There are bans on a range of waste streams being disposed of in general landfills. Asbestos waste, for example, have more stringent management requirements.
 - For hazardous waste, there are also different arrangements regarding the management and regulation of hazardous waste. This includes a tracking system that requires producers, transporters and receivers of hazardous waste to inform the environmental regulator of each movement of hazardous waste. There are typically more stringent requirements imposed on licensees that manage hazardous waste.

Governments are also investing in improving data collection and sharing of data. There's a data quality and calculation framework established which aims to improve the quality of measuring recycling performance and waste generation. Some jurisdictions have also mandated data collection and the use of weighbridges for waste recovery facilities.

Announcements of overseas governments

Overseas governments are also enacting measures to better manage the waste streams from overseas entering their countries.

As its ongoing efforts to shift away from imported wastes as a source of raw materials, China announced its National Sword policy which introduces bans on imports of some waste and scrap materials:

 In July 2017 China notified the World Trade Organisation of banning imports of 4 new classes/24 kinds of solid wastes by the end of 2017;

site/resources/waste/waste-less-recycle-more-2017-21-160538.pdf?la=en&hash=7E4ED3246CA007967D6541EE32EFA31DF0D2CAC4

- At the end of 2017 China's then Ministry of Environmental Protection (MEP) announced that new standards of allowable contaminant threshold for scrap imports would take effect on 1 March 2018; and
- On 19 April 2017 the newly restructured Ministry of Ecology and Environment (MEE) announced that China will further ban imports of 16 types of solid wastes by the end of 2018 and another 16 by the end of 2019.

The CIE 2018 estimated ~1.2 million tonnes valued at ~\$340 million of Australia's waste exports to China a year may be affected by the ban (table 3.24).¹⁸ This represents ~99 per cent in volume or ~77 per cent in value of Australia's total waste exports to China.

	Volume	Value	end 2017	end 2018	end 2019
	kt	\$m	%	%	%
Metals	179.5	163.3	87.5	99.2	100.0
Paper	920.5	135.2	100.0	100.0	100.0
Plastics	124.7	40.5	0.0	100.0	100.0
Hazardous	0.2	0.3	100.0	100.0	100.0
Total	1 224.8	339.2	82.1	99.6	100.0

3.24 Australian exports subject to the China Ban

Note: percentage in the last three columns denotes the timing of the ban taking effect

Source: CIE estimates based on analysis of ABS and Comtrade trade data by Blue Environment (2018).

The industry response to date to China National Sword has been:

- to redirect exports to other South East Asian countries, such as Malaysia, Indonesia and India (chart 3.25). This has been most noticeable for plastic
- a reduction in paper and cardboard exports, although no change for plastic
- a reduction in prices received, for the low value end of the recycled commodity market in particular, such as mixed plastic and mixed paper from kerbside recycling,
- exporting higher quality material, such as commercial paper, and using lower quality material domestically and
- investment in additional sorting of material within Australia so that it is less contaminated.

The immediate impact on waste exports can be seen from chart 3.25 of the waste plastic, paper and cardboard exports.

¹⁸ The CIE 2018, The impact of China's ban on waste material imports on Australia: A special analysis for the updated headline economic values for waste and material efficiency in Australia, June.



3.25 Impact of National Sword on destination for waste paper & cardboard and plastic

Source: The CIE.

Since the original National Sword announcements there have also been other changes:

- In December 2019, China has foreshadowed a new standard on recycled plastics imports to take effect in April 2020.
- In March 2019, India prohibited scrap 'solid plastics' from being imported into the country.
- In April 2019, Indonesia announced more stringent inspections of scrap paper imports
- Since July 2018, Malaysia has introduced significant restrictions on scrap plastics imports.
- From October 2018 Taiwan has introduced restrictions on scrap paper and plastics
- On August 2018 Thailand has introduced restrictions on scrap plastics with tighter controls of e-waste also foreshadowed
- From August 2018 Vietnam has introduced restrictions on scrap plastic, paper, metals and other types of scrap. Low quality plastic imports may also be banned from 2025.¹⁹

¹⁹ Sustainability Victoria, 2020, Recovered Resources Market Bulletin – January 2020, available at: https://www.sustainability.vic.gov.au/Business/Investment-facilitation/Recoveredresources-market-bulletin

 In May 2019 the Basel Convention agreed to make an amendment from January 2021 to treat some types of plastic to be treated as "hazardous waste". This places restrictions on the export of some types of plastic wastes.

The impact of these announcements on Australian waste exports are yet to be fully understood.

Projected waste generation and recycling

For the purposes of this analysis, we have utilised the projections of waste generation and recycling that have been prepared for National Waste Policy Action Plan by Blue Environment. The projections are based on continuation of the underlying historical trends in waste generation and recycling. Waste generation increases over time based on factors, such as population growth, although there is a continued reduction in per capita waste generation over time.

Recycling rates change over time as the different targets discussed in previous sections, are reached (over a phased-in period).

This data provides projections for plastics, as well as, at an aggregate waste level (for generation and recycling). We have also separately provided projections of paper and glass using the CIE's waste model.²⁰ Projections of generation and recycling were provided by Blue Environment. The CIE waste model was also used to disaggregate the projections by state and jurisdiction.

Projections are provided for the period 2017/18 to 2036/37. For the purposes of our analysis we have continued the trend in the later years up to 2040.



3.26 Historical and projected waste generation and fates

Note: All waste, including ash.

Data source: Blue Environment analysis prepared for National Waste Policy Action Plan.

²⁰ The model was created for our recent stud for the Department

https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-policy/publications/headline-economic-values-waste-final-report-2017



3.27 Historical and projected waste generated, by source

Note: All waste, including ash.

Data source: Blue Environment analysis prepared for National Waste Policy Action Plan.





Note: All waste, including ash.

Data source: Blue Environment analysis prepared for National Waste Policy Action Plan.



3.29 Historical and projected waste generation and fates, plastics

Note: All waste, including ash.

Data source: Blue Environment analysis prepared for National Waste Policy Action Plan.

Export projections

The export ban impacts on exports. We model a number of different scenarios for exports:

- for the central case, we maintain export volumes and values at 2018/19 levels
- for sensitivity analysis, we show the impacts if:
 - exports grow in line with the amount of recycling estimated above. This increases export amounts. Note that we do not change values for this scenario. If the additional recycling is lower value materials then this would change both material values and the options available domestically for processing it
 - exports reduce to zero over a period of ten years. This could be because of activities to increase domestic demand, or because of gradual closure of export markets
 - the value of exports reduces to zero. This scenario captures a fairly dramatic decline in export prices.

Further information on the base case for 2019 exports across jurisdictions and sources of material is set out in Appendix C.

4 Options evaluated

The Council of Australia Governments' (COAG) announcement on 9 August 2019 stated two key related objectives: implementing a ban on waste plastic, paper, glass and tyre exports; and building Australia's capacity to generate high value recycled commodities. COAG's agreement reflects increasing concern in Australia and around the world about plastic pollution of our oceans and the need to ensure that exports of waste do not cause harm to human health and the environment.

This chapter provides further details on the materials subject to the ban.

Scenarios assessed

The modelling in this report assesses four alternative scenarios, relative to the base case.

- The base case includes the existing domestic policy settings such as the national/state targets discussed above, as well, the assumptions regarding the overseas policy settings. It does not include the introduction of export bans. A number of variations to the base case are modelled with different material volumes and values.
- Scenario 1 introduces the export ban as defined in the previous section (in terms of the coverage of the material and timing of the bans).
- Scenario 2 is a variant on Scenario 1, with an exemption for clean paper and cardboard. Clean paper and cardboard is currently not well defined. For the modelling we have assumed that any C&I and C&D paper and cardboard will be clean and any municipal will not be clean.
- Scenario 3 is a variant on Scenario 1, with an exemption for whole tyres for retreading. We have assumed that this can be implemented and enforced. There is uncertainty about the extent to which it would be easy to enforce an exemption that relates to the use of the material, rather than to what the material is.
- Scenario 4 is a variant on Scenario 1, which includes an exemption for whole tyres for retreading and an exemption for clean paper and cardboard.

Materials subject to the export ban

In broad terms Commonwealth, state and territory Environment Ministers agreed waste plastic, paper, glass and tyres that have *not been processed into a value-added material* should be subject to the export ban. This would mean:

- Waste plastic, paper, glass and tyres that have not been processed into a value-added material cannot be exported.
- Value-added materials that can be exported would include plastic, paper, glass and tyres that have been processed into materials ready for further use and should not harm human health or the environment in the importing country.

The export bans were targeted waste from the four waste streams with a number of exemptions identified:

- Paper pulp would not be subject to the ban. The ban would apply to the remaining waste products, including mixed paper and cardboard.
- Clean plastics sorted to a single resin type and processed ready for further use (e.g. flakes and pellets). The ban would apply to the remaining mixed plastics waste.
- The ban would apply to all whole tyres including baled tyres. The following tyre wastes would not be subject to the ban
 - Crumb rubber, powder and granules
 - Shredded tyres exported for tyre derived fuel
- The ban applies to all waste glass except washed, colour sorted cullet ready for further use.

The modelled impact of the different export ban options evaluated in this study are shown in table 4.1, for 2019. There is uncertainty about the amount of material subject to an export ban, depending on the specific definitions used for scenarios and different data about current material flows. This is particularly the case for tyres. For this modelling, we have used analysis by Blue Environment indicating about 60 000 tonnes of whole tyre exports per year. The Tyre Stewardship Association estimates about twice this amount are exported whole.²¹ Note that while there have recently been a small amount of exports of glass, we have assumed that this does not continue.

There may be some plastics within this that could be exempt, such as plastic used for fuel. This will depend on more detailed definitions.

ltem	Scenario 1 (full export ban)	Scenario 2 (exempt clean paper)	Scenario 3 (exempt whole tyres for retreading)	Scenario 4 (exemption for tyres for retreading and clean paper)
Paper				
Volume (kT)	1 118	436	1 118	436
Value (\$m)	235	22	235	22
Plastic				
Volume (kT)	187	187	187	187
Value (\$m)	43	43	43	43
Tyres				
Volume (kT)	61	61	53	53
Value (\$m)	12	12	3	3
Glass				
Volume (kT)	0	0	0	0

4.1 Material volume and value impacted by the export ban

²¹ Tyre Stewardship Australia,2018-19 Australian Tyre consumption & recovery.

Item	Scenario 1 (full export ban)	Scenario 2 (exempt clean paper)	Scenario 3 (exempt whole tyres for retreading)	Scenario 4 (exemption for tyres for retreading and clean paper)
Value (\$m)	0	0	0	0
Total				
Volume (kT)	1 367	685	1 358	677
Value (\$m)	291	77	282	68

Source: The CIE, based on analysis of export data and key inputs from Blue Environment.

For each material and material stream, we have developed a view of the next best option if export markets are not available. These assumptions are shown in table 4.2. For mixed paper from municipal sources (MSW) we have assumed this is processed into a pulp, which would then be exported. For commercial paper and cardboard, this would be used to produce recovered paper liner and corrugating medium, which would then be exported. For plastics, material would be sorted into individual polymer types (if it is not already) and then pelletised. This may then be exported or used domestically. For tyres, we assume this is shredded and then exported.

The assumptions about where material goes for the next best option are based on the costs and revenues expected for different options, and knowledge of the markets available and industry interest in different options. If private market participants do not react in this way, particularly in respect of the risks related to these options, then costs and benefits will be different.

The options used are commercially feasible relative to landfilling at current prices. Given that we are expecting that products will predominantly be exported, it is reasonable that Australia's additional production will not impact on the price, as Australia is a small player in global markets.

In terms of domestic and global demand, the expected destinations reflect:

- limited demand for additional fibre from recycled sources domestically, given the production of final products, and hence the likelihood that we add a bit more value and then export to an overseas paper mill. There is active interest from SE Asian and Chinese paper mills in obtaining materials such as pulp, and this is occurring in other countries. However, there is currently not a deep market for pulp as it is more efficient to have pulp feeding directly into production at the same location
- unknown domestic demand for pelletised plastics, but a relatively deep international market
- little demand for tyres domestically, although organisations such as Tyre Stewardship Australia are looking at domestic options such as use in cement kilns
- falling demand for glass domestically for use in bottling, due to declining bottling production, and increasing collections as a result of container deposit schemes.
 Opportunities for using glass as a substitute for sand are very large in terms of volume of material, but these markets have tended to rely on a small number of producers historically.

	MSW	C&I and C&D
Paper	Used to produce recovered paper pulp, which is then exported	Used to produce recovered paper liner and corrugating medium, which is then exported
Plastics	Used to produce single resin pellets, which are then used domestically or exported	Used to produce single resin pellets or film, which are then used domestically or exported
Tyres	Shredded and then exported	Shredded and then exported
Glass	Used to produce construction aggregate (sand), used domestically	Used to produce construction aggregate (sand), used domestically

4.2 Assumed next best option for each material and stream

Source: The CIE.

The timing of the bans have been announced by the state and territory Environment Ministers and include the following:

- Paper by no later than 30 June 2022.
- Plastics by July 2021 for mixed plastics and July 2022 for any waste plastics.
- Tyres by December 2021.
- Glass by July 2020.

Options not evaluated in this study

The current study is limited to assessing a small selection of options related to the export of waste. Other possible options could include:

- exemptions for exports to overseas processors who are accredited for their waste management practices
- exemptions for exports to countries that have 'well regulated' waste management industries
- standards for Australian exports that are more differentiated than a full ban
- pre-planning for closure of overseas markets (or other significant shocks, such as closure of MRFs)
- market access negotiations to manage the time allowed for any closure of overseas markets
- reduction of barriers to domestic activities, which could include planning approvals and regulatory requirements on facilities
- policies to increase domestic demand for recycled material
- development of standards that increase domestic demand for recycled material
- aid-related expenditure to improve waste management practices in overseas countries.

There could also be options that operate in tandem with changes to export arrangements, such as waste levies that impact on diversion of exports to landfill.

These options are outside the scope of this study.

5 Measuring net costs for the waste industry

The starting point for considering a ban on exports is that this must impose a net cost on the waste industry itself. Otherwise, the activities would occur regardless of whether an export ban was put in place. However, and as shown in the numbers, there do appear to be opportunities for net benefits from further processing within Australia for plastic. The reasons for these opportunities not being pursued may reflect the risks inherent in the activities or these opportunities may be taken up over time even without an export ban. Some level of caution should be applied where estimates of gains to the waste industry from an export ban are positive in this case. This may suggest that the industry is unwilling to bear some of the risks, or would require much higher returns for doing so than modelled.

Paper and cardboard

Outcomes for waste in the presence of an export ban

IndustryEdge has provided a view on the most likely outcomes for processing of paper and cardboard waste in the presence of an export ban. These are consistent with views provided by stakeholders and previous CIE work. The main options and potential scale are:

- Manufacture of recovered paper pulp [>100 ktpa <500 ktpa]
 - It should be noted that this is essentially an intermediate level of reprocessing, where in general, recycled corrugating packaging mills will create this product and immediately manufacture recycled corrugated packaging materials
 - Creating this product is straight forward, requiring an addition to normal recycling equipment, primarily the addition of pulp driers
 - Drum pulping could be an option where volumes are smaller, as it is more scaleable.
- Manufacture of recycled corrugated packaging materials [>120 ktpa <300 ktpa]
 - These are <u>corrugating medium</u> (the middle layer of a corrugated box) and <u>testliner/recycled liner</u> (a recycled outer layer that is used for some box applications where the strength of a virgin fibre liner is not required)
- Manufacture of recycled cartonboard/folding box board (eg. cereal boxes) [>120 ktpa
 <300 ktpa]
 - Australia imports all of the supplies of this material, but two of the three major converters are owned by globally integrated manufacturers
 - Barriers to market entry are significant
- Manufacture of recycled office paper [>25 ktpa <100 ktpa]

- A significantly smaller volume than other grades, expansion is not particularly likely without a guaranteed end market, including Government procurement of recycled office paper
- Anaerobic digestion
 - Although a poor option from the perspective of retaining access to a transformed resource, the sheer volume of unexported material in the event of an absolute ban would be c.1.5 million tonnes per annum, in addition to existing utilisation for domestic purposes. Rather than likely, options like this would be required
- Moulded fibre / pet litter / other
 - Small volumes, but strong and fast growing markets. In the event of a total ban, options like these will be required at the margin

Some or all of the first three options would be required to deal with the scale of paper and cardboard requiring processing in the event of an export ban. In the absence of these processing facilities, paper and cardboard would likely be sent to landfill or where available a waste to energy facility. The costs of the above in terms of gate fees will be relatively similar — in both cases a gate fee will be paid for a landfill or waste to energy facility to take material, as compared to being paid for material.

Cost of additional processing

The costs of processing for paper are very high, because of the large volume of the material. Estimates of capex and opex for different scale facilities (excluding land and disposal costs) are shown in table 5.1. To process another million tonnes of paper domestically would have a capital cost of ~\$1 billion depending on the scale of the facilities.

Scale	Low	Moderate	High
Recovered paper pulp			
Throughput (input tonnes)	140 000	280 000	420 000
Capex (\$m)	190	248	295
Opex (\$m/year)	12	22	30
Recycled corrugated packaging			
Throughput (input tonnes)	210 000	448 000	630 000
Capex (\$m)	306	437	661
Opex (\$m/year)	22	45	59
Recycled cartonboard/folding box board			
Throughput (input tonnes)	210 000	336 000	420 000
Capex (\$m)	343	437	534
Opex (\$m/year)	29	44	48

5.1 Capital and operating costs for paper processing facilities

Note: Costs exclude land and disposal costs to landfill. Source: IndustryEdge.

Value of products

The prices of the products produced are shown in table 5.2. This compares to a current average export price for waste paper of \$210 per tonne.

5.2 Prices of products produced

Product	Material input	Stream	Central case
			\$/tonne of output
Recovered Paper Pulp	Paper	MSW	515
Recovered Paper Liner	Paper	C&I/C&D	605
Corrugating Medium	Paper	C&I/C&D	595
Coated Kraftback [Cartonboard]	Paper	NA	1025
Uncoated Cartonboard (Grayback)	Paper	NA	880

Note: All plastic produced is assumed to get the average of HDPE and PET prices. Source: IndustryEdge; Full Circle Advisory; CIE.

Comparing costs and material values

For the waste industry (and those who pay for it such as households and businesses), the main comparison is between the additional processing costs and the higher value of the material produced relative to what it is sold for in export markets. This varies considerably depending on:

- the amount of input material, which determines the scale of the processing facility and unit costs, and whether material would be transported to another state for processing
- which of the different processing options occur
- costs specific to each jurisdiction, such as land prices and waste disposal levies
- the amount of material lost as part of processing typically it takes 1.4 tonnes of inputs to make each tonne of product. However, this is likely higher for more contaminated streams (such as MSW) and lower for other streams such as C&I
- how long it takes before a facility is operational.

An example for a recovered pulp facility is shown in table 5.3, with everything converted to a per tonne basis. This example is at the optimistic end of the paper processing viability, because it uses a high capacity facility. In this example, capital costs per tonne of input are \$98, operating costs are \$72, land costs are \$29 and disposal to landfill of residual costs \$29. Total costs are \$229 per input tonne. Material produced sells for \$515 per tonne — in terms of value per tonne of input, this equates to \$343 per tonne, because it takes 1.5 tonnes to produce 1 tonne of output.

The maximum amount that a paper processor could pay and be commercially viable is \$114 per tonne. This is somewhat below the current average export price, but would be above the price of MSW paper. This suggests that further paper processing is a marginally commercial proposition.

Item	\$/tonne of mixed MSW paper	\$/tonne of product
Capital costs	98	
Operating costs	72	
Land costs	29	
Landfill disposal costs	30	
Total costs	229	
Material value	343	515
Maximum amount to pay for material	114	
1000 kgs of input	1000	667

5.3 Costs for processing of mixed MSW paper to recovered pulp (high capacity facility)

Note: This uses a landfill cost of 150 per tonne, land cost of 400 per m2.

Source: IndustryEdge; CIE.

A similar example is presented for C&I paper processed to recycled corrugated packaging in table 5.4. In this example, the processor would be able to pay at most \$257 per tonne of input material. This would be close to or slightly below the export values received.

5.4 Costs for processing of C&I paper to recycled corrugated packaging (high capacity facility)

Item	\$/tonne of C&I paper	\$/tonne of product
Capital costs	74	
Operating costs	94	
Land costs	29	
Landfill disposal costs	8	
Total costs	204	
Material value	462	600
Maximum amount to pay for material	257	
1000 kgs of input	1000	769

Note: This uses a landfill cost of \$150 per tonne, land cost of \$400 per m2. Source: IndustryEdge; CIE.

The CBA numbers present these estimates systematically accounting for the differences across jurisdictions.

Plastic

Outcomes for waste in the presence of an export ban

Full Circle Advisory has provided a view on the most likely options for processing of plastic waste in the presence of an export ban. These are consistent with views provided by stakeholders and previous CIE work. The high scale options are flaking or pelletising

plastic, which could then be either used domestically or exported — this would cover HDPE and PET primarily.

For C&I plastic, which, where collected, is much cleaner and homogenous (eg baling plastic), processing could be of LDPE into LDPE film and processing of PET and HDPE into pellets or flakes.

Plastics could also be used in chemical recovery or waste to energy facilities. These are broadly equivalent in their costs to landfill disposal, although would reduce the amount of material going to landfill. These are possible destinations for residual material — i.e. recycling undertaken for low value materials. For the purposes of the CBA we model residual material being disposed of to landfill.

There are also many smaller potential uses of recycled plastic. It is not possible to estimate the cost and material change for all of these. However, based on our past experience these would generally accommodate smaller volumes of plastics.

These could accommodate some additional volume but are not of a scale that they could meet the required processing if there was a ban on exports.

Cost of additional sorting

For some plastic waste, prior to processing there would be a need for sorting of mixed plastic bales into individual polymer types. This already occurs at some material recovery facilities. Material from container deposit scheme is also likely to be sorted into types (e.g. PET bottles).

The estimated cost of sorting a mixed plastic bale into its component resins and into colours is shown in table 5.5. This amounts to \$37 per tonne, not including landfill disposal costs.

Sorting equipment, which largely comprises additional optical sorters, would be added to existing material recovery facilities where there was space. However, many MRFs are space constrained, and in this case sorting would have to occur at a different site, potentially then directly feeding into the plastics re-processing.

Item	Note	Estimate	Unit
Capital cost per machine	Assumption	2 650 000	\$/machine
Life of machine	Assumption	7	years
Amortised machine cost	Calc	491 716	\$/machine/year
Output per machine	Assumption	20 000	t/year/machine
Ratio of opex to capex	Assumption	50%	Per cent of capex
Capital cost per tonne	Result	25	\$/t
Opex per tonne	Result	12	\$/t
Total cost per tonne	Result	37	\$/t

5.5 Sorting costs for mixed plastic

Note: The tonnes are the tonnes input. It is assumed that these sorting costs apply to 75 per cent of current MSW plastic. Source: The CIE, based on industry consultations. Landfill disposal costs could be very large for a sorting process. For example, a common product designation in recycling of kerbside material is a 4-4-2 bale, which is a mixed plastic bale containing 40 per cent PET, 40 per cent HDPE and 20 per cent other plastics. Where this is sorted, the output is baled HDPE, baled PET and a residual 2-2-6 bale (i.e. 20 per cent PET, 20 per cent HDPE and 60 per cent mixed plastic). These ratios imply that 83 per cent of HDPE and PET is extracted. The remaining 2-2-6 bale would comprise 32 per cent of the initial material, and it is likely that this would be landfilled domestically if there was an export ban (or sent to another disposal option such as waste to energy).

Cost of additional processing

The costs for equipment to process a PET and HDPE are shown in table 5.6. This is for a facility that has a single HDPE and PET processing line that can process 1 tonne per hour each of HDPE or PET — if operating for 12 hours a day this is ~7000 tonnes per year. A facility may have multiple lines, in which case the costs and volumes processed scale up accordingly.

Item	Capital cost
	\$m
Recycling equipment	
HDPE recycling line	1.7
HDPE pelletising line	2.0
PET recycling line	2.5
PET pelletising line	2.0
Other	
Ancillary equipment	4.6
Waste water treatment	1.0
Total capex	13.7

5.6 Capital costs for HDPE and PET pelletising

Note: Excludes land and buildings. For a HDPE recycling line of 1 tonne per hour and a PET recycling line of 1 tonne per hour. Source: Full Circle Advisory.

The operating costs are \sim \$100 per tonne — slightly higher if operating at lower scale and lower if operating at higher scale.²²

These costs do not include landfill disposal costs or land and building costs, which have also been added into the cost benefit analysis.

The above costs are somewhat below other available figures, such as those compiled by EnvisageWorks for a PET processing line. These are reported in Appendix B.

²² Provided by Full Circle Advisory.

Change in material value

HDPE and PET pellets sell for ~A\$1100 per tonne.²³ This is based on advice by Full Circle Advisory, and is consistent with r-HDPE and r-PET selling at a discount to virgin prices. This compares to a current export value of plastic of \$232 per tonne. Material losses are important in considering these values — the losses from mixed plastic to obtain a bale of PET and HDPE can be substantial. A further 20 per cent in weight could be lost in processing.

Table 5.7 shows the end of September 2019 recycled material prices as reported in Envisage Works 2019²⁴. Prices received for mixed plastics and mixed paper are at very low levels, and have been most impacted by China National Sword.

5.7 Recycled material commodity values end September 2019

Material category	Commodity	Price
		\$/tonne
Plastic	PET	375
Plastic	HDPE	550
Plastic	Mixed (1-7) a	65
Plastic	Mixed (3-7) a	-20

^a Refers to the plastic polymer type. PET (1), HDPE (2), PVC (3), LDPE (4), PP (5), Polystyrene (6) and other (7).

Note: Estimated prices at the out-going MRF gate, and prior to any secondary processing (along with the associated processing costs). Source: Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), p. 7

Table 5.8 shows the end of June 2019 virgin material commodity prices for virgin material commodities that are broadly competing with recycled material, as reported in Envisage Works 2019²⁵. Note that the prices of virgin material below and the price of recycled material above are not directly comparable, as different processing is required for using the materials in production. As noted above, the virgin and recycled material prices operate in a market where the two are substitutes, so their prices will be somewhat related.

5.8	Virgin material	commodity values	end June 2019
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Material category	Value
	\$/tonne
Plastic – PET (1) virgin resin	1 300-1 500
Plastic – HDPE (2) virgin resin	1 700-1 800
Plastic – PVC (3) virgin resin	1 100-1 300
Plastic – LDPE (4) virgin resin	1 700-1 800

²³ Provided by Full Circle Advisory.

²⁴ Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), p. 14

²⁵ Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), p. 14

Material category	Value
	\$/tonne
Plastic – PP (5) virgin resin	1 600-1 700
Plastic – PS (6) virgin resin	1 900-2 000

Source: Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), p. 14.

Comparing costs and material values

A comparison of the costs for processing a MSW plastic stream and the material values achieved is shown in table 5.9. This suggests that a domestic plastic processor could pay at most \$150 per tonne for a mixed plastic stream to achieve commercial viability. That is currently above the market price for a mixed plastic stream.

5.9 Plastic costs at different points of processing

	\$/tonne of mixed plastics	\$/tonne sorted (eg baled PET and HDPE)	\$/tonne product (pellets)
Sorting			
Sorting cost	37		
Disposal cost at sorting	49		
Total sorting cost	85		
Processing costs			
Capex		403	
Opex		98	
Disposal costs at processing		15	
Land costs		14	
Total costs (excluding input material)		530	
Material value			1100
Maximum payable for sorted material		350	
Maximum payable for unsorted material	151		
Material volumes from 1000 kgs unsorted	1000	677	541

Note: Note all material is disposed of to landfill. Losses during processing can occur in other ways. This uses a landfill fee of \$150 per tonne. Not that there are no sorting costs and smaller losses for C&I and C&D plastic. Source: Full Circle Advisory; The CIE.

Tyres

Outcomes for waste in the presence of an export ban

The export ban would apply to whole tyres exported, rather than to tyres that are shredded and exported. The most likely outcomes from an export ban are that:

- tyres are shredded and then exported this is a relatively low cost process. However, it does not add to the value of the material, as some buyers actually prefer whole tyres for use in energy facilities, rather than shredded tyres
- tyres are used in pyrolysis facilities converted back to basic products, such as oils
- tyres are landfilled or stockpiled landfilling is particularly expensive for tyres, as they are a hazardous waste. Financially, stockpiling would be much more likely, but is also limited by regulations.

Cost of additional processing

For the central CBA scenario, we model the cost of tyres being shredded relative to being exported whole in bales. Based on analysis undertaken for Tyre Stewardship Australia, this would have a cost of \$100 per tonne.

Change in material value

Analysis of export data provided by Blue Environment suggests that shredded tyres have a marginally lower reported value than whole waste tyres (\$45 per tonne versus \$66 per tonne). Analysis undertaken for Tyre Stewardship Australia agrees with this view that shredded tyres are actually sold for less per tonne than baled tyres.

There are also whole tyres exported that may not be for energy, but may be for reuse or retreading. The value of these is over \$1000 per tonne. In the event that these are subject to the export ban, we assume that they are also shredded, leading to higher processing cost and a large reduction in value.

Glass

Only small volumes of glass are exported, and this has been fairly intermittent historically. Glass currently exported includes some glass collected through container deposit schemes.

Our understanding is that it is not a long term proposition to export glass, but has occurred because of the need to find a recycling market for CDS glass in order to claim refunds and existing contracts that will run out soon that mean CDS glass is not diverted to glass bottling.

The preferred options for glass are likely to be domestic in the base case. This is because glass is very low value (often negative value). The likely domestic options are glass bottling and as a substitute for sand and aggregates in civil engineering projects.

We note that there is a lack of domestic demand for glass in many jurisdictions. Addressing issues related to this is a separate issue to the impacts of an export ban.

Given this, our central case does not have a continued export of glass and hence no costs. As a sensitivity, we show a scenario where glass currently exported is instead processed into a glass sand, and apply this to 15 000 tonnes per year from both of NSW and Victoria. This leads to:

- a loss of export value of \$49 per tonne
- processing costs of \$75 per tonne, based on previous CIE research and consultation with industry, and
- revenue from the sale of glass sand of \$10 per tonne.

6 Costs to government

There will be costs and benefits to governments arising from waste export ban. These include:

- costs to the Australian government of developing legislation, and for compliance and enforcement activities related to an export ban. These have not been able to be estimated by the Australian Government in the timelines available for this project, and will depend on more specific details about implementation not yet known
- additional revenue to government from waste levies applied to landfills, for material that is landfilled as a result of the export ban. This includes material landfilled where domestic processing is not available and residual material landfilled after processing. Note that this is also reflected as a cost to the waste industry, so it has no net impact
- costs to local councils for renegotiation of contracts for kerbside recycling. An export ban would be a regulatory change that would likely trigger variations to kerbside contracts. Based on past renegotiations in response to China National Sword, the costs of this could be \$50 000 to \$100 000 for a larger council. However, there may also be such costs in the base case, if other countries ban exports and such a change falls within the contract variation arrangements.

These costs are not currently included in the central case numbers reported, except for waste levies accruing to government.

7 Environmental benefits of policy interventions

This chapter firstly examines the environmental impacts from mismanaged waste and subsequently examines environmental impacts throughout the waste supply network.

Key findings with respect to environmental impacts from mismanaged waste are:

- The key focus is mismanaged plastic waste entering the ocean. There is minimal information in the literature on the extent and impacts of other forms of mismanagement (litter, open dumps, uncontrolled burning).
- There is incomplete information on the impacts of plastics in the marine environment, including the magnitude. Potential impacts include impacts on food chains, biodiversity and human health from microplastics, chemical pollution, reduced amenity and tourism, and damage to assets.
- Examples of direct and indirect costs from plastics in the ocean are available. However, without information on the final outcomes of plastics in the ocean a damage cost curve can not be established to quantify the economic value of mismanaged plastic entering the ocean.

The key inputs into the cost benefit analysis regarding mismanagement of waste are:

- 100 per cent of exports from Australia classified as high-valued material are assumed to be appropriately managed in the receiving economy. For example, given the high values of HDPE and PET, we assume that all such material is recycled. The shares of material assumed to be low value is set out in Appendix A, and ranges from 20 per cent for mixed plastic and paper to smaller levels for other materials
- 7 per cent of the residual export waste stream (i.e. low value material) is assumed to be mismanaged and leaked into the ocean, or having some other form of impact
- in the absence of sufficient information to quantify the impacts from plastics in the ocean, a cost effectiveness approach is applied using an estimate of \$550 per tonne of plastic-waste leakage prevented. That is, we compare the cost to the Australian community per tonne of avoided mismanagement material to the cost of improving management in the countries themselves to avoid plastics entering the ocean.

The environmental and health impacts of waste management within Australia is examined, including the relative benefits of recycling compared to landfill and external costs from waste transportation. Key inputs into the cost benefit analysis include:

- amenity externalities related to landfills
- benefits of recycling relative to the alternative of landfilling, from a lifecycle perspective. This covers the air pollution, water pollution and GHG emission impacts across the supply chain

external costs from waste transportation interstate that results from an export ban.
 This covers air pollution, GHG emissions, noise pollution and water pollution. Social impacts are related to congestion., accidents and road wear and tear.

Mismanagement of waste in importing countries

Mismanagement of waste includes inadequate disposal, litter, and uncontrolled burning. Inadequate disposal includes disposal in dumps or open, uncontrolled landfills where it is not fully contained.²⁶

A key focus in the literature is understanding how much mismanaged waste leaks into the ocean, particularly plastic waste. Leakages into the ocean can occur when waste is littered or placed in dumps of open and uncontrolled landfills which subsequently enter the ocean directly or via inland waterways which act as transport channels to the ocean.²⁷

- 32 million tonnes of mismanaged waste per year occurs within 50 kilometres of the coastal zone
- 76 million tonnes of mismanaged waste per year occurs within the area of the global river catchments.²⁸

Available estimates of plastic waste leakage into the ocean vary considerably. Jambeck, et al. (2015) estimated the amount of plastic waste entering the ocean from land each year exceeds 4.8 million tonnes, and may be as high as 12.7 million tonnes.²⁹ Schmidt, et al, 2017, estimated the contribution of plastic waste into oceans that derives from rivers, with an estimate ranging between 0.41 and 4 million metric tonnes of plastic waste per year.³⁰

The focus of this study is the mismanagement of waste types which are imported from Australia into overseas domestic waste systems. Available estimates do not distinguish between leakages from domestic waste and imported waste.

Available estimates of plastic waste mismanagement and plastic waste leakage are discussed from two sources:

²⁶ Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, KL., 2015, Plastic waste inputs from land into the ocean, *Sciencemag, 2015, Vol 347, Issue* 6223.

²⁷ APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics

²⁸ Schmidt, C., Krauth, T., and Wagner, S., 2017, *Export of plastic debris by rivers into the sea*, Environmental Science and Technology 2017, 51, 12246-12253.

²⁹ Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, KL., 2015, Plastic waste inputs from land into the ocean, *Sciencemag, 2015, Vol 347, Issue* 6223.

³⁰ Schmidt, C., Krauth, T., and Wagner, S., 2017, *Export of plastic debris by rivers into the sea*, Environmental Science and Technology 2017, 51, 12246-12253.
- Ocean Conservancy (2015) for the five countries examined (China, Indonesia, the Philippines, Thailand and Vietnam).³¹
- Jambeck, et. Al. (2015) which examined mismanaged plastic waste across 192 countries³²

Another concern is the mismanagement of tyre waste, either at non-complying pyrolysis plants or open burning. This is discussed in detail below.

Ocean Conservancy

The Ocean Conservancy (2015) investigated the key sources of plastic leakage into the ocean and found:

- At least 80 per cent of ocean plastic comes from land-based sources
- Over half of the plastic which enters the ocean comes from five countries China, Indonesia, the Philippines, Thailand, and Vietnam.
- Two drivers of plastic leakage are:
 - waste that remains uncollected 75 per cent of plastic waste leakage from land based sources comes from uncollected waste (e.g. waste piles and dumping of waste into waterways)
 - value of plastic waste, with a higher rate of leakage for low residual value plastic waste.³³
- On average in the five priority countries, 7 per cent of collected waste is currently leaked into the ocean.

The Ocean Conservancy (2015) conducted case studies in China and the Philippines to identify the key sources of plastic waste leakage. The five key sources are:

- low-waste-density rural areas that do not have collection services
- medium-waste-density urban areas that lack proper waste-management infrastructure
- high-waste-density urban areas whose services are overstretched or where the cost to citizens of waste management discourages use of the services
- illegal dumping by trash haulers when waste transport systems are poorly regulated
- dump sites on waterways. Collection systems in the focus countries still make heavy use of informal or 'open' dump sites.

Across the five priority countries examined by Ocean Conservancy (2015), these five leakage points contribute to between 7.0 million and 8.6 million metric tonnes of plastic waste into the ocean per year (table 7.1).

³¹ Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean.

³² Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, KL., 2015, Plastic waste inputs from land into the ocean, *Sciencemag, 2015, Vol 347, Issue* 6223.

³³ Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean.

The leakage points relevant for this study are the two from the collected waste system, illegal dumping by trash haulers and dump sites on waterways. The two sources are estimated to leak between 1.8 million and 2.2 million metric tonnes of plastic in the ocean per year. This is equivalent to between 6 per cent and 7 per cent of the 30 million metric tonnes of collected plastic waste in these five countries.³⁴

Leakage source	Collected or uncollected waste	Plastic entering ocean per year
		metric tonnes
Low-waste-density rural areas	Uncollected	1.7 - 2.1
Medium-waste density urban areas	Uncollected	1.9 - 2.4
High-waste-density urban areas	Uncollected	1.6 - 1.9
Illegal dumping by trash haulers	Collecteda	0.7 - 0.9
Dump sites on waterways	Collecteda	1.1 - 1.3
Total		7.0 - 8.6

7.1 Leakage sources of plastic waste entering ocean in five priority countries

^a Assumed to be from the collected waste stream based on information provided.

Note: The five priority countries in the Ocean Conservancy (2015) study area China, Indonesia, Philippines, Thailand and Vietnam. Source: Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean.

The case studies in China and the Philippines highlighted the nature of the problem differs across countries and there is no single solution. Key findings include:

- Waste management systems differ substantially across countries with collection rates differing between countries, as well as between urban and rural areas. The Philippines has a nationwide average collection rate of 85 per cent. Conversely the overall collection rate in China is just under 40 per cent, with a collection rate of 65 per cent in urban areas, decreasing substantially to 5 per cent in rural areas.
- Countries have different leakage points. Almost three quarters of the plastic waste leakage in the Philippines comes from mismanagement in the collected waste stream. Conversely over 80 per cent of the plastic waste leakage in China comes from mismanagement in the uncollected waste stream (including waste piles and plastic waste in rural communities routinely disposed of into waterways) (table 7.2).
- Proximity to the ocean and waterways is a key driver of plastic waste leakage to the ocean. The Philippines is surround by water coupled with an extensive network of rivers and tributaries which increases the likelihood of mismanaged waste entering waterways and the ocean. In the Philippines, nearly 100 per cent of the population live near a significant waterway.³⁵
- The informal waste collection sector differs across countries depending on waste density and collection coverage
- Treatment options differs, driven largely by government policy. Approximately 80 per cent of China's collected waste is treated at incinerators or sanitary landfills. Conversely, incineration is currently prohibited in the Philippines.

³⁴ Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean.

³⁵ Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean.

Waste system	Type of mismanagement	Proportion of plastic waste leakage into	
		Philippines	China
		per cent	per cent
Collected	Hauler dumpingPoorly located dumps	74	16
Uncollected	Waste pilesLittering	26	84

7.2 Leakage points for Philippines and China

Source: Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean

Study by Jambeck et. Al.

Jambeck et. At. Calculated the amount of mismanaged plastic waste generated annually by populations across 192 coastal countries which potentially could enter the ocean as marine debris. The results were based on waste estimates for 2010 and the authors note the results do not capture some activities such as illegal dumping, informal recycling and waste collection, and international import and export of waste.

The results provide an indication of proportions of mismanaged waste, mismanaged plastic waste and plastic marine debris for the top 20 countries (table 7.3).

Country	Waste generated	Plastic waste	Mis- managed waste	Mis- managed plastic waste	Proportion managed waste that marine	n of mis- plastic becomes debris	Plastic mar	ine debris
	MMT/yr	per cent	per cent	MMT/yr	Per cent (Low)	Per cent (High)	MMT/yr (Low)	MMT/yr (High)
China	105.6	11.0	76.0	8.8	15.0	40.0	1.32	3.53
Indonesia	35.5	11.0	83.0	3.2	14.8	39.8	0.48	1.29
Philippines	15.2	15.0	83.0	1.9	14.8	39.6	0.28	0.75
Vietnam	16.1	13.0	88.0	1.8	15.2	39.6	0.28	0.73
Sri Lanka	27.2	7.0	84.0	1.6	15.0	40.0	0.24	0.64
Thailand	11.4	12.0	75.0	1.0	14.6	40.0	0.15	0.41
Egypt	10.9	13.0	69.0	1.0	15.3	39.9	0.15	0.39
Malaysia	12.7	13.0	57.0	0.9	14.9	39.3	0.14	0.37
Nigeria	7.9	13.0	83.0	0.9	15.2	39.7	0.13	0.34
Bangladesh	11.1	8.0	89.0	0.8	15.1	39.1	0.12	0.31
South Africa	9.4	12.0	56.0	0.6	14.2	39.5	0.09	0.25
India	23.3	3.0	87.0	0.6	14.8	39.5	0.09	0.24
Algeria	7.3	12.0	60.0	0.5	15.3	40.1	0.08	0.21
Turkey	22.0	12.0	18.0	0.5	14.8	40.0	0.07	0.19
Pakistan	4.2	13.0	88.0	0.5	14.5	39.5	0.07	0.19
Brazil	28.1	16.0	11.0	0.5	14.2	38.4	0.07	0.19

7.3 Top 20 countries ranked by mass of mismanaged plastic waste

Country	Waste generated	Plastic waste	Mis- managed waste	Mis- managed plastic waste	Proportion managed waste that marine o	i of mis- plastic becomes debris	Plastic mar	ine debris
Burma	3.1	17.0	89.0	0.5	15.2	39.0	0.07	0.18
Morocco	9.2	5.0	68.0	0.3	16.0	38.3	0.05	0.12
North Korea	3.8	9.0	90.0	0.3	16.3	39.1	0.05	0.12
United States	106.3	13.0	2.0	0.3	14.5	39.8	0.04	0.11

Note: Waste estimates are based on 2010 levels.

Source: Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, KL., 2015, Plastic waste inputs from land into the ocean, Sciencemag, 2015, Vol 347, Issue 6223.

Mismanagement of tyre waste

Mismanagement of tyre waste relates primarily to whole baled tyres. Currently approximately 16 per cent of Australian exported end-of-life (EOL) tyres is baled tyres.³⁶ The key destinations for whole baled tyre waste is India and Malaysia. There are concerns that a large proportion of this tyre waste is mismanaged at non-complying pyrolysis plants or through open burning.

The Australian Tyre Recyclers Association (ATRA) used GPS technology in 2017-18 to track bales of whole tyres leaving Australia. The study found that once landed in India, these bales were on-sold and distributed throughout India to be burnt either at non-complying-pyrolysis plants or in the open (heating various drying kilns).³⁷

A recent Indian tyre manufacturers survey estimated that 20 per cent of used tyres in India are burnt in the open to preheat various kilns, and another 31 per cent are consumed in pyrolysis operations (table 7.4). The ATRA estimate that 100 per cent of imported bales of tyres into India end up in one of these two outcomes.³⁸

Description	Tyre	Tube
	per cent	per cent
Clean/polished and sold (tyres with tread left)	15	15
Used for regrooving/retread	22	23
Used by art and craft creator	2	2
Used in pyrolysis	31	33
Used for burning	20	19
Road crumbs for road	6	4

7.4 End of life tyre outcomes in India

³⁶ MRA Consulting Group, 2019, *Tyre Recycling Capacity and Change: A submission to Australian Tyre Recyclers Association, a division of the Australian Council of Recyclers (ACOR).* Provided to CIE by the Department of the Environment and Energy.

- ³⁷ Australian Tyre Recyclers Association, 2019, *Letter to Indian Ministry of Environment and Forests, 17 January 2019.* Provided to CIE by the Department
- ³⁸ Australian Tyre Recyclers Association, 2019, Letter to Indian Ministry of Environment and Forests, 17 January 2019. Provided to CIE by the Department

Description	Tyre	Tube
	per cent	per cent
Recycle	3	2
Crumbs for recycle	0	0
Others	2	2
Reclaim rubber	0	0
Pulverizing of rubber	0	0

Source: Australian Tyre Recyclers Association, 2019, Letter to Indian Ministry of Environment and Forests, 17 January 2019. Provided to CIE by the Department.

The Central Pollution Control Board (CPCB) has estimated that of the 637 tyre pyrolysis units across India, 251 units are complying, 270 units are not complying and 116 units are closed.³⁹ Approximately 52 per cent of operating units are not complying.

Estimated mismanagement used in this study

There is currently limited information on the type and quantity of Australia's exported waste which is mismanaged. Proportions of mismanaged plastic waste entering the ocean and mismanaged whole baled tyres have been estimated based on the limited information available. These estimates are discussed below.

Plastic waste entering the ocean

As noted above two key determinants in the mismanagement of waste in key countries receiving our waste exports are:

- Whether the waste is collected or uncollected. In general, a lower proportion of waste is mismanaged when it is collected in a formal system.
- The value of the material, with higher mismanagement of low valued materials.

Australia's exported waste is received into the collection system of the import country and approximately 80 per cent of plastic waste and 95 per cent of other waste types (paper, tyres and glass) is high-valued material.⁴⁰ It is assumed that all high-valued material is managed appropriately. The potential for mismanagement is applicable only to the 20 per cent of Australia's exported plastic waste and 5 per cent of exported paper⁴¹, tyres and glass that is low valued materials.⁴²

The results from the Jambeck et al. study do not differentiate between waste that is collected versus uncollected, nor the value of the plastic. As noted above, uncollected and low-value plastic waste are key drivers for the quantity leaked to the ocean. For these

42 Estimates based on CIE modelling.

³⁹ Central Pollution Control Board Dehli, 2019, Status Report on Compliance of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016 and Remedial Measures in Tyre Pyrolysis Industries. Provided to CIE by the Department

⁴⁰ Except in the case of MSW waste for which only 80 per cent of exported paper waste is high valued.

⁴¹ 20 per cent of MSW paper waste is low valued material.

reasons, the Jambeck et al. study results are not used in this study as Australian exports will enter the collection system of the importing country.

Leakage points for collected low-value imported waste include illegal dumping by haulers and disposal in open and uncontrolled landfills. Subsequently, this mismanaged waste can spread resulting in litter on the land or entering waterways and/or the ocean.

The current focus is mismanaged waste that is leaked to the ocean, particularly mismanaged plastic waste. Based on available estimates, it is assumed that 7 per cent of Australia's exported low-valued waste materials (material that is residual to a recycling process) are mismanaged and subsequently leaked into the ocean.

Whole baled tyres

The two forms of mismanagement are burning in the open and processing at non-compliant pyrolysis plants. Based on available information, the following proportions of mismanaged whole baled tyre exports are applied (table 3.2):

- 39 per cent open burning
- 32 per cent processed at non-compliant pyrolysis units.

The estimated proportion of baled tyres processed at non-compliant pyrolysis units is based on the number of non-compliant pyrolysis units relative to total operating pyrolysis units. It does not account for the volume of Australian exported baled tyres received at each unit, as this is currently unknown. The assumption that 32 per cent is processed at non-compliant pyrolysis units therefore assumes that each of the 521 operating (compliant and non-compliant) tyre pyrolysis units receives the same volume of imported baled tyres. Given the uncertainty regarding volume of tyre waste processed at non-compliant pyrolysis units, only the tyre waste that is managed through open burning is included the analysis and results.

The information on mismanagement of whole baled tyres primarily relates to India. There is limited information for Malaysia. Therefore, for this study we apply the same mismanagement proportions for India and Malaysia.

7.5 Assumed mismanagement of baled tyres

End of life	Baled tyres
	per cent
Compliant pyrolysis (not mismanaged)	29
Non-compliant pyrolysis	32
Open burning	39
Total	100

Source: CIE based on Australian Tyre Recyclers Association, 2019, Letter to Indian Ministry of Environment and Forests, 17 January 2019. Provided to CIE by the Department and Central Pollution Control Board Dehli, 2019, Status Report on Compliance of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016 and Remedial Measures in Tyre Pyrolysis Industries.

Environmental, health and social impacts of mismanaged waste

Waste and recycling systems throughout the world are characterised by numerous market failures, as well as policies and regulations to address these, sometimes with unintended outcomes. The extent of market failures and accompanying regulations differ across countries, resulting in varying degrees of environmental, health and social impacts. In the presence of market failures, environmental, health and social impacts will be greatest in the absence of effective regulations.

There are also environmental, health and social impacts from the transportation of waste to disposal points. The impacts from transport of waste within Australian waste management systems is outlined in Appendix D. This discussion does not outline the impacts from shipping export materials abroad, due to an absence of information on shipping externalities, or the transport impacts within importing countries.

Impacts arising from mismanagement of plastic waste leaking into oceans

The current focus on the impacts of plastics in the marine environment is driven by the persistence of plastics within the ocean with effects on wildlife and potentially humans. ⁴³ It is considered that plastics break down over time into micro-plastics and do not decompose.⁴⁴ The lack of decomposition is what distinguishes plastic from other waste types such as paper and cardboard.

There is incomplete information on the impacts of plastics in the marine environment. Potential avenues for impacts are:

- plastics which break down into small particles (microplastics) can be ingested by marine invertebrate, injuring marine wildlife⁴⁵, impact on food chains and biodiversity and potentially human health
- chemical pollution from plastics in the marine environment:
 - plastics in the marine environment can absorb chemical pollutants from surrounding waters and transport them great distances as they move around with ocean currents.
 - when animals eat plastics, these chemical pollutants can leach into their stomachs
 - plastic products also contain chemical additives such as flame retardants, UV stabilisers and colorants which are added to the plastics during manufacturing. In the marine environment, these chemical additives can leach into surrounding waters, posing another chemical threat to marine life.
 - seven plastic items contribute more than 87 000 metric tonnes of plastic debris to our oceans and carry with them 190 metric tonnes of 20 different chemical

⁴³ Thompson, R., Moore, C., vom Saal, F., and Swan, S., 2009, Plastics, the environment and human health: current consensus and future trends, *Phil. Trans. R. Soc. B (2009) 364, 2153-2166.*

⁴⁴ APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics.

⁴⁵ Goldstein, M. C. and Goodwin, D. S., 2013 sourced in Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, KL., 2015, Plastic waste inputs from land into the ocean, *Sciencemag, 2015, Vol 347, Issue 6223.*

additives. These seven items account for only about 1 per cent of the estimated 8 million metric tonnes of plastic entering the oceans each year.⁴⁶

- plastic litter along coastlines can reduce tourism
- plastic debris within the ocean can cause damage to fishing equipment and vessels. It is important to note that plastic debris which causes impediments to the fishing industry include (in order of most concern) old fishing gear, plastic bags and utensils, balloons, cigarette butts and bottle caps.⁴⁷ Many of these types of plastic are sourced from Australian exported waste products.

Impacts arising from mismanagement of tyre waste

Evidence suggests that substantial health and environmental impacts occur from the mismanagement of whole baled tyres in overseas countries, primarily India and Malaysia.

Whole baled tyres can retain water during transportation and processing, which can enable the spread of Malaria, Dengue and Yellow fever. The World Health Organisation has identified the international movement of whole, unprocessed tyres as a key factor in the increase in Dengue incidences.⁴⁸

Non-compliant pyrolysis plants emit high levels of pollution including sulphur dioxide, particulate matter, nitrogen oxides, dioxins and furans, hydrocarbon gases, volatile organic compounds, heavy metals, carbon dioxide and carbon monoxide.⁴⁹ The Indian Green Tribunal observed the following negative outcomes from non-compliant pyrolysis operations:

- spillage of carbon in the working area
- exposure of workers to fine carbon particles
- emissions of pyro gas or uncondensed gases for flaring
- release of odours in plant and local area
- fugitive emissions of charcoal/fine carbon particles
- spillage and floor washing containing charcoal particle and oil.

Open burning of tyres creates smoke, pyrolytic oil, ash, black carbon and harmful chemicals and pollutants (table 7.6). Groundwater and surface water sources can be contaminated by run-off through exposed scrap tyre fires.

⁴⁶ Ocean Conservancy, 2019, Plastic pollution is chemical pollution. https://oceanconservancy.org/blog/2019/04/23/plastic-pollution-chemical-pollution/

⁴⁷ APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics.

⁴⁸ Australian Tyre Recyclers Association (ATRA), 2019, Letter to the Minister for Environment: Used Tyre Exports from Australia, 13 September 2019. Provided to CIE by the Department.

⁴⁹ Australian Tyre Recyclers Association, 2019, *Letter to Indian Ministry of Environment and Forests,* 17 January 2019. Provided to CIE by the Department

Byproduct category	Pollutant
Chemicals	Polycyclic aromatic hydrocarbon, benzenes, naphthalenes, toluene, ethyl benzene, anthracene, thiazoles, dioxins, furans, amines and other different forms of petroleum hydrocarbons
Pollutants and heavy metals	Cadmium, chromium, nickel and zinc, Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), Polynuclear Aromatic Hydrocarbons (PAHs), particulate matter, carbon monoxide, sulfur, nitrogen oxides, acid gasses, sulfates

7.6 Byproducts of open, uncontrolled burning of tyres

Source: Ziadat, Anf. H, and Sood, E., 2014, An Environment Impact Assessment of the Open Burning of Scrap Tires, Journal of Applied Sciences 14 (21): 2695-2703.

Direct health impacts include asthma and respiratory complications, aggravation of existing cardiovascular illnesses, eyes irritation, cough and chest pain, nervous system depression, high blood pressure and subsequent heart disease, adverse effects on kidneys, liver, nervous system, cancer and inflammation of mucous membranes.⁵⁰ The extent of health impacts depends on the length and degree of exposure and the population exposed. The concentration of pollutants is influenced by meteorological conditions and directly influences the degree of exposure.

Studies have estimated the change in ambient air concentration from the open burning of scrap tyres. Anf and Sood (2014) estimated the change in ambient air concentrations of particulate matter and compared it to US EPA's particulate matter Air Quality Index. The results showed the ambient air concentrations were:

- unhealthy for sensitive groups for 14.3 per cent of the study period
- unhealthy for 28.5 per cent of the study period
- very unhealthy for 14.3 per cent of the study period
- hazardous for 42.9 per cent of the study period.⁵¹

Jimoda et al. (2017) investigated the emission of gaseous pollutants, carbon monoxide (CO), nitrogen dioxide (NO₂ and sulphur dioxide (SO₂). The results showed that the levels of each of the three pollutants were categorised as 'unhealthy for sensitive groups' 25 per cent of the study period. Otherwise results were categorised primarily as 'moderate'.⁵²

⁵⁰ Ziadat, Anf. H, and Sood, E., 2014, An Environment Impact Assessment of the Open Burning of Scrap Tires, Journal of Applied Sciences 14 (21): 2695-2703.

⁵¹ Ziadat, Anf. H, and Sood, E., 2014, An Environment Impact Assessment of the Open Burning of Scrap Tires, Journal of Applied Sciences 14 (21): 2695-2703.

⁵² Jimoda, L. A., Sulaymon, I. D., Alade, A. O. and Adebayo, G. A., 2017, Assessment of environmental impact of open burning of scrap tyres on ambient air quality, Int. J. Environ. Sci. Technol. DOI 10.1007/s13762-0.17-1498-5.

Impacts arising from other forms of waste mismanagement

The broad range of environmental, health and social impacts from other waste mismanagement are listed in table 7.7 and include visual dis-amenity, emissions of air pollutants and GHGs, increased risk of disease, and potential risk to groundwater sources through leaching toxins. Impacts from waste mismanagement differ by type of waste disposal and type of waste material. For example, mismanagement of tyre waste can result in greater impact, such as:

- increasing the risk of disease when tyres are dumped and create an ecosystem for rodents and insects enabling disease transmission
- released highly toxic waste into soil and air when burnt without proper controls
- contamination of soil, water and air due to emission of chemical contaminants formed during the decomposition of the scrap tyres. ⁵³

There are also health risks to waste pickers in informal collection systems related to working in proximity to toxic materials and potential for waste to combust and catch on fire.⁵⁴ Ocean Conservancy (2015) notes that open dump sites are responsible for hundreds of deaths of waste pickers.⁵⁵

Incineration conducted with older technology and/or in the absence of appropriate controls emit high levels of air pollutants including dioxins, heavy metals and other contaminants.⁵⁶ Unrecycled plastics imported by Indonesia are often burned to produce heat for tofu factories, which has human health impacts.⁵⁷ A high proportion of collected waste in China is incinerated. There was insufficient information on the proportion of incinerators in China and elsewhere (and other controls using incineration) that meet appropriate controls and standards.

Mismanagement	Environmental, health or social impact
Litter	Visual dis-amenityPotential for disease
Illegal dumping	 Visual dis-amenity Health risks to waste pickers Increased risk of fire (e.g. tyre waste) Increased risk of disease

7.7 Economic, environmental and social impacts of waste mismanagement

- 54 Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean
- 55 Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean
- ⁵⁶ Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free ocean
- 57 See https://www.nytimes.com/2019/11/14/world/asia/indonesia-tofu-dioxin-plastic.html

⁵³ Neto, G. C. d O., Chaves, L. E. C, Pinto, L. F. R, Santana, J.C.C, Amorim, M.P.C. and Rodrigues, M.J.F, 2019, *Economic, Environmental and Social Benefits of Adoption of Pyrolysis Process* of Tires: A Feasible and Ecofriendly Mode to Reduce the Impacts of Scrap Tires in Brazil, Sustainability 2019, 11, 2076; doi:10.3390/su11072076

Mismanagement	Environmental, health or social impact
Open and uncontrolled landfills	 GHG emissions Visual dis-amenity Toxic leachate to soil and groundwater Health risks to waste pickers Increased risk of fire (e.g. tyre waste) Increased risk of disease
Leakage to waterways and the ocean	Visual dis-amenityHealth impacts to marine lifePotential health impacts to human life
Incineration (unmanaged)	 Emissions (dioxin, heavy metals and other contaminants) Release of toxic waste in soil and air (burning tyres) Impacts on human health from use in food preparation (e.g. burning plastic at tofu factories)

Source: The CIE.

Costs that accrue to the Australian economy

All external costs arising from waste management systems conducted within Australia are borne by the Australian economy. In contrast external costs from waste management systems abroad are primarily borne by the local communities with only a select few external costs being borne by the global community. The key external costs that are extend beyond nations boundaries are impacts from greenhouse gas emissions and waste leakage to marine environment (table 7.8).

7.8 Community bearing environmental, health and social impacts

Environmental, health and social impacts	Local or global community
Air pollution	Local
Water pollution	Local
GHG emissions	Local /Global
Visual dis-amenity from landfills/open dumps	Local
Litter on land	Local
Waste leakage to marine environment	Local /Global
Health hazards and potential diseases from landfills/open dumps	Local
Source: The CIE.	

Economic costs of mismanaged waste

The economic cost of mismanaged waste comprises direct costs, remedial costs and indirect damage costs (including health, environmental and social costs). There are two key steps to estimate the economic cost of mismanaged waste:

identify the physical change in environmental condition — how does mismanaged waste impact on the existing environment (e.g. change water or air quality, impact marine species health), and what is the nature of these impacts (e.g. duration and extent of the impact, whether the change is temporary or permanent, or irreversible).

estimate the economic value associated with the physical change — involves estimating the use and non-use values society holds for the impacted environmental attributes. Not all changes to environmental condition can be valued and some environmental attributes are more amenable to non-market valuation techniques.

The environmental and health impacts of mismanaged plastic entering the ocean and open burning of tyre waste have been stated above. However there is insufficient information on the physical change in environmental condition resulting from these mismanagement types to estimate the economic cost. For example, it is not currently known how water quality changes or the mortality/morbidity rates of marine species for a unit change in quantity of plastic entering the ocean. Similarly the change in ambient air concentrations for key pollutants resulting from open burning of tyre waste is not known for the open burning sites in India and Malaysia, along with the population exposed.

In the absence of information to estimate the economic value of mismanaged waste, alternative indicators of economic cost are discussed below for mismanaged plastic waste.

Estimates of direct costs, remedial costs and indirect damage costs for plastic debris

A recent study by APEC estimated the damage costs to the marine industries attributed to marine debris was US\$10.8 billion per annum.⁵⁸ This is an increase from the estimate in the previous APEC 2009 report of \$1.26 billion, increasing due to improved data, growth in the marine economy and growth in the amount of plastic waste in the oceans over the last decade. This direct cost comprises costs associated with damage to fisheries and aquaculture, marine transport, shipbuilding and marine tourism industries from marine debris.⁵⁹ The APEC study did not quantify remedial costs and indirect damage costs.

Table 7.9 lists estimates of direct damage costs, remedial costs, and indirect damage costs from various studies relating to mismanaged plastic waste in the APEC region.

Sector	Type of damage/loss	Type of debris	Estimated cost
Direct damage to marine	industry in APEC region		
Fishing	Damage to fishing boats	Floating objects	6.6 billion Yen
Shipping and transport	Damage to commercial leisure boats	General, entanglement of propellers and ingestion	Cost of repairs, lost sales and downtime of \$792 million
	Loss of fishing product value from ship container spill of plastic pellets	Plastic pellets spill	30-40% price reduction to fish farmers in area of plastic nurdle spill

7.9 Estimates of damage costs in the APEC region from mismanaged plastic waste

⁵⁸ APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics.
⁵⁹ APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics.

Sector	Type of damage/loss	Type of debris	Estimated cost
Marine tourism/leisure	Economic cost of marine debris on Californian beaches	Marine debris	25% capita reduction in marine debris for 31 beaches gave aggregated benefits of \$29.5 million (2013 dollars)
	Flood litter impacts in tourism area	Litter and other waste washed down rivers into beaches	Visitor count at the Island's beaches decreased by 63 percent, with tourism revenue loss of US\$29-\$37 million to the Island
	Mass marine litter wash up reducing tourism revenue	Plastic and marine debris	Tourism expenditure loss of \$379 million to \$3.6 billion in New Jersey
Remedial costs of debris	clean-up in the APEC region		
Shipping and transportation	Loss of a container of plastic pellets	Plastic pellet and container recovery and clean up	USD \$1.29 million to clean up 150 tonnes plastic nurdle spill
Shoreline and ocean clean up and Shipping and Transportation	Subsidy to local government for coastal clean-up or reducing waste generation 2009-2016 program (8 years)	Marine litter and shoreline debris	Total cost of US\$451 million to remove 214,711 tonnes of debris over 8 years. Average cost of US\$2,102/tonne
	Clean up under 2 nd National Marine Litter plan (2014-18). A total of 348,000 tonnes of debris removed	Marine litter – shoreline (63%) and floating (7%) and natural disaster (30%)	US\$282 million spent over 5 years. Cost per tonne US\$810 across 21 programs.
Marine tourism/leisure	Annual cost of cleaning municipal beaches and waterways for New York City	Debris	\$2,719,500 at a per capita cost of \$0.33
	Cost of combatting litter and curtailing marine debris in Washington, Oregon and California	Litter	\$520 million spent annually to combat litter and curtail marine debris.
	Budget implications of marine litter for 30 Local government coastal councils	Litter and waste	Any council that was spending more than 8% has an implied net cost to members.
	Marine Litter leakage prevention	Marco plastic – storm water drains on Sydney beaches over various local government areas	No cost provided
	Examined benefits of reducing debris in six beaches near the mouth of Los Angeles River	Reduction of marine plastics from urban sources to urban beachers	Reducing debris by 75%, visitations to the beaches is estimated to increase 43%, with a revenue of US\$53 million
All sectors	Estimate of global cost of remediation over 10 years to 2020	Marine plastic debris	\$5 billion per annum, \$550 per tonne of leakage prevented
Indirect cost impacts of r	narine debris in the APEC regio	on	
Shipping and transportation	Container spill of plastic pellets	Plastic pellets	MV Rena grounding with US\$600 million spent on recoverv

Sector	Type of damage/loss	Type of debris	Estimated cost
Marine tourism/leisure	Loss of amenity to beaches and reefs	Plastics, fishing and general debris	US\$1 - US\$28 m/yr
	Loss of recreational expenditure and regional economic effects	Marine debris	For Orange Beach, CA. reducing MD to zero would add \$137 million, while doubling MD would cost \$304 million
Wildlife and Marine Ecosystem	Plastic damage of coral reefs via disease	Plastic debris	The likelihood of disease increase from 4% to 89% when corals are in contact with plastic
Community	Clean Up Australia Day	Shore line and waterways, litter and marine debris	US\$26 million per year (Value of volunteers, local government collection services and management and administration costs

Note: Excludes examples of direct damage to the marine industry result from plastic types that are not found in Australia's exported waste materials (e.g. fishing gear).

Source: APEC, 2020, Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economics.

Community value to reduce ocean-based litter

It is clear from community views and from willingness to pay work the CIE has undertaken for Victoria that people place a high value on avoiding marine environmental impacts. The specific value, and the extent to which values relevant for an Australian context are also relevant for overseas contexts is not clear. Values related to biodiversity impacts would likely be more indifferent to where impacts occur as compared to values related to pollution of beaches and other disamenity aspects of pollution.

Current estimates of community's willingness to pay to reduce ocean-based litter are hindered by an absence of information on the final outcomes for marine wildlife and human health. The impacts of existing litter in the ocean on final outcomes are unknown, as are the impacts of a *change* in the quantity of litter entering the ocean.

Cost effectiveness — cost of mitigation measures

In the absence of a damage cost curve for mismanaged plastic waste incorporating direct and indirect damage costs, a cost effectiveness measure is considered to assess the benefits of the proposed policy interventions. The Ocean Conservancy (2015) examined 33 potential solutions to the problem of plastic waste leaking into the ocean and identified 5 options that achieved maximum impact. The five options focusing on collection, mitigation and conversion options are listed below and have different degrees of applicability in the five focus countries depending on the starting point for a particular economy (table 7.10):

- Close leakage points within the collection system through optimising the hauler system (e.g. transparent tendering, GPS monitoring, performance-based payments) and closing/regulating high-leakage dump sites.
- Collection services

- Gasification
- Incineration
- MRF-based recycling

7.10 Applicability of five selected options across priority countries

Selected options	China	Indonesia	Philippines	Vietnam	Thailand
Close leakage points within collection system ^a	Yes	Yes	Yes	Yes	Yes
Collection services	Yes	Yes		Yes	
Gasification		Yes	Yes		
Incineration	Yes			Yes	Yes
MRF-based recycling	Yes	Yes	Yes	Yes	Yes

^a Close leakage points within collection system includes optimising hauler system and closing and regulating high-leakage dumpsites. Source: Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free

The average expected cost of the five options selected was \$550 per tonne of plastic-waste leakage prevented. This is based on total annualised cost between \$4.9 billion and \$5.4 million achieving a reduction in plastic waste leakage of 65 per cent (table 7.11).

7.11 Selected measures to reduce plastic waste leakage in five priority countries

Option	Type of measure	Annualised cost	Plastic waste leakage reduced
		\$m	per cent
Collection services	Collection	4500 to 5000	24
Close leakage points within collection system ^a	Mitigation	600	26
Gasification	Treatment	-200 to -230	2
Incineration	Treatment		5
MRF-based recycling	Treatment		10
Total		4900 to 5370	65

^a Close leakage points within collection system includes optimising hauler system and closing and regulating high-leakage dumpsites. Source: Ocean Conservancy, 2015, Stemming the Tide: Land-based strategies for a plastic-free

Waste management in Australia

Health and environmental impacts

For the purposes of considering externalities, the stages of the waste industry supply chain can be summarised into upstream and downstream activities (chart 7.12):

- Upstream activities are those relating to extraction and use of materials, such as manufacturing and consumption of manufactured products. It includes recycling and reuse of materials.
- Downstream activities are those relating to disposal of waste, such as at landfill. The term 'post-consumer waste' is used to refer to waste that is remaining after consumption of manufactured products and is not recycled/reused.

As shown in chart 7.12, a range of health and environmental impacts may arise with the landfilling of waste. Importantly, significant impacts are also associated with the mismanagement of wastes, which may include its blending (and disposal to inappropriate landfills), stockpiling or dumping.

Incidents at recycling facilities in particular have led to a range of clean-up costs and impacts to the environment and/or local population health (such as fires in Melbourne from material recovery facilities).

Community benefits from increased reuse and recycling may manifest in:

- reduced air and water pollution and greenhouse gas emissions than that which occur during the processing of virgin materials — these may not occur within Australia to the extent that the extraction and processing of materials occurs elsewhere
- increased employment opportunities relative to the processing of virgin materials. This would generally only be considered if there was evidence that employment was additional, rather than displacing employment elsewhere. There may also be negative employment impacts on other industries if recycling has a higher cost, and
- more sustainable resource use from displacing manufacturing based on virgin materials.

These reuse / recycling benefits arise in the material extraction and conversion sectors – that is, in upstream activities.



7.12 A view of the waste stream and its externalities

Source: Adapted from BDA Group and Wright Corporate Strategy (2009)

Safe management in the downstream post-consumer handling and disposal of waste materials, seeks to minimise a range of health and environmental impacts associated with the landfilling of waste or its mismanagement (eg: blending, stockpiling or dumping).

Landfills are subject to a range of regulations that require their appropriate siting and engineering to reduce health and environmental risks, and operate under regulatory requirements and oversight that significantly internalise operational risks and costs to landfill operators, and the gate fees they charge.

Nevertheless, residual health and environmental externalities at landfills may include:

- greenhouse gas emissions
- non-greenhouse gas air emissions
- leachate escaping from landfills
- disamenity caused when houses or recreational areas are located near landfills

These will differ substantially across materials — plastic and glass have no GHG emissions from landfilling, while paper and rubber $do.^{60}$

Table 7.13 lists recent estimates of externality costs of non-hazardous waste landfills in Australia. The cost estimates have been converted to 2019 dollars from the original studies.

7.13 Recent studies estimating the externality cost of non-hazardous waste landfill

	MSW	C&I	C&D		
	2019 dollars per tonne	2019 dollars per tonne	2019 dollars per tonne		
BDA Group 2009,61 best controls	Less than \$5	for both rural and	d urban landfills		
BDA Group 2009, poorest controls	\$20-25 for urban, \$15-20 for rur				
ACIL Allen 2014, 62 Existing WA landfills: No Gas capture technology	\$34	\$31	\$9		
ACIL Allen 2014, Existing WA landfills with gas capture technology	\$12	\$11	\$5		
Schollum (2010) – Existing landfills in Perth.	\$42	\$46	\$33		
Productivity Commission (2006) – Best practice landfills	\$5 to \$25	\$7 to \$33	\$1 to \$10		
Productivity Commission (2006) – Best practice landfills with methane capture and electricity generation	\$0 to \$5	\$0 to \$5	\$0 to \$5		
Note: external costs have been converted to 2019 dollars					

Note: external costs have been converted to 2019 dollars

Source: As noted.

- ⁶¹ BDA Group 2009, *The full cost of landfill disposal in Australia*, report prepared for Department of the Environment, Water, Heritage and the Arts, July, Chapter 6. The study also identified private costs of landfills.
- ⁶² ACIL Allen 2014, *Economic drivers of waste*, prepared for the Department of Environmental Regulation and Waste Authority of Western Australia.

⁶⁰ See National Greenhouse Accounts factors, https://www.environment.gov.au/climatechange/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouseaccounts-factors-august-2019.

By far and away the most pernicious of the externalities associated with waste management arise from not managing waste. For example, littering or illegal dumping of material, or stockpiling (often illegally) of recyclable materials. As shown above, the externalities associated with well managed landfills are relatively small and likely to be less than the current landfill levies.

Aside from the issues noted above, the waste and recycling system is also characterised by a limited ability to directly price waste disposal through the supply chain. For example:

- households are not charged more for generating more waste through municipal systems or for directing waste to more or less efficient outcomes — instead councils use bin sizes and collection frequencies to try to influence household incentives, and
- package producers do not face any price signal related to the disposal costs of their packaging choices —they do face signals if consumers are informed and make choices taking into account environmental impacts

This means that there is no obvious way that disposal costs are incorporated into market behaviour, unlike for other costs that become factored into product prices and consumer choices.

In large part, the lack of price signals reflects the combination of technological constraints such as ability to cheaply measure and monitor (which can now be overcome) and the need to avoid encouraging options such as illegal dumping and littering, with much greater externalities.

Environmental externalities from changes in recycling

It is not a straightforward task to evaluate the overall cost equation for recycling relative to an alternative for many reasons. The most difficult component is the environmental impacts. The best evidence of the overall environmental impacts from different pathways from a Victorian perspective is the RMIT life cycle analysis released in 2016 and undertaken for Sustainability Victoria.⁶³ This considered:

- Global warming Climate change effects resulting from the emission of carbon dioxide (CO₂), methane or other global warming gases into the atmosphere – this indicator is represented in CO₂ equivalents.
- Photochemical oxidation measurement of the increased potential of photochemical smog events due to the chemical reaction between sunlight and specific gases released into the atmosphere. These gases include nitrogen oxides (Nox), volatile organic compounds (VOCs), peroxyacyl nitrates (PANs), aldehydes and ozone. This indicator is of importance in areas where photochemical smog is likely to be a problem, such as in urban transport environments.
- Eutrophication the release of nutrients (mainly phosphorous and nitrogen) into land and water systems, altering biotopes, and potentially causing oxygen depletion effects such as increased algal growth.

⁶³ RMIT 2015, LCA of Kerbside Recycling in Victoria, prepared for Sustainability Victoria.

- Mineral resource depletion the additional investment required to extract minerals resources due to depletion of reserves, leaving lower quality reserves behind, which will require more effort to harvest.
- Fossil fuel depletion the additional investment required to extract fossil fuel resources to depletion of reserves, leaving lower quality reserves behind, which will require more effort to harvest.

The study also measured precursors to environmental impact, such as land use, water use, solid waste and cumulative energy demand.

The first three environmental impacts have been valued. We would expect that mineral and fossil fuel resource depletion is adequately reflected in market prices and would not need to be separately valued. Our approach to monetising these environmental externalities from landfill relative to recycling is detailed in Appendix E.

There are also specific estimates of externalities from landfilling for Australia, shown below. The cost of disposing of waste to landfill depends on a range of factors, including the type of material, the size of the landfill, how it is managed and the local climate. BDA Group (2009) estimated the full cost of landfill disposal in Australia in various climates, under best practice controls, as well as poor controls. BDA Group's cost estimates included:

- private costs
- the cost of greenhouse gas emissions
- the external cost of other air emissions
- external costs associated with leachate
- the disamenity impacts associated with landfills.

The private costs and disamenity impacts estimated by BDA are inflated to 2012/13 dollars using the national Consumer Price Index (table 7.14). These estimates suggest that the total cost of landfill ranges between \$45 per tonne up to around \$113 per tonne, depending on the size of the landfill and the controls in place.

	Small urban	Medium urban	Large urban	Small rural	Medium rural	Large rural
	\$/tonne	\$/tonne	\$/tonne	\$/tonne	\$/tonne	\$/tonne
Best controls						
Private costs	110.4	66.2	44.2	110.4	66.2	44.2
GHG emissions	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Other air emissions	1.1	1.1	1.1	0.1	0.1	0.1
Leachate	0.0	0.0	0.0	0.0	0.0	0.0
Disamenity	1.1	1.1	1.1	1.1	1.1	1.1
Total	112.3	68.1	46.0	111.3	67.1	45.0
Poor controls						
Private costs	81.7	48.6	33.1	81.7	48.6	33.1

7.14 Full cost of landfill disposal in Australia (2012/13 dollars)

	Small urban	Medium urban	Large urban	Small rural	Medium rural	Large rural
	\$/tonne	\$/tonne	\$/tonne	\$/tonne	\$/tonne	\$/tonne
GHG emissions	19.8	19.8	19.8	19.8	19.8	19.8
Other air emissions	0.8	0.8	0.8	0.2	0.2	0.2
Leachate	0.0	0.0	0.0	0.0	0.0	0.0
Disamenity	11.0	11.0	11.0	5.5	5.5	5.5
Total	113.3	80.2	64.8	107.3	74.2	58.7

Note: Estimates reported in the table are for a dry temperate climate and have been converted to 2012/13 dollars using the national CPI.

Source: BDA Group Economics and Environment, 2009, The full cost of landfill disposal in Australia, prepared for the Department of the Environment, Water, Heritage and the Arts, pp. 75-77.

The private costs of landfill are included in the analysis at \$70 per tonne. To ensure that there is no doubling up of costs measured in the lifecycle analysis of RMIT, we only include a \$10 additional disamenity impact from landfilling. This will somewhat understate additional landfill costs accruing to the Australian community, as we apply the RMIT values only to changes in material that is recycled (regardless of whether this is overseas or domestic), while some of the costs will accrue to Australia instead of overseas as a result of domestic landfilling of residual material.

Environmental and social costs of waste transport

The environmental and social externalities from road and rail freight reflect:

- the amount of physical pollution such as emissions of particulates; and
- the impact of these pollutants on people, such as reflecting the density of population impacted by the physical pollution.

A summary of the quantifiable environmental externalities is set out in table 7.15. Estimates of the costs of these environmental impacts are outlined in Appendix D.

Impact	Description
Air pollution	Air pollution reflects the health impacts from additional rail and road vehicle kilometres. Air pollution costs are higher in urban areas, because of the greater population impacted.
GHG emissions	GHG emissions have global impacts in terms of costs arising from changing temperatures
Noise pollution	Noise pollution arises in the immediate vicinity of roads and rail lines. Its impacts are larger in urban areas than in rural areas.
Water pollution	Water pollution includes organic waste or persistent toxicants from run-off from roads and rail lines, generated from vehicle use. It includes engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation for cars.

7.15 Environmental impacts of additional transport

Impact	Description
Nature and landscape	Nature & landscape impact is driven by the infrastructure 'footprint', e.g., habitat loss, loss of natural vegetation or reduction in visual amenity as infrastructure is constructed. Key impacts in rural areas are natural impacts, whilst key impacts in urban areas are mostly amenity / visual as the urban environment is already dominated by infrastructure.
Urban separation	Urban separation is an urban externality only. The unit cost is based on three elements: time loss due to separation for pedestrians, lack of non- motorised transport provision and visual intrusion.
Upstream and downstream impacts	Upstream and downstream costs refer to the indirect costs of transport including energy generation, vehicle production and maintenance and infrastructure construction and maintenance.

Source: TfNSW, Principles and Guidelines for the Economic Appraisal of Transport Investment and Initiatives, March 2015.

Appendix D outlines estimates for three forms of social cost, which apply only to road transport:

- costs from accidents
- costs from congestion imposed on other road users
- costs from wear and tear on the road.

8 Cost benefit analysis results

Central case assumptions

For the presentation of results, we show the costs and benefits under 'central case' assumptions. These assumptions are based on our view of the most likely values for key assumptions, such as the amount exported in the base case, prices for commodities and costs. These are shown in table 8.1.However, there are a wide range of risks around these. To highlight these we have conducted sensitivity analysis of how the costs and benefits differ if the assumptions differ.

Item	Central case assumption
Social discount rate	7 per cent
Time period	20 years, with capital being replaced within this period as required, and a residual value of capital at the end of the evaluation period
Export market prices	Based on 2018/19 average export prices
Export volumes	Fixed at 2018/19 levels. Scenarios for a decline in export volumes over ten years and export volumes increasing in proportion to the amount recycled are included as sensitivities.
Costs	No additional contingency allowed for in cost estimates. A plus and minus 20 per cent scenario is shown in sensitivity analysis.
Mismanaged material overseas	That this is 7 per cent of the residual low value material for residual plastic waste and remains constant through time. Net costs per tonne of avoided marine waste are also presented using a scenario where the level of mismanagement declines. Assumed 39 per cent of exported whole baled tyres sent to open burning.
Cost of uncertainty	Not included in the central case. A scenario is included where all overseas countries ban waste imports with x months notice, and the costs of this versus the export ban compared.
Timing for facilities to be operational	The central case uses 3 years for paper and 2 years for other facilities. Sensitivity analysis is conducted where facilities are operational before the ban occurs and for facilities taking twice as long as the central case.
Location of facilities	For each state, if the volume of material to be processed is less than the minimum facility size, then material is transported to nearest of Melbourne or Sydney.
	If the volume of material is sufficient, the costs of processing in the home state versus sending to Melbourne or Sydney are estimated, and the cheapest option chosen.

8.1 Central case cost benefit analysis assumptions

Source: The CIE.

Net benefits of options

The overall net benefits of the scenarios are shown in table 8.2.

- A full export ban (Scenario 1) would impose a net cost of \$902 million in present value terms.
- Exempting clean paper and cardboard reduces the net cost to \$48 million in present value terms (Scenario 2).
- Exempting whole tyres for retreading reduces the net cost to \$826 million in present value terms (Scenario 3).
- Exempting both clean paper and whole tyres for retreading leads to a net benefit of \$28 million (Scenario 4). Note that the risks to this are largely downside, if additional capacity is not in place for domestic processing rapidly, or costs are higher than expected.

8.2 Summary of cost benefit analysis results

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Excludes clean paper	Excludes tyres for retread	Excludes clean paper and tyres for retread
Net benefit (\$m, present value)	-902	-48	-826	28
Change in problem exports (tonnes, present value)	-90 614	-73 046	-89 279	-71 711
Net cost per tonne	9 949	656	9 251	- 387

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent. Source: The CIE.

Net benefits across commodities

A detailed view of the components of net benefits across the commodities and the different types of costs and benefits is shown in table 8.3, for a full export ban (Scenario 1).

- The largest net cost is from banning paper exports (at \$835 million) and then tyres (at \$138 million).
- Banning plastic exports has an estimated net benefit this predominantly reflects that there is a waste industry benefit from plastic processing, because the higher value material more than outweighs the costs. Some caution should be placed on this, as it suggests that plastic processing will occur in the base case, or that there are other risks stopping processing from occurring more than it currently does. It indicates that the costs of the export ban will likely be markedly lower for plastic than for other materials.
- The largest costs from an export ban are the loss of the export value, and a range of capital and operating costs to process material domestically. Landfill costs are also higher
 this is mostly from landfilling of residual material but also reflects landfilling of paper and tyres for a year because facilities will not be operational.
- The largest benefit is the value of the material produced through further processing. In present value terms, \$4.6 billion of material would be produced.

- There are some positive government impacts from additional waste levy revenue (which is also part of the cost to the waste industry). These would be offset by compliance and enforcement costs — such costs cannot be estimated presently.
- There are also some negative community impacts from additional landfilling impacts and environmental impacts from reduced recycling (most of which are only for the period when facilities are not operational).
- Relative to the tonnes of problem exports avoided, plastic is the most effective, paper is second and tyres is third. The measure of mismanagement is different, with plastic and paper mismanagement reflecting residual plastic contamination entering the marine environment, while tyre mismanagement reflects open burning of tyres. We note that the amount of mismanaged waste from our exports is subject to a wide degree of error, as little is known about exactly what happens to material that we export.

	Paper	Plastics	Tyres	Total
	\$m, PV	\$m, PV	\$m, PV	\$m, PV
Waste industry costs and benefits				
Loss of export value	-1 751	- 323	- 99	-2 173
Sorting cost	0	- 19	0	- 19
Processing capital cost	-1 253	- 591	0	-1 844
Processing land cost	- 398	- 18	- 6	- 423
Processing operating cost	- 711	- 128	- 50	- 890
Transport cost	- 313	- 2	0	- 315
Landfill cost	- 269	- 60	- 13	- 342
Value of material	3 460	1 156	22	4 638
Residual value of assets	309	25	2	336
Net waste industry	- 927	40	- 145	-1 032
Government costs and benefits				
Developing legislation	NA	NA	NA	NA
Compliance and enforcement	NA	NA	NA	NA
Additional waste levy revenue	147	35	7	189
Net Government	147	35	7	189
Community costs and benefits				
Domestic landfill externalities	- 18	- 4	- 1	- 22
Externalities from reduction in recycling	- 16	0	0	- 16
Domestic transport externalities	- 21	- 1	0	- 21
Net community	- 54	- 4	- 1	- 59
Net benefit	- 835	71	- 138	- 902
Change in exports (MT over period)	- 19.0	- 3.2	- 1.1	- 23
Avoided tonnes of problem exports (tonnes, pv)	-62 513	-18 290	-9 811	-90 614
Net cost per avoided problem tonne (\$/tonne)	13 351	-3 889	14 071	9 949

8.3 Costs and benefits of Scenario 1

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent. Source: The CIE. Scenario 2 exempts clean paper from the ban. We have applied this as exempting C&I and C&D paper, while continuing to ban mixed paper from MSW sources.

- A ban only applying to MSW paper is broadly neutral in a cost benefit analysis sense, if processing facilities set up and process this facility (table 8.4).
- Little export value is lost from banning only MSW paper, because it has a low value. Banning only MSW waste from export continues to remove a large part of the problem, because a higher share of MSW waste will be problematic overseas than C&I waste.

The risks around this analysis are largely downside. If paper processing facilities do not set up to process mixed paper, because of risks around entering a market to sell recovered pulp, then there would be a net cost of \$0.5 billion.

It is also possible that rather than processing paper into a pulp, there is instead other activities to make mixed paper meet the definition of 'clean'. This could include further sorting or changes to kerbside collection arrangements. Given that the central case analysis shows a close to zero net benefit for processing to a pulp, these options are not likely to be any better in terms of their impact on social welfare. However, they do have lower capital requirements and may be pursued by industry for that reason. Past consultations have suggested that, if enforced, MSW paper would not be likely to meet China Sword contamination standards even if sorted, and even if collected separately from households. Hence the extent to which additional cleaning would occur will depend heavily on the specific standard set for clean paper.

	Ban on exports of all paper	Ban excludes clean paper
	\$m, PV	\$m, PV
Waste industry costs and benefits		
Loss of export value	-1 751	- 162
Sorting cost	0	0
Processing capital cost	-1 253	- 376
Processing land cost	- 398	- 161
Processing operating cost	- 711	- 234
Transport cost	- 313	- 174
Landfill cost	- 269	- 154
Value of material	3 460	1 115
Residual value of assets	309	106
Net waste industry	- 927	- 40
Government costs and benefits		
Developing legislation	NA	NA
Compliance and enforcement	NA	NA
Additional waste levy revenue	147	86
Net Government	147	86

8.4 Costs and benefits of ban applied in different ways to paper

	Ban on exports of all paper	Ban excludes clean paper
	\$m, PV	\$m, PV
Community costs and benefits		
Domestic landfill externalities	- 18	- 10
Externalities from reduction in recycling	- 16	- 6
Domestic transport externalities	- 21	- 10
Net community	- 54	- 26
Net benefit	- 835	19
Change in exports (MT over period)	- 19.0	- 7.4
Avoided tonnes of problem exports (tonnes, pv)	-62 513	-44 944
Net cost per avoided problem tonne (\$/tonne)	13 351	- 424

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent. Source: The CIE.

Alternatives scenarios for tyres

In scenario 1, all tyre waste exports were banned, including whole tyres for retreading. If whole tyres for retreading were exempt, then the net costs are substantially lower (table 8.5). This is because the value of tyres sent for retreading is much higher than those sent for energy production as whole baled tyres. The best information available on this suggests the value of baled tyres for export is \$66 per tonne, compared to over \$1000 for retreads.

	Ban on exports of all whole tyres	Ban excludes whole tyres for retread
	\$m, PV	\$m, PV
Waste industry costs and benefits		
Loss of export value	- 99	- 29
Sorting cost	0	0
Processing capital cost	0	0
Processing land cost	- 6	- 5
Processing operating cost	- 50	- 43
Transport cost	0	0
Landfill cost	- 13	- 11
Value of material	22	19
Residual value of assets	2	2
Net waste industry	- 145	- 68
Government costs and benefits		
Developing legislation	NA	NA
Compliance and enforcement	NA	NA

8.5 Costs and benefits of ban applied in different ways to tyres

	Ban on exports of all whole tyres	Ban excludes whole tyres for retread
	\$m, PV	\$m, PV
Additional waste levy revenue	7	6
Net Government	7	6
Community costs and benefits		
Domestic landfill externalities	- 1	- 1
Externalities from reduction in recycling	0	0
Domestic transport externalities	0	0
Net community	-1	-1
Net benefit	- 138	- 62
Change in exports (MT over period)	- 1.1	- 1.0
Avoided tonnes of problem exports (tonnes, pv)	-9 811	-8 476
Net cost per avoided problem tonne (\$/tonne)	14 071	7 366

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent. Source: The CIE.

Alternative scenarios for plastic

The options that have been modelled do not have any different options for plastics. Alternative options to that modelled could include exempting plastic that is of a certain standard, such as low contamination levels or already sorted to a particular resin type (such as baled PET and HDPE).

Options that exempted material that has minimal levels of residual waste will generally be more effective in terms of costs per tonne of mismanaged waste overseas. We would expect that should there be an exemption for single resin baled material, a substantial amount of material would be sorted to individual resin types and then baled, rather than undertaking flaking or pelletisation domestically. This already happens for some material, such as CDS material and MRF material sorted by plastic type.

The scope for the report did not include specific exemptions for plastics waste and has not been examined in detail. Nevertheless, to highlight the likely changes if single resin plastics were able to be exported even if these were not flaked or pelletised (or otherwise made into a direct input into manufacturing), we have developed a scenario, and this is set out in table 8.6. This scenario:

- assumes that plastics that are currently exported are instead sorted into resin types within Australia where required — for example, mixed plastics is sorted into PET, HDPE and a residual
- the PET and HDPE attracts a price of \$300 per tonne and \$650 per tonne, as reported in the Victorian Resource Recovery Market Bulleting (January 2020)⁶⁴

Envisage Works 2020, Recovered Resources Market Bulletin: January 2020, Victorian Market Intelligence Pilot Project (edition #10), p. 4,

https://www.sustainability.vic.gov.au/Business/Investment-facilitation/Recovered-resources-market-bulletin.

• the residual material is landfilled under an export ban.

Under this scenario, the net benefits would be higher at \$129 million, compared to \$71 million. This suggests that it is commercially more feasible to only sort plastics, rather than to sort and to process.

These conclusions reflect existing prices and are testing whether it is viable to process within Australia versus other available export markets. If there was no export market then we can consider whether further processing is viable relative to landfilling, by using the price of landfilling as the purchase cost. For most materials, further processing would be highly viable, relative to landfilling, if the material has already been separately collected and sorted.

The estimate of cost effectiveness assumes that all residual material has been removed. Most would be removed, but in reality baled PET and HDPE would still retain an amount of material that would be residual when sent overseas (e.g. labels, contamination).

	All waste plastics	Ban excludes sorted PET and HDPE
	\$m, PV	\$m, PV
Waste industry costs and benefits		
Loss of export value	- 323	- 323
Sorting cost	- 19	- 19
Processing capital cost	- 591	0
Processing land cost	- 18	0
Processing operating cost	- 128	0
Transport cost	- 2	0
Landfill cost	- 60	- 60
Value of material	1 156	499
Residual value of assets	25	0
Net waste industry	40	97
Government costs and benefits		
Developing legislation	NA	NA
Compliance and enforcement	NA	NA
Additional waste levy revenue	35	35
Net Government	35	35
Community costs and benefits		
Domestic landfill externalities	- 4	- 4
Externalities from reduction in recycling	0	0
Domestic transport externalities	- 1	0
Net community	- 4	- 4
Net benefit	71	129

8.6 Costs and benefits of ban applied in different ways to plastics

	All waste plastics	Ban excludes sorted PET and HDPE
	\$m, PV	\$m, PV
Change in exports (MT over period)	- 3.2	- 3.2
Avoided tonnes of problem exports (tonnes, pv)	-18 290	-18 290
Net cost per avoided problem tonne (\$/tonne)	-3 889	-7 029

Note: Using an evaluation period of 20 years and a social discount rate of 7 per cent. Source: The CIE.

Net benefits across jurisdictions

The net benefits per person across the jurisdictions is shown in table 8.7. The largest per capita impacts are in states that are currently more export dependent and that would send material to other states (mainly for paper) in the event of an export ban, because of scale.

- Western Australia has the highest net costs per person, at \$119 per person for the full ban. Note that this is not an annual cost, but an equivalent once-off cost.
- Victoria and South Australia also have substantial negative impacts.
- NSW has smaller per person impacts because it is less export reliant than other states.

Impacts for some states are less reliable than others, such as Tasmania and potentially South Australia, because it is not possible to identify exports that originate in one state but are exported through a port in another state. This will tend to overstate the costs to Victoria and understate the costs to Tasmania and South Australia.

8.7 Net benefits across jurisdictions (all scenarios)

	NSW/ACT	VIC	QLD	SA	WA	TAS	NT
	\$/person						
Scenario 1	-10	-52	-11	-51	-119	-8	-28
Scenario 2	2	5	7	-10	-44	0	-13
Scenario 3	-7	-48	-10	-48	-116	-8	-28
Scenario 4	5	9	9	-7	-41	0	-13

Source: The CIE.

Further detail on the impacts of Scenario 1 across jurisdictions is shown in table 8.8.

8.8 Costs and benefits across jurisdictions (Scenario 1)

	NSW	VIC	QLD	SA	WA	TAS	NT
	\$m, pv						
Waste industry costs and benefits							
Loss of export value	- 415	-1071	- 299	- 120	- 255	- 8	- 4
Sorting cost	- 6	- 9	- 2	0	- 2	0	0
Processing capital cost	- 460	- 804	- 250	- 91	- 230	- 6	- 3
Processing land cost	- 121	- 163	- 50	- 24	- 61	- 1	- 2
Processing operating cost	- 186	- 389	- 131	- 52	- 126	- 3	- 2
Transport cost	0	0	0	- 42	- 265	- 1	- 6
Landfill cost	- 103	- 114	- 50	- 24	- 51	0	0
Value of material	1 068	2 024	658	245	618	15	10
Residual value of assets	75	144	47	20	49	1	1
Net waste industry	- 148	- 383	- 78	- 88	- 323	- 4	- 7
Government costs and benefits							
Developing legislation	NA						
Compliance and enforcement	NA						
Additional waste levy revenue	69	54	26	14	25	0	0
Net Government	69	54	26	14	25	0	0
Community costs and benefits							
Domestic landfill externalities	- 5	- 9	- 3	- 1	- 4	0	0
Externalities from reduction in recycling	- 3	- 7	- 3	- 1	- 3	0	0
Domestic transport externalities	0	0	0	- 13	- 8	0	0
Net community	- 7	- 15	- 6	- 15	- 15	0	0
Net benefit	- 86	- 345	- 58	- 89	- 312	- 4	- 7
Change in exports (MT over period)	- 4.8	- 9.9	- 3.5	- 1.4	- 3.5	- 0.1	- 0.1
Avoided tonnes of problem exports (tonnes, pv)	-23 117	-32 296	-13 996	-5 468	-15 290	- 198	- 249
Net cost per avoided problem tonne (\$/tonne)	3 734	10 668	4 140	16 299	20 430	21 970	27 847

www.TheCIE.com.au

Source: The CIE.

8.9 Net benefits by stream, jurisdiction and material, Scenario 1

	NSW	VIC	QLD	SA	WA	TAS	NT
	\$/person						
Paper							
MSW	3	9	9	-4	-40	0	-12
C&I and C&D	-12	-57	-19	-40	-75	-8	-16
Total	-9	-48	-10	-45	-115	-8	-28
Plastics							
MSW	-1	-1	0	-1	-1	0	0
C&I and C&D	6	5	1	0	2	0	0
Total	5	4	1	0	1	0	0
Tyres							
MSW	-3	-3	-1	-3	-3	0	0
C&I and C&D	-3	-4	-2	-3	-3	0	0
Total	-6	-8	-3	-6	-6	0	0
Glass							
MSW	0	0	0	0	0	0	0
C&I and C&D	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Total							
MSW	0	4	8	-7	-43	0	-13
C&I and C&D	-10	-56	-19	-44	-76	-8	-16
Total	-10	-52	-11	-51	-119	-8	-28

Source: The CIE.

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9 Sensitivity analysis

There are a wide range of uncertainties that could impact on the results of the cost benefit analysis, ranging from costs being different to expected, differences in what happens to exports in the base case and timing for facilities to be operational. The net benefits under different assumptions are shown in table 9.1 for Scenario 1, and further explained below.

- The central case, repeated from the previous chapter, is a net cost of \$902 million.
- If processing facilities do not set up, the net costs are substantially higher at \$3 297 million, as excess material is landfilled. This risk is particularly important for paper, where a range of complicated market and competition dynamics are at play. This assessment of the net cost assumes that there are no upstream changes to stop collecting materials given that they are landfilled — reducing collection costs would mitigate the cost, and be a sensible response if material was being landfilled anyway.
- Under the central case, exports were assumed to remain at 2018/19 levels. If exports grow in line with expected volumes of recycling, then the export ban would impose a larger net cost. If exports decline over the next ten years, such as reflecting other policies to increase domestic demand, then the net cost would be lower, at \$334 million.
- Under the central case, tyre and paper facilities would not be fully operational at the time of the policy being implemented, and there would be a year of landfilling. If facilities were operational, then the net costs are substantially lower at \$643 million, mainly from paper not being landfilled.
- If facilities took substantially longer to become operational than allowed for, then the net costs would be much larger, at \$1 727 million. This allows for paper facilities to be operational in six years and other material processing to be operational in four years. By far the largest risk is for paper in this regard, as plastic and tyre processing facilities can be put together fairly simply, while paper facilities will require large sites and much more extensive environmental approvals.
- If costs are higher than expected by 20 per cent then this substantially increases the net costs, and vice versa. Higher costs would make plastic a net cost rather than a net benefit. A higher cost for plastic processing is consistent with other estimates, such as those of EnvisageWorks cited in Appendix B.
- A higher discount rate applied would increase the net cost, and a lower discount rate would reduce the net cost.
- If export prices fell to zero, then an export ban would have a net benefit. In this scenario, no value is being given up by not exporting any more. This could be representative of a dramatic decline in export markets without any domestic response.

- If higher tyre volume estimates are used, consistent with information reported by Tyre Stewardship Australia then the net cost for tyres increases from \$138 million to \$289 million.
- If the MSW paper is of lower quality than the central case, requiring 1.8 tonnes of input to achieve 1 tonne of output (instead of 1.5 in the central case), then the net cost for paper increases by \$186 million.
- Under the central case, we assume that glass exports do not continue, as CDS glass supplants kerbside glass once contracts end. If glass exports continue at a level of 30 000 tonnes per year, there would be a net cost of \$40 million.

	Paper	Plastic	Tyres	Total
	\$m, PV	\$m, PV	\$m, PV	\$m, PV
Central case	- 835	71	- 138	- 902
Material landfilled	-2 653	- 501	- 143	-3 297
Exports grow with recycling	- 996	98	- 647	-1 545
Exports decline over 10 years to zero	- 308	7	- 33	- 334
Facilities operational by the time of the ban	- 576	71	- 137	- 643
Facilities take twice time to set up	-1 502	- 85	- 139	-1 727
Costs 20 per cent higher than expected	-1 254	- 69	- 148	-1 471
Costs 20 per cent lower than expected	- 416	211	- 128	- 332
Discount rate of 10 per cent	- 881	- 1	- 106	- 988
Discount rate of 3 per cent	- 632	244	- 206	- 594
Base case export price falls to \$0	916	395	- 39	1 272
Higher tyre estimates	- 835	71	- 289	-1 053
Lower quality MSW paper	-1 021	71	- 138	-1 087
Glass exports continue				- 40 (glass only)

9.1 Net benefits of alternative assumptions (full export ban, Scenario 1)

Source: The CIE.

Sensitivity analysis is also shown in table 9.2 for Scenario 4 — an exemption for clean paper and an exemption for whole tyres for retreading. There remain substantial downside risks to this scenario, with many sensitivities indicating net costs.

	Paper	Plastic	Tyres	Total
	\$m, PV	\$m, PV	\$m, PV	\$m, PV
Central case	19	71	- 62	28
Material landfilled	- 514	- 501	- 67	-1 082
Exports grow with recycling	126	98	- 89	135
Exports decline over 10 years to zero	- 50	7	- 16	- 59
Facilities operational by the time of the ban	97	71	- 62	106
Facilities take twice time to set up	- 182	- 85	- 64	- 331
Costs 20 per cent higher than expected	- 127	- 69	- 71	- 267
Costs 20 per cent lower than expected	165	211	- 54	322
Discount rate of 10 per cent	- 77	- 1	- 49	- 127
Discount rate of 3 per cent	263	244	- 91	416
Base case export price falls to \$0	181	395	- 34	542
Higher tyre estimates	19	71	- 131	- 41
Lower quality MSW paper	- 167	71	- 62	- 158

9.2 Net benefits of alternative assumptions (partial export ban, Scenario 4)

Source: The CIE.

The above sensitivities highlight the key risks and ones that can be managed. In particular, an export ban will be more costly if paper processing facilities are not in place, as timing for these facilities can be long and uncertain.

In terms of cost effectiveness relative to the amount no longer mismanaged overseas, the results are shown in table 9.3. For paper and plastics, the costs per avoided tonne mismanaged is order of magnitudes higher than the estimated cost from chapter 7 of \$550 per tonne, under all sensitivities. For plastic, for many sensitivities there is a net benefit and hence there is no cost per tonne avoided. However, if costs are 20 per cent higher, then there would be a net cost per tonne of \$3 779, which is again higher than the estimated cost from the previous chapter. As noted above, a higher cost is consistent with the EnvisageWorks costs cited in Appendix B.

9.3 Cost per avoided mismanaged tonne, Scenario 1

	Paper	Plastic	Tyres	Total
	\$/tonne	\$/tonne	\$/tonne	\$/tonne
Central case	13 351	-3 889	14 071	9 949
Material landfilled	42 435	27 405	14 601	36 387
Exports grow with recycling	11 940	-3 891	29 539	11 831
Exports decline over 10 years to zero	27 285	-2 127	14 816	19 852
Facilities operational by the time of the ban	9 219	-3 889	13 995	7 091
Facilities take twice time to set up	24 024	4 667	14 206	19 054
Costs 20 per cent higher than expected	20 052	3 779	15 097	16 231
Costs 20 per cent lower than expected	6 651	-11 557	13 045	3 668

	Paper	Plastic	Tyres	Total
Discount rate of 10 per cent	19 156	89	14 368	14 788
Discount rate of 3 per cent	6 433	-8 486	13 699	4 184
Base case export price falls to \$0	-14 655	-21 570	3 980	-14 033
Higher tyre estimates	13 351	-3 889	14 071	10 386
Lower quality MSW paper	16 325	-3 889	14 071	12 001
Mismanagement declines in receiving countries by 5% per year	22 134	-6 447	22 449	16 425
Base case export price falls to \$0 Higher tyre estimates Lower quality MSW paper Mismanagement declines in receiving countries by 5% per year	-14 655 13 351 16 325 22 134	-21 570 -3 889 -3 889 -6 447	3 980 14 071 14 071 22 449	-14 033 10 386 12 001 16 425

Source: The CIE.
10 Other benefits of policy interventions

For the purpose of estimating costs and benefits in previous chapters, under the central case assumptions we have assumed no further change in openness of export markets.⁶⁵

However, this may not be the case. If export market conditions continue to change unpredictably and suddenly, then there are:

- costs of landfilling that would occur due to a sudden and unpredicted closure of export markets, and
- costs of renegotiating waste-related contracts, potentially multiple times if countries change their policies at different times and councils and recyclers do not arrive at more flexible contract arrangements.

A benefit of the export ban is that, by creating certainty about export markets, it would avoid such costs. We cannot quantify the probability of further export market restrictions and therefore cannot quantify these benefits for the CBA. Nonetheless, this chapter discusses the types of benefits that are associated with creating certainty. Further, we discuss how the timing between announcement and enforcement of an export ban would affect the costs of the export ban.

Unpredictable and sudden changes can result in higher costs

In recent years, a number of key export destinations for Australian recyclables have imposed restrictions or bans on import of recyclables from Australia. The impact of this is a reduction in demand for Australian recyclables, which leads to decreases in prices and worsening commercial viability of recycling.

The impacts of existing export market restrictions likely have not been fully realised. Further tightening may arise due to:

- more countries announcing and/or implementing restrictions or bans on imports of recyclables,
- countries with existing restrictions/bans making changes to their practices in terms of enforcement, contamination thresholds, or the set of materials affected.

To illustrate, in April 2019 Indonesia announced a change in their inspection regime for scrap paper imports. The proportion of shipments being inspected was increased from 10 per cent of shipments to 100 per cent. The contamination rate that inspected shipments

⁶⁵ Note that under the base case we assume market prices (e.g. for sorted PET recyclates) remain at their current levels. These current levels do account for uncertainty about additional import restrictions or more stringent enforcement of restrictions by foreign governments.

had to meet was reported to be 0.5 per cent.⁶⁶ However, since then, the contamination threshold has become unclear, with the industry interpreting the threshold as being at 0 per cent. APCO (2020) reports that the impact is uncertain. Further, the set of materials affects has been widened to include plastics, metals, tyres and more.

The most important currently announced and implemented export restrictions imposed by overseas governments are those in Indonesia, Vietnam, China and Malaysia (table 10.1). This is because of the magnitude of exports that are sent to those destinations. Impacts from the bans vary, depending on enforcement stringency, how low contamination thresholds are set, and other factors.

Country	Scope of restrictions	Associated types of waste	Associated exports in October 2019	Impact and uncertainties
			Tonnes/month	
Indonesia	Previously announced increases in inspections, but contamination thresholds are unclear. Now have instituted a temporary moratorium on all scrap imports commenced 23 November 2019.	Plastics, paper and cardboard, metals, glass, hazardous waste, tyres, other	54 800	Impact uncertain
Vietnam	Imports must meet environmental standards and importers must show there is capacity in Vietnam to process	Plastic, paper, metals	34 900	Impacts evident for plastics
China	Contamination threshold of 0.5 per cent, covering specific commodity codes. At the end of December 2019, government foreshadowed a further change that will probably restrict imports of recyclates into China, whether in flake or pellet form. ^a	Plastic, paper, metals, other	34 400	Impact evident (decrease from 105 300 tonnes per month on average in 2016/17 to 62 000 in 2017/18
Malaysia	Many import permits removed, focussed on scrap plastic imports	Plastic	5 200	No impact apparent
Thailand	Restrictions escalating since August 2018 implementation. Low quality plastic waste may be banned from 2021	Plastic	1 800	No impact apparent
Taiwan	Import of plastic waste is banned, with some exceptions Paper imports restricted to deinked, kraft or corrugated paper and cardboard	Plastic, paper	1 100	No impact apparent
Philippines	August 2019 3-month moratorium on recyclable waste imports	Plastic, metals	600	Impact uncertain
India	Bans announced prohibiting scrap plastic imports. Announced in March 2019 with exemptions, which have been removed since August 2019.	Plastic	0	Impact uncertain

10.1 Current status of waste import restrictions

^a See Recovered Resources Bulletin January 2020 published by Sustainability Victoria, p. 15.

Source: Adapted from APCO (2020) and Sustainability Victoria Recovered Resources Bulletin.

66 See: Sustainability Victoria, 2019, Recovered Resources Bulletin June 2019, available at: https://www.sustainability.vic.gov.au/-/media/SV/Publications/Business/Investmentfacilitation/Resource-Recovery-Market-Bulletins/Recovered-Resources-Market-Bulletin-June-2019.pdf The uncertain future path of export restrictions makes it difficult for the domestic processing sector to justify capital investments.

In addition to costs created by uncertainty, there are costs associated with the suddenness of changes to export markets. When waste export markets tighten suddenly, the domestic processing sector is unable to respond immediately. Rather, there is a three-year lag based on the time taken to build and begin operating a new facility (such as a plastics flaking and pelletising plant). As a result, material can be landfilled.

Box 10.2 provides a case study of how sudden changes in market conditions can result in large volumes of recyclables that were previously stockpiled being rapidly landfilled.

10.2 Materialisation of market risks in the Victoria waste sector

The set of commercial market considerations affecting paper and plastic waste markets also impact on existing waste markets. In Victoria, these factors have led to a range of poor outcomes, such as stockpiling, landfilling of significant volumes of kerbside recyclables, and a significant loss of confidence in the kerbside system.

There were a range of interrelated events/circumstances that contributed to the deterioration in market conditions in Victoria. Overseas jurisdictions imposing restrictions/bans on import of Australian recyclables, e.g. China's National Sword policy. This lead to significant reductions in the value of kerbside recyclables, and accordingly the commercial feasibility of MRF operations. As a result of the deterioration in market conditions and rigid contractual arrangements for MRF services, SKM entered voluntary administration in early August.

As a result of the closure of three SKM MRFs, around 15 000 tonnes per month were sent to landfill in August to October 2019. This volume represented 60 per cent of the receivables at the SKM MRFs, with the remaining 40 per cent being diverted to other MRFs. October 2019 was the month with the largest additional volume of material sent to landfill (almost 60 000 tonnes), of which around 35 000 tonnes was material that was being stockpiled over the previous year.

Source: Sustainability Victoria Recovered Resources Bulletin January 2020, CIE.

Costs of landfilling due to sudden and unpredictable changes in exports

A benefit of the export ban is that, by creating certainty about export markets, it would avoid such costs. We cannot quantify the probability of further export market restrictions and therefore cannot quantify these benefits for the CBA. Nonetheless, we can measure the magnitude of impacts from a sudden export market closure relative to a more certain timed closure as per the Australian export ban.

To model the costs of an unpredictable export closure situation we compare the costs and benefits of a sudden unannounced export ban in 2022, to a staged pre-announced ban as per Scenario 1 (table 10.3).

- The unannounced ban would have net costs of \$1267 million in present value terms. The higher costs represent landfilling of material for 3 years for paper and two years for tyres and plastic, while facilities became operational to process material domestically.
- This is \$366 million higher than a structured ban, as per scenario 1. It would be even higher if the Australian Government's ban had longer timelines for implementation.

10.3 Impacts of an uncertain export shock versus proposed export ban

	Paper	Plastics	Tyres	Total
	\$m, pv	\$m, pv	\$m, pv	\$m, pv
Net benefit of export ban in 2022, no notice	-1 170	- 34	- 63	-1 267
Net benefit of proposed export ban	- 835	71	- 138	- 902
Net benefit of own ban relative to sudden ban	335	105	- 75	366

Source: The CIE.

Contract renegotiations due to changes in export markets

The waste supply chain is characterised by multiple stages where stable commercial relationships are important to ensure returns on investment. For example, MRFs need certainty that they will receive recyclables for processing in order for their investment to deliver returns because the fixed costs of MRFs are high.⁶⁷

Long-term contracts can become untenable in situations where prices and costs change dramatically. This is illustrated by the circumstances in Victoria, where deteriorating material values (and to a lesser extent increases in operating costs)⁶⁸ decreased the net revenue from SKM's contracts with councils to the point that they entered voluntary administration.

Therefore, when circumstances change dramatically contracts are often renegotiated. This has been the experience for councils and MRFs as a result of falling material values due to tightening export markets. Events such as the implementation of China's National Sword policy, which precipitated large declines in material values, require councils to spend time negotiating new contracts with MRFs.

This process of renegotiation is costly. The main types of costs are labour costs for staff of the negotiating parties, legal costs, and costs of risk associated with the uncertain outcomes of negotiations.⁶⁹

⁶⁷ This is in contrast to other markets with lower capital investment requirements, where long-term contracts are not as important.

⁶⁸ An example of increasing operating costs faced by MRFs is increases in the landfill levy that make disposal of contamination removed at the MRF more expensive.

⁶⁹ For example, a council bears a cost of having an uncertain budgetary liability for waste services if there is an ongoing renegotiation.

Impact of an export ban on frequency of renegotiations

An export results in a certain requirement for one renegotiation, but this replaces the requirement for an uncertain number of renegotiations if export markets close unpredictably due to foreign government restrictions. That is, under the base case where there is uncertainty about export market closures, there may be 3 renegotiations required over a 5-year period. However, under the policy options where an export ban is implemented, there is a certainty that one renegotiation is required.

A caveat to this stylised comparison is that renegotiations may happen for other reasons. For example, the closure of SKM resulted in contract renegotiations for Victorian councils.⁷⁰ Therefore, even with an export ban, the number of renegotiations required over any period of time is not known with certainty.

Avoided costs of contract renegotiations

As described above, an export ban would replace an uncertainty number of renegotiations with the certainty of one renegotiation. Whether this results in higher or lower costs depends on what the probability of renegotiations are under the base case, and this is unknown. Accordingly, it is not possible to estimate the total avoided (or additional) costs of renegotiations under an export ban.

However, based on data provided by a large Sydney council we estimate that the cost of each renegotiation is between \$50 000 – \$100 000. This includes costs of council staff and external consultants plus costs of legal advice. Given that there are a total of 562 local government areas in Australia,⁷¹ this would suggest a cost of between \$28-56 million for each significant change in export market conditions that warrants a renegotiation.⁷² APCO (2020)⁷³ states that there are 71 known MRFs in Australia. If each of these facilities also bore a cost of \$100 000 for a single renegotiation with each council with whom they have a contract, this would amount to \$7.1 million in costs.

However, there may be policy options by government that are able to reduce the costs of renegotiations or reduce their likelihood. For example, government provision of information about export restrictions imposed overseas and how strictly they are being

⁷⁰ Councils affected by the SKM closure were permitted by the ACCC to collectively bargain for replacement MRF services and potentially alternative options such as waste-to-energy or landfill services.

⁷¹ Australian Bureau of Statistics, 2019, Australian Statistical Geography Standard (ASGS): Volume 3 -Non ABS Structures, July 2019, Catalogue number 1270.0.55.003, accessed on 7 February 2020, available at: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.003~July%202

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⁷² This simple calculation does not account for the proportion of local government bodies that do not procure MRF services, nor the costs of renegotiations that do not involve local government, such as renegotiations between MRFs and secondary processors.

⁷³ APCO (2020): Towards the 2025 Targets: Evidential companion report to Our Packaging Future.

enforced can be valuable in informing the variation that would be warranted in response to a change in restrictions.

Implications for timing of an export ban

Sudden and unpredictable changes in export markets can result in significant costs to industry of landfilling and foregone value from recycling that material. Unpredictability is associated with risks that discourage capital investment in domestic processing capacity.

While a planned export ban will improve certainty and promote investment in new capital, if the implementation of the ban is sudden there will still be costs in the intervening period taken for industry to build new facilities.

In choosing the timing of implementation for an export ban, the environmental benefits and avoided costs of contract renegotiations must be balanced against the costs of landfilling while industry adapts.

11 The distribution of costs and benefits

Competition for purchase of recycled materials

The pattern of impacts will be influenced by the level of competition domestically to purchase recycled commodities. Australia has a small number of potential buyers of paper and cardboard in particular. A lack of competition from overseas buyers could lead to prices falling substantially more than necessary to make processing in Australia viable.

Below we assess the level of competition in each of the sectors.

Paper and cardboard

The paper and cardboard recycling sector is characterised by (table 11.1):

- an oligopolistic market, with a small number of participants and concentrated market power over price
- high barriers to entry, namely:
 - high establishment capital costs
 - site availability constraints
 - preference for long term contracts, which favour incumbent operators and reduce incentives for periodic market testing
 - ... processors prefer long contracts to guarantee input materials, which carry price risks
 - wastepaper suppliers prefer long term contracts to guarantee waste disposal services, often motivated by non-financial incentives

	Market characteristic	Analysis	
Domestic market buyers		 Domestic manufacturing of recovered paper is concentrated to three companies: 	
		 Visy Industries^a 	
		 Orora, and 	
		– Australian Paper	
		 High degree of vertical integration with all domestic manufactures involved in the collection, processing and re-processing of recovered paper. 	
		 Recycled paper is an oligopoly market, with a small number of participants and some degree of market power over price. 	

11.1 Paper and cardboard competition analysis

Market characteristic	Analysis
Barriers to entry – High establishment costs	 High establishment costs source contamination and tighter export market standards have resulted in high cost of capital investment to install new sorting technologies. industry participants estimate additional investment of \$60 - \$100 million required for current facilities and ~\$500 million to build a new facility.
Barriers to entry – Availability of new sites	 Gaining access to land to build new re-processing facilities is time-consuming, with associated transaction costs, largely attributable to environmental and development approvals. For example, the Visy paper mill in Tumut required 4 years (1998-2002) from development application to first operations of stage 1 (300 000 tonnes per year). A further 1 year (2006-2007) was required to obtain approval for stage 2 expansion to 700 000 tonnes per year.
Barriers to entry – Long term contract risks	 Domestic processors enter long term contracts with individual local councils (4-5 years) and other wastepaper sources to ensure a reliable supply of inputs However, long term contracts carry (up-side and downside) price risks. Industry reports some operators are locked into contracts requiring them to take wastepaper at pre international demand reduction prices, which when added to sorting and processing costs are above recovered paper prices. Contracts are often rigid, with elongated negotiations with non-financial considerations, as local councils prefer supply certainty, sometimes at the expense of reduced waste disposal costs.

^a Visy recently acquired the Norske Skog paper mill at Albury following its closure. It is not yet known what Visy's intentions are for the facility.

Sources: IndustryEdge 2019, Assessment of Australian paper & paperboard recycling infrastructure and 2018-19 exports, including to China, p. 9; Envisage Works, IndustryEdge and Sustainable Resource Use 2020, Resource Recovery Market Bulletin (January 2020): Victorian Market Intelligence Pilot Project (edition #10), pp. 16-19, https://www.sustainability.vic.gov.au/Business/Investment-facilitation/Recovered-resources-market-bulletin; https://www.visy.com.au/env-appv-mgmt-plan/; The CIE (2018), Final Report: Impacts of the China National Sword and NSW Container Deposit Scheme on MRFs and Western Sydney Councils, July 2018 (unpublished)

Plastic

The plastic recycling sector is characterised by (table 11.2):

- Many industry participants
 - most domestic recycled material is re-processed by a small number of large facilities as part of a vertically integrated supply chain
 - smaller market participants specialise in either plastic recycling, or manufacturing
- barriers to entry, namely:
 - low cost virgin material substitutes
 - moderate establishment capital costs
 - requirement for a reliable supply of input materials
 - long term contract risks.
- Despite, the known barriers to entry, the threat of new entrants is increasing with:

- several new plastics reprocessing facilities anticipated to commence in the next few years, and
- increased research and development activity in plastic recycling technologies.

11.2 Plastic competition analysis

Market characteristic	Analysis
Domestic market buyers	 Domestic reprocessing of recovered plastic is characterised by many niche industry participants, however most domestic recycled material is re-processed by a small number of large facilities
	 66 reprocesses were known to be operating during 2017–18, with a total output of ~146 000 tonnes
	 The 8 largest facilities, with throughput of greater than 5 000 tonnes/year accounted for ~67 000 (46 per cent) of the total output
	 The larger facilities are typically part of a vertically integrated supply chain (commencing with a MRF), with the smaller market participants specialising in plastic recycling, or manufacturing.
Barriers to entry – Low cost virgin material substitutes	Recycled plastic competes aggressively with virgin resins on price and quality/consistency. Industry analysis suggests it is not financially viable to process recycled PET bottles back into a virgin PET resin, given the current virgin resin price.
Barriers to entry – Moderate	 Moderate establishment costs
establishment costs	 source contamination and tighter export market standards have resulted in the need to invest in upgraded sorting equipment at MRFs
	 industry participants estimate additional investment of ~\$20 million is required to build new and upgrade current facilities. For example, the Advanced Circular Polymers facility recently developed has a stated capacity of 70,000 tonnes per annum for flaking of plastics (which is large for plastic recycling). The cost of this facility is stated as \$20 million.
Barriers to entry – Reliable supply of input materials	Demand (and prices) remain strong for high-quality PET and HDPE packaging recyclate for remanufacturing, both domestically and internationally. However, there is a shortage of reliable domestic supply due to contamination from other polymer types and limited domestic suitable reprocessing capacity.
Barriers to entry – Long term contract risks	 Domestic processors enter long term contracts with individual local councils (4-5 years) and other waste plastic sources to ensure a reliable supply of inputs.
	 Industry reports some operators are locked into contracts requiring them to take mixed waste plastic at pre international demand reduction prices, which when added to sorting and processing costs are above recovered mixed plastic prices.
	Waste disposal contracts are often rigid, with elongated negotiations and non-financial considerations, as local councils prefer supply certainty, sometimes at the expense of reduced waste disposal costs.

Market characteristic	Analysis
Threat of new entrants increasing	 Despite the known barriers to entry, several new plastics reprocessing facilities have recently been commissioned or are anticipated to commence in the next few years. For example:
	- Advanced Circular Polymers (ACP) - up to 70 000 tonnes/year
	 Astron Sustainability - up to 20 000 tonnes/year
	 Martogg LCM - up to 20 000 tonnes/year
	 Recycled Plastics Australia - up to 20 000 tonnes/year
	 Research and development activity in plastic recycling technologies has also been strong in recent years:
	 approximately 50% of relevant patents (i.e. 407 patent families) have been filed in the 5 years to 2016
	 China and the rest of Asia dominate the research and development landscape, accounting for 70% of the patents filed.

Sources: Envisage Works 2019, Plastics infrastructure analysis update – Project report, October, pp. 28-29; Locock, KES (2017), The Recycled Plastics Market: Global Analysis and Trends. CSIRO, Australia, https://www.csiro.au/en/Research/MF/Areas/Chemicalsand-fibres/plastic-recycling-analysis; https://www.acpolymers.com.au/about/; Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), pp. 14-15; IndustryEdge and Sustainable Resource Use 2020, Resource Recovery Market Bulletin (January 2020): Victorian Market Intelligence Pilot Project (edition #10), p. 24, https://www.sustainability.vic.gov.au/Business/Investment-facilitation/Recovered-resources-market-bulletin; https://www.acpolymers.com.au/; The CIE (2018), Final Report: Impacts of the China National Sword and NSW Container Deposit Scheme on MRFs and Western Sydney Councils, July 2018 (unpublished); Stellarix. Final Report: Landscape study on recycling of polymers; 2017 as published in CSIRO, Australia, p. 12, https://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/plasticrecycling-analysis; https://www.acpolymers.com.au/about/

Tyres

The tyre recycling sector is characterised by (table 11.3):

- a reliable and growing supply of end-of-life tyres
- a small number of specialised domestic tyre recycling operators⁷⁴
 - baling, shredding and crumbing are the most common domestic recycling outcomes
 - pyrolysis capacity is increasing with new facilities imminently coming online
 - export markets account for over half of-end-of life tyre fates, likely for Tyre Derived Fuel (or TDF) applications
- a voluntary financial product stewardship scheme to investigate new recycled tyre markets
- barriers to entry, namely:
 - site availability constraints for new entrants
 - constrained demand for the use of tyres in higher market applications due to competition from lower cost readily available substitutes and immature demand.

⁷⁴ Excludes an unknown number of companies specialising in baling and exporting of tyres, most likely to Asia for Tyre-Derived Fuel applications.

11.3 Tyre recycling competition analysis

Market characteristic	Analysis
Reliable supply	 Rising vehicle registrations and the subsequent increase in new tyre sales is underpinning the forecast increase in End of Life Tyre (EOLT) generation, estimated to exceed 506 000 tonnes by 2024-25.
Domestic market buyers	 Approximately 19 domestic tyre recycling operators have been identified, with a broad range of specialised recycling processing techniques: ^a Baling, shredding and crumbing - 8 Pyrolysis - 3 Casings - 3 Shredding - 2 Civil works - 2 Retreading - 1 Pyrolysis capacity is increasing with Green Distillation Technologies 2019 opening its facility in Warren NSW and upcoming Toowoomba facility. Exports remain the dominant form of end-of life tyre disposal. 2018-19 end-of life tyre fates are: Export (for use as TDF) - 56 per cent On-site disposal - 20 per cent Landfill - 8 per cent Crumb, granules and buffing - 7 per cent Casing and seconds - 6 per cent Stockpile - 1 per cent Civil works - 1 per cent Pyrolysis - 41 per cent
Product stewardship scheme	The National Tyre Product Stewardship Scheme is funded by the tyre industry, paid for by end consumers. Tyre Stewardship Australia has been accredited by the ACCC to administer the National Tyre Product Stewardship Scheme and to this end has entered into partnerships with end-use-stakeholders and research organisations.
Barriers to entry – Availability of new sites	 Access to land to build new re-processing facilities is time-consuming, with associated transaction costs, largely attributable to environmental and development approvals. For example, the Tyre Recycling Plant in Warren NSW, owned by Green Distillation Technologies required ~7 years (2011-2019) to achieve operational approval.
Barriers to entry – Infant demand for high value applications	 REC et. al., 2017 assess potential domestic market opportunities and competition analysis for tyre derived products in Australia. However, most of these are in early development with either cost barriers and/or infant demand. For example: Further uptake of crumb rubber in road spray surfacing, spray seal and concrete. Plausible to increase use domestically, but not clear by how much as in early phase of domestic applications. Cost and market scale identified as potential constraints. Further uptake of crumbed rubber for playgrounds/soft-fall surfaces and sports fields. However, cost compared to substitute materials identified as a potential constraint.

^a Excludes an unknown number of companies specialising in baling and exporting of tyres, most likely to Asia for TDF applications. Sources: Envisage Works 2019, Tyre flows and recycling analysis: Final Report, October, pp. 21-22; REC, et. al., 2017, *National market development strategy for used tyres 2017-2022*, Melbourne: Report prepared by Randell Environmental Consulting, Reincarnate and Envisage Works on behalf of Sustainability Victoria; https://www.aumanufacturing.com.au/green-light-for-new-tyre-recycling-plant; https://www.abc.net.au/news/2019-06-02/recycling-australias-tyre-piles/11169386; REC, et. al., 2019, End-of-life tyres supply chain and fate analysis, November, pp.37-40

Glass

The recycled glass industry is characterised by low demand and concentrated supply. This situation is likely to worsen due to the closure of domestic processing facilities (table 11.4).

11.4 Glass competition analysis

Market characteristic	Analysis
Domestic market buyers	nearly all recycled glass sold domestically, rather than exported.
	 glass from kerbside recycling is struggling to find domestic buyers, due to cheaper imports of glass packaging and reduced glass consumption.
	end use-domestic market for recycled glass is highly concentrated to three main businesses:
	 Owens Illinois (glass packaging)
	 Orora (glass packaging), and
	 Alex Fraser (glass into road base and asphalt).
Supply constraints	 recycled glass used in manufacturing must be cleaned and sorted (known as beneficiation) prior to use in manufacturing.
	beneficiation occurs in four concentrated capital cities:
	– Melbourne (3 facility)
	 Brisbane (1 facility)
	- Sydney (1 facility), and
	 Adelaide (1 facility).
	beneficiation ownership is also concentrated to four entities:
	 Visy (Adelaide and Melbourne)
	 SKM^a (Sydney and Melbourne)
	 Polytrade (Melbourne), and
	 Owens Illinois (Brisbane)^b.

^a SKM recently became insolvent, new ownership arrangements are unknown. ^b Australian operations have recently been put up for sale.

Source: Australian Packaging Covenant Organisation (2020): Towards the 2025 Targets: Evidential companion report to Our Packaging Future; CIE

Distribution of impacts from a ban on waste exports

The net costs of a waste export ban will be distributed across households, businesses and government. The way that these costs are distributed will reflect the market structure and level of competition.

The pattern of costs in a competitive market can be seen:

- The net cost measured in the market (i.e. not factoring in spillovers such as environmental impacts) is A
- The cost to waste generators is A plus B, as the material that they generate now receives a lower price.
- The benefits to processors of recycled materials is B, as they pay a lower price for all their inputs, including those inputs they already use domestically.



11.5 The market for recycled commodities with fixed supply

Data source: The CIE.

That is, the processors of material are expected to derive a benefit from banning of waste exports, while households and businesses will incur the costs. Those in the middle — the waste collectors and sorted — will either face costs in the short term because they cannot pass on lower material prices, or will be able to do this and will end up without much of an impact.

This conceptual picture of the distribution of costs and benefits matches exactly how negotiations were conducted in response to China National Sword. Regardless of whether a processor was using material domestically, they still sought to pass on the cost of China Sword to export prices across all their tonnes, not just the exported tonnes. It has been the export market that has determined the price for materials and costs for those generating waste, such as households through council waste collections.

The illustration above is what would occur if there was a competitive market for the purchase of materials by waste processors. If there is not, then the price could fall further. The most likely outcome is the purchasers would set their price with reference to the landfill gate fees. For example, if it cost \$200 to landfill a tonne of paper, then a paper processor might ask for \$150 per tonne for them to take the material instead. That is, just enough so that material doesn't go to landfill, but no more.

As documented above, the paper market, and particularly the market for mixed paper, is likely to be the least competitive. C&I paper, plastics and tyres are expected to be more competitive.

Using the CBA model, we can distribute the costs based on the expected price impacts and level of competition. For Scenario 1, a full export ban, the results are shown in table 11.6. Households and businesses face large costs, of \$2.8 billion and \$5.3 billion, respectively, over a 20 year period, as their fees for disposing of material increase, because of lower prices for recycled material. For MSW waste, this would be reflected in higher waste charges from local councils. The recycling industry — meaning the processors of material rather than collectors and sorters — face large net financial gains. This is because they will have lower prices for their input materials. State governments

receive a benefit in the form of additional landfill levies — this is also a part of the higher cost for households and businesses.

	Paper	Plastics	Tyres	Glass	Total
	\$m, pv	\$m, pv	\$m, pv	\$m, pv	\$m, pv
Households as waste generators	-2 451	- 157	- 151	0	-2 759
Businesses as waste generators	-5 158	0	- 168	0	-5 325
Recycling industry	6 681	197	174	0	7 053
Government (state)	147	35	7	0	189
Total	- 781	75	- 137	0	- 843

Source: The CIE.

Focusing specifically on the impact on generators of waste — households and businesses — and looking across states and different material streams, the impacts of Scenario 1 are shown in table 11.7. These are equivalent one-off costs. Households will face costs of around \$100 per person (once-off) for municipal paper waste (or around \$10 per year if amortised over a period of 20 years). There are larger costs for business for waste paper (around \$200 per person across Australia), reflecting the larger reduction in price expected for C&I paper as a result of the export ban and large volumes of this paper.

The costs for plastic and tyres are smaller, at around \$6 per person for plastics for MSW waste and a similar amount for tyres used on passenger cars.

	NSW	VIC	QLD	SA	WA	TAS	NT	Total
	\$/person							
Paper								
MSW	-102	-85	-90	-132	-106	-52	-2	-96
C&I and C&D	-106	-369	-125	-241	-171	-600	-2	-203
Total	-208	-453	-215	-372	-277	-652	-3	-299
Plastics								
MSW	-4	-8	-3	-23	-2	-1	-7	-6
C&I and C&D	0	0	0	0	0	0	0	0
Total	-4	-8	-3	-23	-2	-1	-7	-6
Tyres								
MSW	-6	-7	-5	-10	-5	-5	-6	-6
C&I and C&D	-6	-8	-5	-11	-5	-7	-7	-7
Total	-12	-15	-10	-21	-10	-12	-13	-13

11.7 Impact on households and businesses (waste generators)

	NSW	VIC	QLD	SA	WA	TAS	NT	Total
	\$/person							
Total								
MSW	-112	-100	-98	-165	-113	-58	-14	-108
C&I and C&D	-112	-376	-130	-252	-176	-607	-9	-210
Total	-224	-476	-228	-416	-290	-665	-23	-318

Source: The CIE.

If some material is exempt, then the impacts will be smaller. The MSW impacts would be the same under exemptions, but C&I and C&D impacts would be smaller, as it is this material that has been modelled as meeting the exemptions.

The above estimates are based on all sectors being competitive in terms of purchase of materials, except for MSW paper. The impacts for paper with and without competition are shown in table 7. If there was competition to purchase MSW paper, the impacts would be substantially smaller, at ~\$14 per person (once-off) compared to almost \$100 otherwise. The impacts without competition are based on paper purchase charging the landfill gate fee less \$50 to take mixed paper. This may be somewhat low, if paper purchasers are considering the overall viability of the recycling system — at this level councils would financially be better off not having separate kerbside collections. However, financial impacts are only one aspect of councils' recycling decisions.

For C&I and C&D paper, the costs if markets are uncompetitive would be even larger. There are several purchasers of C&I paper currently. However, there may be less competition in some jurisdictions than in others.

	NSW	VIC	QLD	SA	WA	TAS	NT	Total
	\$/person							
MSW								
Uncompetitive	-102	-85	-90	-132	-106	-52	-2	-96
Competitive	-18	14	17	-48	-106	-2	-2	-14
C&I and C&D								
Uncompetitive	-219	-805	-290	-406	-184	-926	-2	-408
Competitive	-106	-369	-125	-241	-171	-600	-2	-203

11.8 Impacts on paper with and without competitive markets to purchase material

Source: The CIE.

12 Risks and unintended consequences

The main risks around an export ban are that there will not be sufficient demand domestically by the time of the export ban, leading to material being landfilled or stockpiled, and leading to financial distress for sellers of recycled commodities. This risk breaks into multiple components that are interrelated across parts of the supply chain (chart 12.1). These risks relate to the supply chain, but we focus on them in the context of an export ban.





Source: CIE.

At the top of the risk hierarchy are commercial market considerations. These relate to the risks and barriers which stop recycling operators from developing processing

infrastructure or undertaking domestic recycling. This affects the level of investment in infrastructure and capacity. Key elements which affect commercial feasibility are:

- Frictions in changing prices of materials. For example, contracts may make it time consuming and costly to respond to a change in the prices a material recovery facility (MRF) receives. These frictions can have dramatic consequences, such as financial distress and closure of facilities. When the China Sword policy was introduced the profitability of several MRFs, in particular in Victoria, was compromised by contracts which required MRFs to accept material which had a significantly lower value (see box 10.2).
- Development constraints. This relates to the availability of suitable development sites, the time to get planning and environmental approvals as well as the time to construct facilities. Development constraints increase the costs of investing in new infrastructure and increases project risk and uncertainty, in particular where market conditions, such as prices, availability of inputs and regulation are variable. They also mean that in the short term facilities may not be developed in time for the export ban. Long lead times of several years are required for re-processing facilities to achieve development and environmental approval.
- Reliance on export markets for reprocessed material. This introduces currency risk for operators, as well as exposes operators to the variability in overseas markets. For paper, most of the additional processed recycled material would be expected to be sold overseas; and operators would be exposed to overseas market risks. Operations that are not vertically integrated are also subject to much greater risk.
- Competition. Some markets for processing recyclable materials are very thin for instance paper and cardboard processing in Australia is dominated by Visy for mixed paper inputs.

Taken together, these factors all impact on commercial risks. Commercial risks include variability in prices, availability and costs of inputs (including labour, capital, other intermediate inputs and material for processing), costs of substitutes (virgin material) as well as general economic risks. This also includes uncertainty around the definitions of material covered by the export ban and exempted by the export ban. These risks determine the commercial feasibility/viability of recycling.

The outcome of the commercial market considerations has a direct market impact on the available processing capacity. Processing capacity is directly related to commercial feasibility; where it is feasible and the risks of development can be managed, investment in processes sing capacity can be expected to occur without government intervention. Under the estimates of costs and revenues for this study:

- it would be commercially feasible to put in place new paper processing relative to landfilling it. However, there are major risks that may deter this from happening
- it would be commercially feasible to put in place new plastic processing. The risks are much lower for plastic, but would mainly address the higher value materials
- for tyres, it would be commercially feasible to put in place new tyre processing relative to landfilling, but potentially less so relative to stockpiling.

The availability of capacity directly impacts the outcome of materials collected for recycling. Without exports of unsorted recycling material, the possible outcomes for material are:

- Materials being recycled. This involves processing of material till it can either be used by domestic manufacturers or exported as a commodity (e.g. plastic flake or pellets)
- Material going to landfill. Landfills are subject to a range of regulations that require their appropriate siting and engineering to reduce health and environmental risks, and operate under regulatory requirements and oversight that significantly internalise operational risks and costs to landfill operators, and the gate fees they charge.

Nevertheless, residual health and environmental externalities at landfills may include:

- greenhouse gas emissions
- non-greenhouse gas air emissions
- leachate escaping from landfills
- disamenity caused when houses or recreational areas are located near landfills
- Materials being stockpiled or illegally disposed of. Stockpiling of materials can result in increased risk of fire as well as negative externalities including damage to the environment, amenity impacts, health impacts and clean-up costs. In Victoria, the China Sword has resulted in stockpiling of comingled recyclables (see box 10.2).

The outcomes of recyclable materials are likely to have downstream impacts on household recycling. If recyclable material is not being recycled, there a risk the public will lose confidence in the kerbside recycling system. The outcomes of this could include increased contamination rates or reduced volumes. This will affect the viability of the sector, where MRFs are able to extract less value from recycled material, due to increasing contamination as well as a lack of end markets.

Risks by material

Table 12.2 reports risk ratings for the paper and cardboard, plastic and tyres sectors. Risks are scored as low, moderate or high. Green cells indicate a score is good/positive (i.e. low risk), red cells indicate a score is bad/negative, and yellow cells are in between. We have also considered whether risks are short run or long run risks in accordance with the timing of their impact. Where a quantitative measure is available to indicate the magnitude of risk, this is provided and units are shown in the row heading.

We view paper and cardboard involving the greatest risks, primarily relating to the low commercial feasibility of domestic processing of this material and large scale required. PET and HDPE are likely to be commercially feasible which significantly reduces the downstream risks around material ending up in landfill or being stockpiled in the long run. However, the central case for the economic analysis in earlier chapters has landfilling of polymer types 3-7, and there is little upside risk to this outcome. This poses risks for achieving government policy objectives, such as increased recovery rates.

Commercial viability measures shown in the table are visually represented in chart 12.3. These measures are the net industry benefit of processing or landfilling a tonne of material rather than exporting it. A net industry benefit for processing a tonne of plastics

rather than exporting it of \$29 suggests that processing is commercially viable at current prices (i.e. under the base case). Net industry costs from processing paper and cardboard and tyres suggest they are not commercial viable currently. All materials are commercially viable to process if the alternative is only landfill, since there is a very large net cost from landfilling rather than export which outweighs the net cost/benefit from processing rather than export. In this case, commercial take-up will reflect consideration of risks.

Risks	Long run or Short run risk	Paper and cardboard	Plastic	Tyres
Commercial market consideration				
Lack of commercial feasibility currently (net benefit per tonne processed rather than exported, \$/t)	LR	-111	29	-287
Lack of commercial feasibility relative to landfill or stockpiling (net benefit per tonne processed versus landfilled, \$/t)	LR	+267	+449	+93
Commercial risks for operators	LR	High	Moderate	Moderate
Time to establish facility (years)	SR	2 - 6	1 - 3	1 - 7
Lack of competition	LR	High	Moderate	High
Amount of capital for a facility (\$million)		150	<20	Unknown
Market capacity and contracts				
Lack of capacity in existing facilities	SR	High	High	Not known
Rigidities in existing contracts	SR	High	Moderate	Low
Outcomes				
Increased material going to landfill	SR and LR	High	Moderate	Low
Increased material going to stockpiles	SR and LR	Moderate	Moderate	High
Downstream impacts				
Public confidence in recycling	LR	High	Moderate	Na
Increase in contamination of kerbside recycling	LR	Moderate	Low	Na
Challenge to viability of kerbside recycling	LR	High	Moderate	Na
Overall risk		High	Moderate	Moderate

12.2 Risk ratings by material

Source: The CIE.



12.3 Net industry benefit per tonne of processing and landfill relative to export

Data source: The CIE.

Paper and cardboard

There are high risks for the export ban on paper and cardboard, including:

- Poor conditions for investment in greater capacity, due to demand side, supply side and market structure risks
- Risk of landfilling of paper and cardboard, particularly in the short term, due to lacking capacity
- A loss of public confidence in kerbside recycling and worsened viability of the system

Commercial market considerations

The economic analysis shows that domestic paper and cardboard processing facilities are not commercially viable at current prices, as the costs of processing are likely to be greater than the revenue from the higher value-added product. However, they would be viable relative to landfilling.

The CBA of processing infrastructure for paper and cardboard uses point estimates; in reality there are risks around the parameters used in the analysis. These risks include the following:

the domestic market for processed paper and cardboard is saturated. This means that any additional processing would need to be geared towards export. Economic conditions are currently supressing domestic demand for corrugated cardboard boxes, for which most of the recovered paper is used. This is driven by ongoing drought⁷⁵ and generally weak economic conditions and pose a general risk through the business cycle.

⁷⁵ The drought affects the volume of food production and therefore the number of cardboard boxes required to transport that produce.

- pricing risks exist in export markets. This comes from:
 - fluctuations in demand and prices overseas. The prices of exported paper and cardboard have fallen and remained low at the end of 2019 due to external factors, particularly a downturn in Chinese industrial production (reducing demand for paper and cardboard).⁷⁶
 - fluctuation in the Australian dollar; exporting recycled materials exposes operators to currency risks. Financial market instruments can be used to manage this risk to some extent, but this adds to long run uncertainty, against the large initial capital investment required.
- Prices for virgin pulp have been falling recently which has contributed to weak demand for recovered paper and cardboard. As relative prices change so does demand for pulp since manufacturers of paper and cardboard products can substitute from recycled to virgin material inputs. Long-term contracts and vertical integration can mitigate these risks.⁷⁷
- a deep market for pulp does not really exist overseas which increases risks around finding buyers. Most pulp moved internationally is within the same business, rather than traded.
- some collectors of paper are bound by "take or pay" contracts and struggle to adjust quickly. This obliges collectors to take recovered paper at a specified price or pay a penalty. As demand and prices for these materials fall, this results in losses for businesses, which is a challenge for the ongoing viability of recyclers as prices remain subdued and contracts do not adjust quickly enough.⁷⁸
- paper and cardboard processing facilities are very large and expensive. Their development requires large fixed capital costs, against small margins from processing recovered material. This amplifies the price and demand risks faced by processors, as small falls in demand or prices can affect the overall viability of an investment.
- a lack of competition in the market for paper processing. Paper and cardboard processing in Australia is dominated by Visy. This may increase barriers to entry for a new operator as a monopolist may exercise their market power to deter new entrants.
- development constraints on new processing sites. The availability of sites is not an issue, as these would be located on the outskirts of significant industrial centres where there is lots of available land. The main issue is around the time to gain planning and environmental approvals, and then to construct. Approvals would generally take 24 months. However, in the past it has taken between 3 and 15 years to plan, gain

⁷⁶ Envisage Works, IndustryEdge and Sustainable Resource Use 2020, Recovered Resources Market Bulletin, Edition 10, prepared for Waste Management and Resource Recovery Association of Australia and Sustainability Victoria, January 2020.

⁷⁷ Envisage Works, IndustryEdge and Sustainable Resource Use 2019, Recovered Resources Market Bulletin, Edition 8, prepared for Waste Management and Resource Recovery Association of Australia and Sustainability Victoria, November 2019, p. 16.

⁷⁸ Envisage Works, IndustryEdge and Sustainable Resource Use 2020, Recovered Resources Market Bulletin, Edition 10, prepared for Waste Management and Resource Recovery Association of Australia and Sustainability Victoria, January 2020, p. 19.

approval and construct a paper processing facility.⁷⁹ The sensitivity analysis in table 9.1 highlights the large increase in the net cost if paper facilities take twice as long to be in operation, as large volumes of material would be landfilled in the interim.

- The Visy paper mill in Tumut required 4 years (1998-2002) from development application to first operations of stage 1 (300 000 tonnes per year). A further 1 year (2006-2007) was required to obtain approval for stage 2 expansion to 700 000 tonnes per year.⁸⁰
- The Orora paper mill in Port Botany received its development approval in 2007 and began operations in 2013.⁸¹

Market capacity and constraints

Because of the limited commercial feasibility at current prices, there has not been much expansion of capacity to process paper and cardboard domestically. Recent weakness in export markets for paper and cardboard has resulted in increased materials available for domestic processors. However, a combination of a lack of capacity and saturated demand for end products (corrugated boxes) has resulted in high quality recovered paper from the commercial and industrial stream going to landfill.⁸²

Given high quality material is currently going to landfills, the additional material due to an export ban would also be at risk of going to landfill for some period of time.

A key development in terms of market capacity is the cessation of operations at the Norske Skog mill at Albury in December 2019. The mill has since been acquired by Visy at a price understood to be significantly below the costs of construction for the facility. It is unclear what future processing is going to occur at the mill.

Outcomes

As noted above, some paper and cardboard material is currently going to landfill and being stockpiled given the lack of processing capacity and lack of excess demand for end products. The risks of material going to landfill and being stockpiled is greater for material from kerbside collection than material from commercial and industrial streams which tend to be of much higher quality.

⁸² Envisage Works, IndustryEdge and Sustainable Resource Use 2019, Recovered Resources Market Bulletin, Edition 9, prepared for Waste Management and Resource Recovery Association of Australia and Sustainability Victoria, December 2019, p. 18.

⁷⁹ For example, the Visy paper mill in Tumut required 4 years (1998-2002) from development application to first operations of stage 1 (300 000 tonnes per year). A further 1 year (2006-2007) was required to obtain approval for stage 2 expansion to 700 000 tonnes per year. See: https://www.visy.com.au/env-appv-mgmt-plan

⁸⁰ https://www.visy.com.au/env-appv-mgmt-plan

⁸¹

https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent? AttachRef=MP05_0120-MOD-8%2120190507T022815.291%20GMT

These risks of landfill/stockpiling outcomes are highest in the period after implementation of an export ban and before facilities have time to be constructed. This highlights the importance of allowing sufficient time between announcement and implementation for industry to respond by adding sufficient capacity.

The market activities which will result in response to the ban will depend on the exemptions that are allowed. In particular, depending on the nature of the exemption for clean paper and cardboard, it may mean that MSW could be sorted sufficiently to meet the exemption and be exported. That is, if the threshold for 'clean' is achievable for kerbside material, MRFs may determine that the optimal response is to sort paper and cardboard more and produce a cleaner product for export, rather than to sort material to the standards for domestic processing. This would mean that our assumption that MSW would not ever meet the exemption would not hold, and that the risk of landfilling is decreased.

Downstream impacts

Ongoing limitations in the capacity for paper and cardboard processing pose risks to the viability of kerbside recycling:

- In the short run there may be an increase in contamination of paper and cardboard. In Victoria there are reports of contamination rates of 20 per cent in some instances, as soft markets for recovered paper and cardboard are being met by higher contamination.⁸³ It is unclear whether this is due to
 - households putting in less effort to sort/clean their recyclables in response to reports of kerbside recyclables being landfilled, or
 - MRFs choosing to remove more material as contamination due to the costs of sorting being greater than the value of sorted material. That is, as material values fall, and the returns to sorting decreases, MRFs may choose to keep (i.e. not landfill) only the material that is cleaner from the source

Regardless, in the long run there is a risk that landfilling of collected material has a negative impact on household recycling behaviours.

- In the long run there may be an unwillingness of local government to pay MRFs to collect paper and cardboard. This could be also driven by MRFs requiring additional funds to place recovered material with a processor given capacity constraints. There is a risk that paper and cardboard would no longer be collected by some local government areas, with that material instead going to landfill.
- Paper is the mainstay of the kerbside recycling system, comprising half of the volume and historically most of the value. Glass is the second largest and has had a negative value for some time. If paper and glass together both become low value recyclables, then this covers 80 per cent of kerbside materials and would likely mean councils could find better financial options for managing MSW that recycle less material.

⁸³ Envisage Works, IndustryEdge and Sustainable Resource Use 2020, Recovered Resources Market Bulletin, Edition 10, prepared for Waste Management and Resource Recovery Association of Australia and Sustainability Victoria, January 2020.

Options for mitigation of risks

The overarching risk for paper and carboard processing is whether businesses will invest in processing facilities, and whether this will happen quickly enough after the export ban to avoid landfilling of recyclables. Our analysis indicates that that commercial viability of paper and cardboard processing may be marginal at best, before accounting for the further risks discussed above (namely demand and price risk).

To-date, the main approach to mitigate these commercial feasibility risks has been for vertical integration of supply chains by Visy, the main domestic processor. Visy owns and operates packaging manufacturing facilities overseas, which allows them to export domestically processed paper and cardboard to their own facilities overseas, as well as using collected paper and cardboard to produce products in Australia. This helps mitigate risks around finding end markets, prices and diversifies their operations from the economic conditions in any one country.

Possible strategies to mitigate the risks noted above include:

- providing a subsidy for an overseas packaging manufacturer to establish paper and processing facilities in Australia. This would enable vertical integration, to overcome a range of issues noted above, and would support a new entrant improving competitive conditions
- streamlining the planning process to develop a facility. This will enable capacity to be developed more rapidly in response to announcement of the export ban, and reduce the likelihood of landfilling paper and cardboard recyclables.
- investing in some smaller volume activities which create new end markets for processed paper and cardboard. This includes moulded fibre, compressed insulation panels and some waste to energy solutions. Note this option has added risks around producing products for which there is no market (i.e. the costs exceed the willingness to pay of consumers such that an ongoing subsidy is required for it to be feasible) and is unlikely to deal with the volumes required
- reconsider stockpiling regulations or increase policing of existing regulations. Given the recent issues around stockpiling, we expect that enforcement and restrictions may already have been tightened. Where paper does not have a market, it is preferable from a societal perspective to landfill it rather than stockpile it.⁸⁴
- considering options to mitigate the impacts of paper and cardboard going to landfill, such as researching and implementing anaerobic digestion and gas creation.
- if an exemption is made for clean paper and cardboard, changing kerbside collection systems to collect paper and cardboard in a separate bin to make it clean enough to be exempt from the ban. Under a scenario with such an exemption, this would be an alternative to MRFs conducting additional sorting to prepare the material for export. However, the collection costs for an additional bin would be larger than the increase in material values obtained. The costs of MRF upgrades are lower than a separate bin,

⁸⁴ Landfills are engineered to mitigate risks of fire, leakage of waste, and other harms. Several fires have been experienced at stockpiling sites, such as the fire at SKM's Laverton North facility in July 2019, see: https://www.theage.com.au/national/victoria/major-fire-at-factorybelonging-to-notorious-melbourne-recycler-20190709-p525d5.html

suggesting this would be a more cost-effective approach to producing a clean paper and cardboard stream.⁸⁵

Plastics

There are moderate risks associated with the success of the export ban on plastics. Under the central case for the cost-benefit analysis, polymer types 3-7 are landfilled because of insufficiently developed or no end-markets. This poses a risk to achievement of government policy objectives such as increasing recovery rates. For HDPE and PET, the economic analysis in earlier chapters has shown that domestic processing is likely to be viable, but there are still risks associated with virgin pellet prices.

Commercial market considerations

The economic analysis shows that domestic processing is likely to be viable for rigid PET and HDPE, which fetch higher prices than other polymer types. Some investment has recently or is currently occurring for facilities to process these polymer types. However, apart from the existing market players, any newcomer to the plastics sector will take considerable time and effort to secure longer term secure supply of suitable materials and volumes of input material.

For plastic other than rigid PET/HDPE, there is a lack of end-market demand or saturated demand from niche applications. Soft plastics, mixed polymers and PVC do not have economically viable end markets. Even with additional processing, there is a significant risk that these materials will have negative values. End markets for flaked/pelletised Low-density Polyethylene and polystyrene are shallow and end markets for polypropylene are only emerging.

The market for plastics waste is closely interrelated with virgin polymer markets, because virgin and recycled pellets are substitutable for many applications. The price of virgin PET felled rose gradually throughout 2018 due to increased demand for manufacturing in China as recyclates imports to China decreased. Significant falls in prices occurred from October 2018 until early 2019, yet have since steadied.⁸⁶ These sort of fluctuations create pricing risk for flaking/pelletising businesses, which influences viability.

Development of processing capacity is more rapid and involves lower fixed costs than for paper and cardboard. The time to gain planning and environmental approvals is typically 12-18 months, and there are moderate risks associated with obtaining reasonable consent conditions. Further, it is a challenge to find a suitable site with appropriate zoning, and then to acquire or lease that particular site. This process can take up to 12 months. Moderate fixed capital investments are required for increased domestic plastics processing.

⁸⁵ This is based on collection cost, material values and MRF upgrade cost data supplied by industry to The CIE.

⁸⁶ See Sustainability Victoria, 2019, Recovered Resources Bulletin - October

Further, obtaining the social licence to operate is one of the big hurdles any waste related activity has to take. Community opposition can arise against any waste-related activities, whether recycling or landfilling. Many landlords see such activities as "negative" in regards to the value of their land, or neighbouring land (especially neighbouring residential land).

Market capacity and constraints

There is currently limited local manufacturing capacity to process plastics back into new products. This is related to the need for sufficiently deep end markets to allow additional investment, and much plastic packaging is manufactured overseas. Products manufactured from virgin resin in Australia accounted for 38 per cent of plastic consumed in 2017–18, while only 4 per cent was manufactured from locally processed recyclates.⁸⁷

There is some capacity to process PET and HDPE domestically, however this is far below the volume of available material. With the apparent commercial feasibility, we would expect capacity to increase for PET and HDPE.

Industry views indicate that there is limited secondary processing for other plastic types. for other materials this is less certain. Domestic processing capacity for polymer types 3–7 consists mostly of applications outdoor furniture, railway sleepers, and similar applications. These applications struggle to accept current volumes of soft plastics and rigid polymer types 3–7. They are not expected to be capable of sufficient expansion to meet the increased volumes associated with an export ban.

The ability of the market to respond with additional capacity is affected by an extension of typical reprocessor businesses up the supply chain. That is, businesses, in a drive to secure suitable input material flows, are offering services upstream of the reprocessing stage of the supply chain. For example, a market player may offer MRF or transfer station services together with reprocessing in order to secure the desired material stream. The consequence is an increase in risk for such facilities, since there are two facilities rather than one that must be planned, built, operated and financed. This can be a barrier to new entrants, and therefore to expansion of market capacity.

Outcomes

Plastic which is not being processed domestically is either exported, landfilled or stockpiled. With the implementation of the export ban, and in the absence of processing capacity expansion, the main risk will be around increased landfill and stockpiling and their associated risks.

For high value plastics, the likelihood of material being landfilled is low to moderate. We expect that processing facilities can be set up rapidly and with sufficient returns, even in without implementation of an export ban.

⁸⁷ The remainder (58 per cent) was sourced from imports for finished and semi-finished goods. See: Envisage Works, 2019, *Plastics infrastructure analysis update*, prepared for Department of the Environment and Energy, November 2019.

The likelihood of low-value plastics (soft and rigid polymer types 3-7) being landfilled is high. This risk is high even without implementation of export ban and would be exacerbated by the expansion in processing capacity required under an export ban. The central case for the cost-benefit analysis is that with the implementation of an export ban, this material is landfilled. This poses a risk for achievement of the Government's policy objectives, such as increasing recovery rates.

One potential upside risk for this material is that it could be used for waste-to-energy. Plastics have a high calorific value, including polymer types 3-7. Regulatory policy settings are a key determinant of the emergence of waste-to-energy as an alternative to landfill in Australia. This includes issues such as the acceptance of standards for fuel, such as acceptance of Refuse Derived Fuel (RDF). This may be a commercially viable proposition, but it may not be a socially optimal alternative to landfill. Social optimality depends on the magnitude of the externalities from waste-to-energy compared to landfill, while the choice of whether to landfill or put material through waste-to-energy will depend on financial costs and regulatory settings.

Downstream impacts

Plastics is less important than paper in kerbside recycling, due mainly to the lower volumes and smaller proportion of total value. However, its importance has been increasing as glass and paper/cardboard values deteriorate, while the value of PET and HDPE has remained relatively strong.

Changes to collection processes would have an impact on these downstream impacts. For example, having separate bins for glass or paper and cardboard would result in decreased sorting costs for kerbside plastics, increasing the viability of reprocessing this material.

The types of downstream impacts could include changes to what material is collected in kerbside recycling or C&I recycling. For example, removal of some plastics that are not being recycled.

Options for mitigation of risks

Possible strategies to mitigate the risks noted above include:

- Providing a subsidy for new processing facilities outside of the highest value plastics. This would resolve issues around commercial feasibility.
 - Subsidies may also take the form of grants for new technologies that provide endmarkets for this material (e.g. chemical recycling of polymers)
 - A similar strategy would be government procurement of the products which are produced from low-value recycled polymers (e.g. outdoor furniture made by RePlas). However, these markets may be insufficient to meet the supply of mixed plastic recyclate, even with significant government procurement.
- Streamlining the planning process to develop a facility. Planning processes are not the primary obstacle for viability of plastics reprocessing, but restrictions on other types of waste facilities such as MRFs may be obstacles towards securing consistent sources of

input material or obstruct vertical integration of processing facilities to achieve consistent supply of inputs.

- Reconsider stockpiling regulations or increase policing of existing regulations. Given the recent issues around stockpiling, we expect that enforcement and restrictions may already have been tightened.
- Considering alternative end markets, such as chemical recycling or waste to energy for low value materials.

Tyres

The National Tyre Product Stewardship Scheme launched in 2014 with the aim to increase domestic tyre recycling and expand the market for tyre-derived products. The National Tyre Product Stewardship Scheme is funded by the tyre industry, paid for by end consumers. Tyre Stewardship Australia has been accredited by the ACCC to administer the National Tyre Product Stewardship Scheme and to this end has entered into partnerships with end-use-stakeholders and research organisations. This includes collaborations with universities, local councils and EDI Downer during the 2018-19 financial year to research and develop new tyre derived products, such as:

- Crumbed Rubber Concrete for residential construction
- Permeable Pavement, and
- Concrete road barriers.⁸⁸

The stewardship scheme is funded by a levy of 25 cents per equivalent passenger unit (EPU, this corresponds to 9.5 kg of tyre) sold by members of the scheme.⁸⁹ In 2018/19 the levy scheme covered 43 per cent of the market.⁹⁰

Commercial market considerations

Given the product stewardship scheme in place, recycling of tyres is somewhat insulated from the commercial costs of recycling as it can be funded through a levy on the sale of new tyres. The incomplete coverage of the scheme means creates a risk that the costs of recycling will outstrip the capacity of the scheme.

Lead times for developing infrastructure is a key risk for tyre processing. Consultation with waste industry operators indicates a highly variable lead time of 2 to 11 years to establish new or upgraded facilities. A significant contributor to this timeframe is the time required to achieve development planning approval, with anywhere from 18 months to

⁸⁸ Tyre Stewardships Australia, 2018 -19 Annual Report, p. 12, https://www.tyrestewardship.org.au/static/uploads/files/tsa-annual-report-2018-19-webwffnfpdpvgos.pdf

⁸⁹ For a definition of EPU, see: https://www.tyrestewardship.org.au/resource/understandingequivalent-passenger-unit-ratios-epus

⁹⁰ Tyre Stewardships Australia, 2018 -19 Annual Report, p. 54, https://www.tyrestewardship.org.au/static/uploads/files/tsa-annual-report-2018-19-webwffnfpdpvgos.pdf

5 years suggested.⁹¹ For example, the Tyre Recycling Plant in Warren NSW, owned by Green Distillation Technologies required ~7 years (2011-2019) to achieve operational approval.^{92, 93}

These timelines are likely to be longer for facilities such as pyrolysis plants, and shorter for simple shredding operations.

There is also the risk of disrupting existing supply chains for recycling of tyres. In particular:

- TSA has been undertaking verification of the downstream processing of end-of-life tyres at a number of tyre processing facilities identified in India, Malaysia and Korea. Where these supply chains can be verified there are risks around the specification of the export ban as it may be diverting material from being recycled overseas to some less efficient use
- used tyres are often exported for retreading (in particular off-the-road tyres used for large machinery in agriculture, construction and mining), before being imported back to Australia. This allows significant cost savings compared to replacing old tyres with new once the treads wears out. Again there is a risk that the specification of the export ban interrupts this supply chain.

As noted above, recycled tyres can be used to produce a number of different products. However, there is a risk that increased processing of material for domestic use may result in these markets becoming oversupplied. This could result in material going to landfill, or more likely stockpiled, or the production of products for which there is no value to society.

There are challenges around compliance and enforcement of a ban that is based on the purpose for which tyres are exported rather than the actual nature of the good being exported. That is, it may be difficult or costly to identify whether a good is subject to a ban or not.

Market capacity and constraints

The TSA recovered 40.3 million used tyres EPUs out of a total of 56 million used tyres (69 per cent of used tyre EPU). As the tyre stewardship scheme does not operate on a commercial basis, we expect that there would be scope to increase capacity to meet additional processing requirement. The main risk to this capacity is likely to be increasing coverage of the levy on new tyres, as this only covers 43 per cent of the market.

⁹¹ Emails from the Commonwealth Department of Environment

⁹² https://www.aumanufacturing.com.au/green-light-for-new-tyre-recycling-plant

⁹³ https://www.abc.net.au/news/2019-06-02/recycling-australias-tyre-piles/11169386

Outcomes

The TSA recovered 40.3 million used tyres EPUs out of a total of 56 million used tyres (69 per cent of used tyre EPU). This consist of:⁹⁴

- 10.6 million EPU for reuse, including re-treading or repair
- 23.8 million EPU for processing into tyre derived products, including crumbed rubber for construction and tyre derived fuel for use in cement kilns, boilers or furnaces.
- 5.9 million EPU for use whole in thermal processing, such as cement kilns

Of the material which was not recovered:

- 16.2 million EPU was disposed to landfill or onsite (i.e. buried at a mine site)
- 1.6 million EPU were dumped or stockpiled.

Historically stockpiling had been a major issue for end of life tyres, however recently this been reduced as a result of tighter EPA regulations around the country and increased baling and export of tyres. Exporting of whole tyres is also lower cost than exporting shredded tyres.

Landfilling of tyres is expensive due to landfill levies and because often tyres must be shredded before being disposed of in landfill, or may be restricted to some landfills.

Taking this together the main risks around the export ban are that there is an increase in stockpiling of used tyres as the reduction overtime has been driven by low cost export options. Given the large costs associated with landfill, it seems unlikely that landfilling of tyres would increase.

Downstream impacts

We do not anticipate there are any risks around downstream impacts or confidence in the recycling system associated with tyre recycling.

Options for mitigation of risks

The main risk to providing the required capacity appears to be around funding. The stewardship scheme provides a mechanism by which the cost of disposing of tyres can be passed on to users, which is an economically efficient outcome. Funding risks could be mitigated by increasing participation in the scheme.

As with other materials, the time to gain planning and environmental approvals is a significant barrier, which could be mitigated by streamlining these processes.

Risks around stockpiling appear to be mitigated in recent years due a combination of EPA regulations and the ability to export baled tyres. With the implementation of an export ban, there is a risk that collectors will not adjust their fees accordingly and stockpiling or more widespread diffuse dumping of tyres will occur.⁹⁵ These will come under increased pressure if the export options are less attractive.

⁹⁴ https://www.tyrestewardship.org.au/static/uploads/files/tsa-2018-19-australian-tyreconsumption-and-recovery-factsheet-wfqcxknopblh.pdf

⁹⁵ Randell Environmental Consulting, 2019, End-of-life tyres supply chain and fate analysis, p.33.

A Detailed cost benefit analysis assumptions

Segment	Material	Time implemented	Share of material covered			
		All scenarios	Scenario 1	Scenario 2	Scenario 3	Scenario 4
MSW	Plastics	2022	100%	100%	100%	100%
MSW	Paper	2022	100%	100%	100%	100%
MSW	Tyres	2021	100%	100%	100%	100%
MSW	Glass	2020	100%	100%	100%	100%
C&I	Plastics	2022	100%	100%	100%	100%
C&I	Paper	2022	100%	0%	100%	0%
C&I	Tyres	2021	100%	100%	0%	0%
C&I	Glass	2020	100%	100%	100%	100%
C&D	Plastics	2022	100%	100%	100%	100%
C&D	Paper	2022	100%	0%	100%	0%
C&D	Tyres	2021	100%	100%	0%	0%
C&D	Glass	2020	100%	100%	100%	100%

A.1 Timing of policy scenarios

Note: The quantity of whole tyres that are baled and exported has been allocated as MSW waste, and whole tyres for retreading has been allocated as C&I waste. In the National Waste Report, all tyres are allocated as C&I. Source: Department of

A.2 Time required for a new facility to be operational

	Paper	Plastics	Tyres	Glass
Years	3	2	2	1

Note: The policy is assumed to be decided by 2020. This means that a paper facility would be operational in 2024. Source: The CIE; IndustryEdge and Full Circle Advisory.

A.3 Export prices

Waste stream	Material	Average price	Export volume	Export value
		\$/tonne	KT	\$m
MSW	Plastics	232	84	20
MSW	Paper	50	436	22
MSW	Tyres	66	53	3
MSW	Glass	49	0	0
C&I	Plastics	232	95	22
C&I	Paper	313	656	205
C&I	Tyres	1026.83	8	9
C&I	Glass	49	0	0

Waste stream	Material	Average price	Export volume	Export value
		\$/tonne	KT	\$m
C&D	Plastics	232	8	2
C&D	Paper	313	26	8
C&D	Tyres	1 027	0	0
C&D	Glass	49	0	0
Total	Plastics	232	187	43
Total	Paper	210	1 118	235
Total	Tyres	216	61	13
Total	Glass	49	0	0
Total	All	213	2 733	582

Note: Prices for paper are differentiated across streams so that the weighted average export price is achieved. The price of MSW paper is set at \$50/tonne. For tyres, the price for MSW tyres is the price for whole waste tyres and the price for C&I/C&D is the price of whole tyres not designated as waste, both from Blue Environment analysis of customs data. The price for plastic is not differentiated across streams as we do not have good information on which to base this. Mixed MSW plastic prices are substantially lower than the estimate in this table, while sorted MSW is substantially higher (eg baled HDPE and PET). Because there are no options that limit the type of plastic, differentiating prices by stream does not make a difference to the analysis. Prices for tyres are based on customs data provided by Blue Environment and allocated to whole baled versus exempted.

Source: CIE analysis; Blue Environment analysis of customs data.

A.4 Land requirements and costs

	Industrial land values	Paper	Plastics	Tyres	Glass
	\$/m2	m2	m2	m2	m2
NSW/ACT	725	1	0.25	0.25	0.25
VIC	393	1	0.25	0.25	0.25
QLD	321	1	0.25	0.25	0.25
SA	205	1	0.25	0.25	0.25
WA	438	1	0.25	0.25	0.25
TAS	205	1	0.25	0.25	0.25
NT	205	1	0.25	0.25	0.25

Note: The industrial price for Sydney is set at the lower bound, as the average price from Colliers is too high to be representative of locations for new paper facilities.

Source: https://www.colliers.com.au/en-AU/Research/Industrial-Research-and-Forecast-Report-Second-Half-2019; Paper land requirements provided by IndustryEdge; plastic land requirements provided by Full Circle Advisory; Tyres and glass assumed to be the same as plastic.

A.5 Landfill costs and levies

	Levy	Cost	Total
	\$/tonne	\$/tonne	\$/tonne
NSW/ACT	143.6	70	213.6
VIC	63.3	70	133.3
QLD	75	70	145
SA	110	70	180
WA	70	70	140
TAS	0	70	70

	Levy	Cost	Total
	\$/tonne	\$/tonne	\$/tonne
NT	0	70	70

Note: The landfill resource cost is set equal across jurisdictions. The actual gate fees charged are potentially higher than this in NSW and lower in QLD.

Sources: NSW EPA, Waste levy rates 2019–20 http://www.epa.nsw.gov.au/wasteregulation/waste-levy.htm; Victorian Auditor-General's Office 2018, Victorian Auditor-General's Report - Managing the Municipal and Industrial Landfill Levy, p.21, EPA South Australia, Waste levy rates 2019, http://www.epa.sa.gov.au/business_and_industry/waste-levy; WA Department of Environment Regulation, Landfill levy rates 1 July 2019 onwards, https://www.der.wa.gov.au/about-us/media-statements/112-landfill-levy-rates-to-rise-from-january-2015, https://www.qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/waste-levy-map, Transport Canberra and City Services 2019-20, Landfill fees for household waste, https://www.tccs.act.gov.au/about-us/fees_and_charges

A.6 Transport costs

	Economic	Environmental	Social
	\$/tonne	\$/tonne	\$/tonne
NSW	0	0	0
VIC	0	0	0
QLD	102	13	17
SA	74	10	12
WA	193	5	1
TAS	44	1	1
NT	237	3	1

Note: This assumes road transport for all states except WA (rail) and NT/TAS (shipping). NT and QLD are transported to NSW if there is no facility in their state. WA, SA and TAS are transported to Victoria. This is based on the cheapest transport cost option. Source: CIE interstate waste transport model.

A.7 Material that is residual

Segment	Material	Overseas residual	Domestic residual
		Per cent	Per cent
MSW	Plastics	19%	39%
MSW	Paper	20%	20%
MSW	Tyres	5%	5%
MSW	Glass	5%	5%
C&I	Plastics	20%	20%
C&I	Paper	5%	5%
C&I	Tyres	5%	5%
C&I	Glass	5%	5%
C&D	Plastics	20%	20%
C&D	Paper	5%	5%
C&D	Tyres	5%	5%
C&D	Glass	5%	5%

Note: The MSW plastic for domestic is based on the sorting efficiency of going from a 4-4-2 (HDPE-PET-Other) bale of mixed plastic to a 2-2-6 share. This implies about 80-85 per cent of PET and HDPE is extracted in domestic sorting. For overseas sorting we assume all HDPE and PET is extracted. For C&I and C&D plastic, there is little information amount recycled and that is residual and the resin types are very different to MSW – much more plastic LDPE film from packaging, for example. For paper, the residual is based on discussions with the waste industry and IndustryEdge, although contamination rates are not readily available.

The destination of residual waste overseas is not known. Anecdotally, this is likely to be predominantly burning, as a source of energy. For residual waste in Australia, we assume this is landfilled. If this is instead directed to waste to energy facilities then the costs would be about the same.

Source: The CIE, as per above.

A.8 Prices of products produced

Product	Material input	Stream	Central case
			\$/tonne of output
HDPE pellets	Plastic	All	1100
PET pellets	Plastic	All	1100
Shredded tyres	Tyres	All	45
Recovered Paper Pulp	Paper	MSW	515
Recovered Paper Liner	Paper	C&I/C&D	605
Corrugating Medium	Paper	C&I/C&D	595
Coated Kraftback [Cartonboard]	Paper	NA	1025
Uncoated Cartonboard (Grayback)	Paper	NA	880

Note: All plastic produced is assumed to get the average of HDPE and PET prices. Source: IndustryEdge; Full Circle Advisory; The CIE.

A.9 Paper facility costs and market synopsis

		Recovered Paper Pulp			Recycled Corrugated Packaging			Recycled Cartonboard/Folding Box Board		
		Low	Medium	High	Low (2.8m)	Medium (5.7m)	High (8.4m)	Low	Medium	High
Capacity										
Reference output capacity (tpa)		100 000	200 000	300 000	150 000	320 000	450 000	150 000	240 000	300 000
Implied input capacity (tpa)		140 000	280 000	420 000	210 000	448 000	630 000	210 000	336 000	420 000
Facility life (Yrs)		12	14	16	25	25	25	25	25	25
Capex										
Total Facility Capex (No Land)		190 000 000	248 000 000	295 000 000	306 000 000	437 000 000	661 000 000	342 500 000	437 000 000	534 000 000
Opex										
Operating expenses per input tonne (AUD/t)		85.00	77.00	72.00	105.00	100.00	94.00	138.00	130.00	115.00
Operating expenses per input tonne (AUD pa)		11 900 000	21 560 000	30 240 000	22 050 000	44 800 000	59 220 000	28 980 000	43 680 000	48 300 000
Market Synopsis										
Global market (Mt)~	2018			3.5			110.0			49.6
Australian market (t)^	2018-19			80 000			808 100			133 800
New Zealand market (t)^	2018-19			20 0000			115 000			110 000
Australia 2018-19										
Production (t)				80 000			1 188 000			0
Imports (t)				0			69 200			134 100
Exports (t)				0			449 100			300
Apparent Consumption (t)				80 000			808 100			133 800

Source: IndustryEdge.

www. TheCIE.com.au
B Envisage works estimates of costs of further processing

Envisage Works 2019 compare the differences between the recovered and virgin commodity prices, based on existing prices, and conclude:⁹⁶

- it is not financially viable to process recycled PET bottles back into a virgin PET resin, given the current virgin resin price
- the use of recycled glass instead of virgin materials for new glass packaging is marginal, and
- the use of recycling fibre-based packaging instead of virgin pulp is also marginal.

The indicative costs of using recycling PET bottles and fibre based packaging are shown in tables B.1 and B.2 respectively. These totals would be compared to the virgin material prices in table 5.8, less some adjustment for the price of recycled versus virgin resin.

Note that these conclusions reflect existing prices and are testing whether it is viable to process within Australia versus other available export markets. If there was no export market then we can consider whether further processing if viable relative to landfilling, by using the price of landfilling as the purchase cost. For PET, further processing would be highly viable, relative to landfilling.

Cost component	Cost	Comments
	\$/tonne of product	
Purchase cost ^a	500	Sorted PET bottles (1.3 tonnes to produce 1.0 tonne of PET pellets).
Transport	40	Transport from the MRF to the reprocessing facility. Assumed around 100 km. Includes handling.
Sorting, chipping and hot washing	300-400	Opex and capex estimate. Includes float separation, rinsing and drying.
Decontaminated, extrusion and pelletising (pellets production)	400-500	Opex and capex estimate. Assumed suitable for food- grade applications or fibre spinning.
Landfill costs	40	Disposal of residual processing wastes (~20% of incoming material).
Total	1 300-1 500 ª	Approximate production cost.

B.1 Indicative costs for recycling PET bottles

^a Co-product processing cost or sale value (e.g. recovered HDPE bottle caps) is not considered

Source: Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), p. 14

⁹⁶ Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #07), pp. 14-15

B.2 Indicative costs for recycling fibre-based packaging (based on mixed kerbside paper & cardboard)

Cost component	Cost	Comments
	\$/tonne of product	
Purchase cost ^a	-50	Unsorted kerbside paper & cardboard at the ingoing MRF gate of 1.4 tonnes. Assumed typical gate fee for councils.
MRF sorting cost	100-150	Approximate MRF cost for sorting 1.4 tonnes of mixed paper & paperboard with assumed 10% lost to landfill at the MRF level.
Transport	20	Transport from the MRF to the paper mill of 1.25 tonnes. Assumed around 50 km return.
Stock preparation and board production	300-350	Approximate cost for pulping and paper production, with assumed 20% lost to landfill.
Reel handling, storage & delivery to box plant	130	Transport from paper mill to box forming facility of 1.0 tonnes.
Landfill cost	80	Disposal of both sorting and processing wastes (~30% of collected paper & paperboard).
Total	580-\$680 ^a	Approximate production cost.

 $^{\rm a}$ Note that the cost excludes the kerbside collection cost

Source: Envisage Works 2019, Recovered Resources Market Bulletin: October 2019, Victorian Market Intelligence Pilot Project (edition #06), p. 16

C Exports under the base case

C.1 Exports 2019

Jurisdiction	Segment	Material	Indicator	2019
				kT
NSW	MSW	Plastics	Exported	28.43
VIC	MSW	Plastics	Exported	39.58
QLD	MSW	Plastics	Exported	7.95
SA	MSW	Plastics	Exported	1.34
WA	MSW	Plastics	Exported	6.89
TAS	MSW	Plastics	Exported	0.09
NT	MSW	Plastics	Exported	0.01
ACT	MSW	Plastics	Exported	0.00
NSW	MSW	Paper	Exported	91.87
VIC	MSW	Paper	Exported	116.23
QLD	MSW	Paper	Exported	86.23
SA	MSW	Paper	Exported	32.62
WA	MSW	Paper	Exported	106.26
TAS	MSW	Paper	Exported	0.88
NT	MSW	Paper	Exported	2.07
ACT	MSW	Paper	Exported	0.00
NSW	MSW	Tyres	Exported	18.33
VIC	MSW	Tyres	Exported	19.09
QLD	MSW	Tyres	Exported	5.51
SA	MSW	Tyres	Exported	4.02
WA	MSW	Tyres	Exported	5.98
TAS	MSW	Tyres	Exported	0.00
NT	MSW	Tyres	Exported	0.00
ACT	MSW	Tyres	Exported	0.00
NSW	MSW	Glass	Exported	0.00
VIC	MSW	Glass	Exported	0.00
QLD	MSW	Glass	Exported	0.00
SA	MSW	Glass	Exported	0.00
WA	MSW	Glass	Exported	0.00
TAS	MSW	Glass	Exported	0.00
NT	MSW	Glass	Exported	0.00
ACT	MSW	Glass	Exported	0.00
NSW	C&I	Plastics	Exported	51.16

Jurisdiction	Segment	Material	Indicator	2019
				kT
VIC	C&I	Plastics	Exported	30.55
QLD	C&I	Plastics	Exported	6.67
SA	C&I	Plastics	Exported	1.61
WA	C&I	Plastics	Exported	5.10
TAS	C&I	Plastics	Exported	0.12
NT	C&I	Plastics	Exported	0.00
ACT	C&I	Plastics	Exported	0.00
NSW	C&I	Paper	Exported	88.43
VIC	C&I	Paper	Exported	366.89
QLD	C&I	Paper	Exported	81.96
SA	C&I	Paper	Exported	40.66
WA	C&I	Paper	Exported	74.15
TAS	C&I	Paper	Exported	3.31
NT	C&I	Paper	Exported	0.81
ACT	C&I	Paper	Exported	0.00
NSW	C&I	Tyres	Exported	2.89
VIC	C&I	Tyres	Exported	3.01
QLD	C&I	Tyres	Exported	0.87
SA	C&I	Tyres	Exported	0.63
WA	C&I	Tyres	Exported	0.94
TAS	C&I	Tyres	Exported	0.00
NT	C&I	Tyres	Exported	0.00
ACT	C&I	Tyres	Exported	0.00
NSW	C&I	Glass	Exported	0.00
VIC	C&I	Glass	Exported	0.00
QLD	C&I	Glass	Exported	0.00
SA	C&I	Glass	Exported	0.00
WA	C&I	Glass	Exported	0.00
TAS	C&I	Glass	Exported	0.00
NT	C&I	Glass	Exported	0.00
ACT	C&I	Glass	Exported	0.00
NSW	C&D	Plastics	Exported	1.82
VIC	C&D	Plastics	Exported	4.05
QLD	C&D	Plastics	Exported	1.28
SA	C&D	Plastics	Exported	0.19
WA	C&D	Plastics	Exported	0.41
TAS	C&D	Plastics	Exported	0.00
NT	C&D	Plastics	Exported	0.00
ACT	C&D	Plastics	Exported	0.00
NSW	C&D	Paper	Exported	0.00
VIC	C&D	Paper	Exported	4.00

Jurisdiction	Segment	Material	Indicator	2019
				kT
QLD	C&D	Paper	Exported	16.58
SA	C&D	Paper	Exported	0.29
WA	C&D	Paper	Exported	4.42
TAS	C&D	Paper	Exported	0.01
NT	C&D	Paper	Exported	0.47
ACT	C&D	Paper	Exported	0.00

Note: MSW tyres is whole waste tyres, C&I tyres is other whole tyres.

Source: The CIE, based on inputs from Blue Environment.

D Environmental and social costs of waste transport

The environmental and social costs of transport utilised in domestic waste management are outlined below. The environmental and social costs of shipping exports internationally are not discussed.

Estimating environmental costs

Estimates of the costs of these environmental impacts are set out below (table D.1 for mid-point estimates, table D.2 for low estimates and table D.3 for high estimates). These break costs into:

- mode rail and road. There is no information available for sea freight. We have assumed sea freight has no environmental externalities except for GHG emissions, and that GHG emissions are the same as those of rail freight. There may be other environmental impacts related to shipping of waste, such as oil pollution of water that we have not included
- rural and urban environmental externalities are substantially higher in urban areas because a larger human population is impacted.

	Urban	Urban	Rural	Rural
	Road	Rail	Road	Rail
	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms
Air pollution	26.32	4.25	0.26	0
GHG emissions	5.86	0.44	5.86	0.44
Noise pollution	4.39	1.85	0.44	0
Water pollution	3.95	0.11	1.58	0.11
Nature and landscape	0.43	1.09	4.4	1.09
Urban separation	2.93	1.09	0	0
Upstream and downstream costs	23.43		23.43	

D.1 General environmental costs (medium)

Source: TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 60, March.

	Urban	Urban	Rural	Rural
	Road	Rail	Road	Rail
	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms
Air pollution	12.77	4.25	0.14	0
GHG emissions	2.93	0.44	2.93	0.44
Noise pollution	2.92	1.85	0.3	0
Water pollution	1.32	0.11	0.8	0.11
Nature and landscape	0.43	1.09	4.4	1.09
Urban separation	1.47	1.09	0	0
Upstream and downstream costs	20.5		20.5	

D.2 General environmental costs (low)

Source: TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 60, March.

D.3 General environmental costs (high)

	Urban	Urban	Rural	Rural
	Road	Rail	Road	Rail
	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms	\$/000 tonne kms
Air pollution	32.21	4.25	0.32	0
GHG emissions	10.24	0.44	10.24	0.44
Noise pollution	5.86	1.85	0.61	0
Water pollution	4.83	0.11	1.93	0.11
Nature and landscape	0.89	1.09	8.79	1.09
Urban separation	4.4	1.09	0	0
Upstream and downstream costs	26.36		26.36	

Source: TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 60, March.

To give an example of these costs, suppose a tonne of waste was transported 1000kms by road, of which 100kms was urban.⁹⁷ Then the environmental cost would be (table D.4):

- \$11.40 for road transport for air pollution, GHG emissions, noise and water pollution, and a potential \$27.70 for additional environmental externalities
- \$1.20 for rail transport for air pollution, GHG emissions, noise and water pollution, and a potential \$1.20 for additional environmental externalities
 - note that this does not include any environmental impacts from the transport of waste from the generator or transfer facility to the rail terminal and from the terminal to the receiver — these are included in the costs measured in the next chapter

⁹⁷ This is roughly the distance and task between Sydney and South East Queensland landfills.

D.4 Example of environmental costs

	Road	Rail
Journey length (kms)	1 000	1 000
Share urban (per cent)	10	10
Environmental cost (using mid-point estimates, \$/tonne)		
air, water, noise and GHG emissions	11.4	1.2
other potential environmental impacts	27.7	1.2

Source: The CIE.

For some types of environmental impacts, there is additional information beyond that contained in the TfNSW Guidelines.

The NSW Office of Environment and Heritage has previously compiled a detailed inventory of the physical air pollution within the greater Sydney metropolitan area from different sources, including rail freight.⁹⁸ The NSW EPA has also commissioned Environ to investigate options to reduce locomotive air and noise emissions.⁹⁹ Environ notes that

Diesel-fuelled locomotives are an important contributor to anthropogenic fine particulate and oxides of nitrogen emissions (NO_x). The World Health Organisation (WHO) has classified diesel engine exhaust as being carcinogenic to humans. It found that exposure to diesel exhaust is a cause of lung cancer and increases the risk of bladder cancer. In Australia, there are no air emission limits for new or remanufactured locomotives.¹⁰⁰

This study found that the overall health costs associated with locomotive emissions from diesel fuel were \$66 million per year. This included costs related to particulates less than 10 micrometres (PM10) and Oxides of Nitrogen (NOx) only.

While it is difficult to compare across studies, the air pollution costs per tonne kilometre from Environ 2013 for urban areas appear to be smaller than those in the TfNSW Guidelines. We use the TfNSW Guideline figures as these cover a wider range of air emissions.

The transport of waste may have greater environmental impacts than the transport of general freight, particularly the transportation of hazardous waste. Issues could include:

greater dust issues from transport of construction waste and the potential for asbestos escaping during transportation. NSW EPA have sampled some containers containing asbestos with only tarpaulin coverings. Note that it is not possible to place a cost on this, as the extent to which asbestos may escape and cause asbestos-related disease cannot be easily estimated

⁹⁸ NSW Environment Protection Authority 2008, Air emissions inventory for the Greater Metropolitan Region in NSW: Off-road mobile emissions, Technical Paper 6.

⁹⁹ Environ 2013, *Scoping Study of Potential Measures to Reduce Emissions from New and In-Service Locomotives in NSW and Australia*, prepared for NSW Environment Protection Authority.

¹⁰⁰ Environ 2013, Scoping Study of Potential Measures to Reduce Emissions from New and In-Service Locomotives in NSW and Australia, prepared for NSW Environment Protection Authority, p. vii.

- leaking of waste during transport or in rail yards, particularly from water entering unsealed containers and leaching out of containers
- biosecurity concerns around the transportation of waste, including:
 - the spread of fire ants in NSW. There is a fire ant exclusion zone in Port Botany and the EPA indicates that relevant interstate recipient waste facilities are in the Queensland fire ant exclusion zone. The Queensland Government has estimated that fire ants would impose costs of \$43 billion in South East Queensland alone over a 30 year period.¹⁰¹ Federal and State Governments have collectively spent \$300 million in fire ant eradication, from the first known incursion of red fire ants into Australia in 2001.¹⁰² Overseas evidence also suggests that the potential impacts are substantial.¹⁰³ The extent to which freight related to waste poses a higher risk than other freight has not been investigated by the CIE
 - the spread of phylloxera (a type of insect) which can severely damage wine growing areas . Most areas of Sydney are infected. Regional areas to the north of Sydney are not currently infected.¹⁰⁴
 - shipping can lead to costs associated with ballast water and biofouling, such as movement of barnacles and other water-based invasive pests.¹⁰⁵ These issues are not specific to the movement of waste.

Estimating social costs

We estimate three forms of social cost, which apply only to road transport:

- costs from accidents
- costs from congestion imposed on other road users
- costs from wear and tear on the road.

Accidents

Additional road transportation is expected to lead to additional accident costs imposed. Accident costs are borne by both the heavy vehicle and its occupant and other vehicles involved in an accident. Crashes involving heavy trucks accounted for 20 per cent of NSW road fatalities in 2012.¹⁰⁶ Note that we estimate accident costs for the additional road freight only, as the accident costs related to rail freight would be negligible.

- 103 EPA website, http://www.environment.nsw.gov.au/pestsweeds/FireAntsSpread.htm.
- 104 NSW Government Gazette, No. 189, 22nd December 2006.

105 See for example National Oceans Office 2011, South East Regional Marine Plan: Impacts of Shipping, http://www.environment.gov.au/resource/impacts-shipping; and PWC 2011, Proposed Australian Biofouling Management Requirements, *Consultation Regulation Impact Statement*, prepared for Department of Agriculture Fisheries and Forestry, December.

¹⁰¹ Invasive Species Council 2015, *Red imported fire ants,* Fact sheet, January.

¹⁰² Invasive Species Council 2015, *Red imported fire ants,* Fact sheet, January.

¹⁰⁶ NSW Centre for Road Safety 2014, Heavy Truck Fatal Crash Trends and Single Vehicle Heavy Truck Crash Characteristics, January.

The amount of accident costs reflects:

- the number and severity of the additional accidents related to the long haul transport of waste, and
- the costs associated with these accidents.

We use accident data from the federal Bureau of Infrastructure Transport and Regional Economics (BITRE) Road Fatalities Database, and collected by BITRE for injuries to estimate heavy vehicle crash rates. We only include crashes where there are reported injuries. The crash rates for fatalities and other injuries are shown in chart D.5 from 2010 to 2014.





Note: The fatality rate is fatalities per billion vkm, while the injury rate is the number of crashes involving injuries per vkm. The injury data does not include data from Queensland.

Data source: The CIE, based on: BTRE 2016, Heavy vehicle safety: crash analysis and trends, Information sheet 78; BTRE 2015, Australian Infrastructure Statistics Yearbook 2015, Table T 4-2; BTRE 2017, Australian Roads Death Database.

The cost of fatalities and other crashes is taken from TfNSW Principles and Guidelines. We use estimates for serious injury crashes, given that heavy vehicle crashes are more severe than those involving light vehicles, and BTRE 2016 indicates most reported injuries involved hospitalisations.¹⁰⁷ We do not include any costs for crashes without reported injuries.

The overall crash costs per vehicle kilometre are shown in table D.6. This would mean a 1000 km trip would have a crash cost externality of \sim \$7 per tonne from crashes.

¹⁰⁷ BITRE 2016, *Heavy truck safety: crash analysis and trends*, Information sheet 78.

D.6 Crash costs for heavy vehicles

Item	Low	High	Mid
Fatalities per billion vehicle kms	9	15	12
Cost of fatality (\$m/fatality)	7.3	7.3	7.3
Non-fatal injury crashes per billion vehicle kms	125	150	137.5
Cost of non-fatal injury crash (\$m/crash)	0.5	0.5	0.5
Cost per 1000 tonne kms	5.8	8.3	7.0

Note: We assume each truck carries 23 tonnes on average. This is consistent with BTRE data for articulated trucks in BTRE 2011, *Truck productivity: sources, trends and future prospects,* Research Report, Chart F2.7.

Source: The CIE; as noted in text; TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 52, March.

Note that we do not differentiate the safety impacts by urban and rural areas. The rates outside of capital cities are lower, although very close to the average rates because most vehicle kms are outside of capital cities.¹⁰⁸

There may be additional costs related to the clean-up of hazardous wastes following an accident. Because of a lack of data we do not include any additional cost from this.

Additional road congestion

Where heavy vehicle movements happen during periods when there are other road users and roads are busy, then this can lead to congestion impacts on other road users. These congestion costs include additional time (delays) and higher vehicle operating costs. These are only relevant for urban areas, as rural areas are not in general subject to congestion.

To estimate congestion costs, we start with TfNSW estimates of an average congestion cost per vehicle km of 180 cents for articulated trucks.¹⁰⁹

- The TfNSW estimate is based on scaling up the congestion cost for a passenger car.
 We expect that the transport of waste will be less distributed to peak periods than light vehicle movements.
- The TfNSW estimate is for Sydney as a whole. We expect that the urban areas for heavy vehicle traffic will tend to have less congestion than Sydney, noting that this includes urban areas of towns that are not bypassed, and outer areas of Brisbane.

Given the above, we have halved and then halved again the TfNSW congestion cost figure to give an estimate of 45 cents per vehicle km. With an average assumed waste load of 23 tonnes, this gives a cost of 2 cents per urban tonne km.

To give an example, a 1000 km journey, in which 10 per cent was in urban areas, would have a congestion cost of \$2 per tonne.

¹⁰⁸ BITRE 2016, *Heavy truck safety: crash analysis and trends*, Information sheet 78.

¹⁰⁹ TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 21, March.

Road wear and tear

Heavy vehicles impose road wear and tear. The heavy vehicle charging arrangements are designed to cover these costs, such as charges per litre of fuel. We do not include the fuel excise costs and instead include these costs as a social cost.

The cost is based on TfNSW Principles and Guidelines, which estimates a cost of 18 cents per vehicle km for a six axle articulated truck.¹¹⁰ This amounts to slightly less than 1 cent per tonne km, or \$8 for a 1000 km trip per tonne.

This may overstate marginal costs, as it is based on the NTC's method of allocating out road maintenance costs, some of which may not be incremental to the number of heavy vehicles. Hence, we use this as the high estimate. The alternative method is the ARRB lifecycle costing method. This estimates a marginal cost for rural arterial roads of 0.8 cents per standard axle repetition¹¹¹ km, which gives a lower marginal cost than the NTC method. The cost for freeways would be below that for arterials. Given this, we take a lower bound as zero and an upper bound from the TfNSW Guidelines, with the mid-point as the average of the two.

¹¹⁰ TfNSW 2016, Principles and Guidelines for Economic Appraisal of Transport Investments and Initiatives, Table 65, March

¹¹¹ Martin, T., Thoresen, T., Clarke, M. and Hore-Lacey, W. 2010, 'Estimating the marginal cost of road wear on Australia's sealed road network', HVTT11: International Heavy Vehicle Symposium, 2010, Melbourne, Victoria, Australia, Victorian Transport Association, Melbourne, Vic, 12pp.

E Environmental externalities from changes in recycling

For changes in the amount of material that is recycled and landfilled, we use lifecycle analysis prepared by RMIT for Sustainability Victoria.¹¹²

This study considered:

- Global warming Climate change effects resulting from the emission of carbon dioxide (CO₂), methane or other global warming gases into the atmosphere – this indicator is represented in CO₂ equivalents.
- Photochemical oxidation measurement of the increased potential of photochemical smog events due to the chemical reaction between sunlight and specific gases released into the atmosphere. These gases include nitrogen oxides (NOx), volatile organic compounds (VOCs), peroxyacyl nitrates (PANs), aldehydes and ozone. This indicator is of importance in areas where photochemical smog is likely to be a problem, such as in urban transport environments.
- Eutrophication the release of nutrients (mainly phosphorous and nitrogen) into land and water systems, altering biotopes, and potentially causing oxygen depletion effects such as increased algal growth.
- Mineral resource depletion the additional investment required to extract minerals resources due to depletion of reserves, leaving lower quality reserves behind, which will require more effort to harvest.
- Fossil fuel depletion the additional investment required to extract fossil fuel resources to depletion of reserves, leaving lower quality reserves behind, which will require more effort to harvest.

The study also measured precursors to environmental impact, such as land use, water use, solid waste and cumulative energy demand.

The first three environmental impacts are valued. We would expect that mineral and fossil fuel resource depletion is adequately reflected in market prices and would not need to be separately valued.

The cost of emissions in \$/t of CO2 equivalent emissions is \$34,21, based on the average carbon value between 2018 and 2027 supplied by DELWP.¹¹³

¹¹² RMIT 2015, LCA of Kerbside Recycling in Victoria, prepared for Sustainability Victoria.

¹¹³ DELWP carbon values are projections for a lower, central and upper case of carbon valuations to 2050. We adopt the nominal \$2016 carbon values from the central case estimate, and convert these into real \$2019 using the ABS CPI for Melbourne to-date and a projected 2.5 per cent rate of inflation to 2027.

For photochemical oxidation, we use PAE Holmes 2013 values for Victoria.¹¹⁴ These estimates are damage costs for PM2.5. The estimates from RMIT are for volatile organics compounds). The damage costs for VOCs are estimated by applying the relative ratio of damage costs for these pollutants relative to $PM_{2.5}$ as estimated by EEA (2014) to the $PM_{2.5}$ damage cost estimated by PAE Holmes (2013).¹¹⁵ As noted above, EEA quantified the health effects of VOCs resulting from the formation of secondary PM and ozone. As such the damage costs for VOCs do not include damages relating to the primary components. However as noted by EEA (2014), including the damages relating to primary VOCs. The estimates applied are shown in table E.1. Values shown are escalated using the CPI to \$2019.

SUA code	SUA	Area	Population	Population density	Damage cost PM2.5	Damage cost VOCs
		Km2	No.	People/km2	\$/tonne	\$/tonne
2011	Melbourne	5 679	3 847 567	677	\$190 000	\$9 107
2016	Sale	46	14 259	313	\$88 000	\$4 218
2020	Wangaratta	58	17 687	307	\$86 000	\$4 122
2004	Bendigo	287	86 078	299	\$84 000	\$4 026
2003	Ballarat	344	91 800	267	\$75 000	\$3 595
2005	Colac	55	11 776	215	\$60 000	\$2 876
2010	Horsham	83	15 894	191	\$54 000	\$2 588
2008	Geelong	919	173 450	189	\$53 000	\$2 540
2017	Shepparton - Mooroopna	249	46 503	187	\$52 000	\$2 492
2006	Drysdale - Clifton Springs	65	11 699	180	\$50 000	\$2 397
2012	Melton	266	47 670	179	\$50 000	\$2 397
2022	Warrnambool	183	32 381	177	\$50 000	\$2 397
2019	Traralgon - Morwell	235	39 706	169	\$47 000	\$2 253
2014	Moe - Newborough	105	16 675	158	\$44 000	\$2 109
2018	Torquay	126	15 043	119	\$33 000	\$1 582
2015	Ocean Grove - Point Lonsdale	219	22 424	103	\$29 000	\$1 390
2001	Bacchus March	196	17 156	87	\$24 000	\$1 150
2002	Bairnsdale	155	13 239	85	\$24 000	\$1 150
2013	Mildura - Wentworth	589	47 538	81	\$23 000	\$1 102
2007	Echuca - Moama	351	19 308	55	\$15 000	\$719

E.1 Damage costs for air pollution

114 PAE Holmes 2013, *Methodology for valuing the health impacts of changes in particle emissions,* prepared for NSW EPA, p. viii,

https://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/methodology-valuing-health-impacts-changes-particle-emissions.pdf.

¹¹⁵ European Environmental Agency, 2014, *Costs of air pollution from European industrial facilities* 2008-2012 – an updated assessment.

SUA code	SUA	Area	Population	Population density	Damage cost PM2.5	Damage cost VOCs
		Km2	No.	People/km2	\$/tonne	\$/tonne
2009	Gisborne - Macedon	367	18 014	49	\$14 000	\$671
2021	Warragul - Drouin	680	29 946	44	\$12 000	\$575
2000	Not in any SUA	216 296	693 578	3	\$900	\$43

Source: PAE Holmes 2013, Methodology for valuing the health impacts of changes in particle emissions, prepared for NSW EPA, p. viii, https://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/methodology-valuing-healthimpacts-changes-particle-emissions.pdf; European Environmental Agency, 2014, Costs of air pollution from European industrial facilities 2008-2012 – an updated assessment.

Note that air pollution costs may not actually be incurred in Victoria, as manufacturing activity is often in other locations. We apply the full air pollution cost, even this is outside of Victoria.

For eutrophication, RMIT presented estimates in terms of the cost of phosphates. Using previous unpublished estimates prepared by BDA and CIE for the cost of water pollution in NSW (averaging ~\$3000 per tonne of total phosphorus) and a conversion from phosphorus to phosphate of 3. Based on this we then use a value of \$1000 per tonne of phosphate in real \$2019.

There are also specific estimates of externalities from landfilling for Australia, shown below. The cost of disposing of waste to landfill depends on a range of factors, including the type of material, the size of the landfill, how it is managed and the local climate. BDA Group (2009) estimated the full cost of landfill disposal in Australia in various climates, under best practice controls, as well as poor controls. BDA Group's cost estimates included:

- private costs
- the cost of greenhouse gas emissions
- the external cost of other air emissions
- external costs associated with leachate
- the disamenity impacts associated with landfills.

The private costs and disamenity impacts estimated by BDA are inflated to 2012/13 dollars using the national Consumer Price Index (see table 7.14). These estimates suggest that the total cost of landfill ranges between \$45 per tonne up to around \$113 per tonne, depending on the size of the landfill and the controls in place.

In our analysis we include resource costs and pollution costs directly based on the RMIT LCA. We add a further \$10 per tonne for disamenity impacts not covered already.

Comparisons across material types

This study measures the environmental impacts for each material type separately, such as glass and PET. However, while it estimates the impacts from garden organics, it does not measure the impacts from food organics. We have assumed that the environmental

impacts of diverting one tonne of food organics from landfill to recycling are equal to the estimated impacts for diverting one tonne of garden organics.¹¹⁶

The impacts for each material type, measured in physical units such as tonnes of greenhouse gas emissions, are shown in table E.2. These impacts are all positive, meaning that there are greater environmental impacts from landfill compared to recycling.

Material type	Global warming	Eutrophication	Photochemical oxidation
	CO2 tonnes	PO4 tonnes	VOC tonnes
Glass	0.53000	0.00036	0.00230
Paper/cardboard	0.42131	0.00176	0.00190
Plastics	0.77724	0.00086	0.00281
Organics	0.72200	0.00012	0.00150

E.2 Environmental impacts from landfill relative to recycling, physical measures

Source: RMIT LCA, The CIE.

Comparison across impact types cannot be made without placing a weighting on the importance of each impact type. We use the monetary value of these impacts to compare their importance.

Monetised environmental impacts

The assumed value of environmental externalities in per tonne terms is shown in table E.3.

E.3 Cost of environmental impacts from landfill relative to recycling, by region

Cost category	Units	Dense urban (rearloaders)	Low density urban (sideloaders)	Inner regional	Outer regional
Cost of global warming	\$/t CO2	34	34	34	34
Cost of eutrophication	\$/t PO4	1000	1000	1000	1000
Cost of photochemical oxidation	\$/t VOC	9107	9107	2361	861

Note: CO2 refers to carbon-dioxide equivalent, PO4 refers to phosphates, and VOC refers to volatile organic compounds. Source: The CIE.

We multiply the cost per physical unit (e.g. tonne of volatile organic compounds) by the physical measure of environmental impact by material type. For example, the cost of

¹¹⁶ One study that considered the environmental impacts of food and garden organics found that the net benefit of recycling (rather than landfilling) FOGO was around 20 per cent less than the net benefits of recycling garden organics. This suggests our approach may slightly overestimate the externalities from food organics. However, this study was from NSW, is older than the RMIT analysis (2010 compared to 2014), and didn't consider photochemical oxidation or eutrophication. For these reasons and to maintain simplicity, we have assumed there are equal impacts from diversion to recycling of food and garden organics. See: NSW EPA, 2010, *Environmental benefits of recycling*, available at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/warrlocal/100058-benefits-of-recycling.pdf

global warming associated with a tonne of glass to landfill (relative to recycling that glass) is 0.53 tonnes of CO2-equivalent emissions multiplied by \$34/tonne of CO2, equating to \$18 per tonne of glass to landfill.

Summing together the monetary cost of global warming, eutrophication and photochemical oxidation impacts from each material type gives the costs of landfill relative to recycling shown in table E.4.

Material type	Dense urban (rearloaders)	Low density urban (sideloaders)	Inner regional	Outer regional
	\$/VOC	\$/VOC	\$/VOC	\$/VOC
Glass	39	39	24	20
Paper/cardboard	34	34	21	18
Plastics	53	53	34	30
Organics	38	38	28	26
Source: The CIE				

E.4 Total environmental costs of landfill relative to recycling

Source: The CIE.

F Summary of jurisdiction policy settings

F.1 Summary of state and territory policy settings

	Landfill levy (2019-20)		Strategy document (including targets)	Other (please see table notes for key)		
ACT	MSW	\$98.45/t	ACT Waste Management Strategy: Towards a sustainable	Container deposit scheme	✓	Introduced Jun 2018
	C&I	\$170.55/t	Waste generation grows less than population. Expand reuse of	Landfill bans	\checkmark	TVs & computers
	Mixed C&I with >50% recyclable material	\$232.70/t	goods. Waste sector is carbon neutral by 2020. Double energy generated from waste and recover waste resources for carbon sequestration.	Single-use plastics ban	✓	Cutlery, stirrers, polystyrene containers
	(The dollar figures are prices rather than levy amounts, as ACT owns the landfill and sets fees)		Recovery rate increases to over: = 85% by 2020	Internal hazwaste tracking	×	
			■ 90% by 2025.	Household chemical collections	✓	Free drop-off at two facilities
NSW	Metro area:		NSW Waste Avoidance and Resource Recovery Strategy 2014-			
	 Waste 	\$143.60/t	12.	Container deposit scheme	\checkmark	Introduced Dec 2017
	 Virgin excavated natural 	\$129.20/t	By 2021–22:			
	material Shredder floc Regional area:	\$71.80/t	reduce waste generation per capita increase recycling rates for: - MSW from 52% (in 2010-11) to 70%	Landfill bans	×	
	 Waste 	\$143.60/t	 C&I waste from 57% to 70% 			
	 Virgin excavated natural material 	\$129.20/t	 C&D waste from 75% to 80% increase landfill waste diversion from 63% (in 2010-11) to 	Single-use plastics ban	×	
	Shredder floc	\$71.80/t	75%			
	Coal washery rejects	\$15.00/t	 establish or upgrade 86 drop-off facilities or services for household problem wastes 	Internal hazwaste tracking	✓	
			continue to reduce litter items.			
			NSW Circular Economy Policy Statement 2019 outlines next steps to incorporate circular economic principles into NSW's 20-year Waste Strategy.	Household chemical collections	~	CleanOut events and Community Recycling Centres

	Landfill levy (2019-20)	Strategy document (including targets)	Other (please see table notes for key)		
	No landfill levy	Waste Management Strategy for the Northern Territory 2015-2022	Container deposit scheme	✓	Introduced Jan 2012
		No specific targets are included in the strategy.	Landfill bans	×	
NT			Single-use plastics ban	✓	Only bags
			Internal hazwaste tracking	x	
			Household chemical collections	×	
	General waste: MSW, C&I, \$75/t C&D (proposed)	Waste Management and Resource Recovery Strategy 2019 By 2025:	Container deposit scheme	√	Introduced 1 Nov 2018
QLD	Regulated waste: • Category 1 \$155/t • Category 2 \$105/t	 reduce MSW per capita by 5% increase state average MSW recycling rate to 55% (from 32% in 2018) increase C&I recycling rate to 65% (from 47%) increase C&D recycling rate to 75% (from 51%) reduce waste to landfill by 10% Targets are also set for 2030, 2040 and 2050. 	Landfill bans	× √ √	Plastic, compostable and biodegradable bags Drop-off availability subject to arrangements by individual councils
	Metro Adelaide: Solid waste \$110/t Shredder floc \$62/t	South Australia's Waste Strategy 2015-2020 Column 1 By 2020: Column 2 35% reduction in landfill disposal from 2002-03 level Column 2 5% reduction in waste generation per capita (from 2015 baseline) La Iandfill diversion targets in the metro area are: La	Container deposit scheme	√	Introduced 1977
SA	Non-metro Adelaide: Solid waste \$55/t Shredder floc \$31/t		Landfill bans	✓	Ban on a range of hazardous, problematic and recyclable materials, including most e- waste

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	Landfill levy (2019-20)	Strategy document (including targets)	Other (please see table notes for key)		
	No levy for packaged asbestos waste - 70% for MSW		Single-use plastics ban	✓	Bag ban. Ban on other plastics under consideration.
		- 90% for C&D	Internal hazwaste tracking	✓	
		 maximise diversion in non-metro area 	Household chemical collections	✓	Statewide household chemical drop-off
		Draft Waste Action Plan (2019) (pending outcome after consultation)	Container deposit scheme	×	Under consideration
		The Tasmanian Waste and Resource Management Strategy (2009) (under review at the time of writing)	Landfill bans	×	-
TAS	Voluntary levy adopted by regional waste groups at levels of \$0 to \$7.50/t		Single-use plastics ban	✓	Introduced Nov 2013
		No numerical targets are included in the strategy	Internal hazwaste tracking	×	Framework in place but not operational
			Household chemical collections	✓	Selected regional programs
	Metro and reginal:	Statewide Waste and Resource Recovery Infrastructure Plan (2016-2046)			
	• MSW \$65.90/t		Container deposit scheme	×	
	C&I and C&D \$65.90/t	No numerical targets included in the plan.			
VIC	Rural: MSW \$33.03/t C&I and C&D \$57.76/t	Circular economy policy expected to be published in early 2020.	Landfill bans	✓	'Category A' prescribed industrial waste, paint, industrial transformers, grease trap waste, oil filters, whole tyres and large containers, E-
	Prescribed industrial (hazardous) waste:				waste ban from 1 Jul 2019.
	Category B \$250/t		Single-use plastics ban	✓	Plastic bag ban introduced Nov 2019
	Category C \$70/t		Internal hazwaste tracking	✓	
			Household chemical collections	\checkmark	Statewide program

	Landfill levy (2019-20)		Strategy document (including targets)	Other (please see table notes for key)		
	Putrescible Inert \$105/m ³	\$70/t \$70/t approx.	Waste Avoidance and Resource Recovery Strategy 2030 From 2020, recover energy only from residual waste	Container deposit scheme	✓	To be introduced Jun 2020
			By 2025: 10% reduction in waste generation per capita Increase material recovery to 70%	Landfill bans	×	
WA		 Increase material recovery to 70% By 2030: Less than 15% of waste generated in metro regions is 	Single-use plastics ban	✓	Plastic bag ban introduced Jul 2018	
	landf = All wa facilit = 20% = Incre	landfilled All waste is managed and/or disposed to better practice	Internal hazwaste tracking	~		
		20% reduction in waste generation per capitaIncrease material recovery to 75%	Household chemical collections	✓	Eight metropolitan and five regional, permanent household chemical drop-off points	

Source: BlueEnvironment and Randell Consulting, 2020, National Waste Report, 2020 forthcoming.

G Details of recycling capacity

Paper and cardboard

G.1 Paper and cardboard re-processing facilities

Facility operator	Facility location	Capacity (tonnes/year)	Accepts MSW	Accepts other
NSW				
Visy Recycling	Smithfield	250 000	\checkmark	\checkmark
Visy Recycling	Tumut	700 000	\checkmark	\checkmark
Visy Recycling	Albury a	265 000	\checkmark	\checkmark
Orora	Botany	425 000	×	\checkmark
Victoria				
Australian Paper	Maryvale	80 000	\checkmark	\checkmark
Huhtamaki	Preston	15 000	×	\checkmark
Visy Recycling	Coolaroo	280 000	\checkmark	\checkmark
Visy Recycling	Reservoir	110 000	\checkmark	\checkmark
Queensland				
Fibre Cycle	Toowoomba	7 000	×	\checkmark
Fibre Cycle	Helensvale	9 000	×	\checkmark
Visy Recycling	Gibson Island	170 000	\checkmark	\checkmark
South Australia				
Fibre Cycle	Lonsdale	12 000	×	\checkmark
Tasmania				
Norske Skog	Boyer	290 000	N/A	N/A
Western Australia				
Nil			N/A	N/A
Northern Territory				
Nil			N/A	N/A
ACT				
Nil			N/A	N/A

^a Not operational, facility closed after being sold by Norske Skog in 2019.

Sources: Industry Edge communications; https://www.norskeskog.com/About-Norske-Skog/Press-room/Press-releases/English-press-releases/Norske-Skog-announces-sale-and-closure-of-Albury-mill?PID=4123&M=NewsV2&Action=1; https://planetark.org/ourpartners/PaperRecyclingPlant.cfm;

https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=MP05_0120-MOD-8%2120190507T022815.291%20GMT; https://www.norskeskog.com/Business-units/Australasia/Norske-Skog-Boyer

G.2 Paper and cardboard collection and sorting facilities

Facility operator	Facility location	Capacity (tonnes/year)	Accepts MSW	Accepts C&I
NSW				
Visy Recycling	Smithfield	300 000	\checkmark	\checkmark
Visy Recycling	Tumut	750 000	\checkmark	\checkmark
Visy Recycling	Albury	200 000	\checkmark	\checkmark
Cellmark	Mona Vale	80 000	×	\checkmark
Cleanaway	Albury	Unknown	\checkmark	\checkmark
Orora	Botany	500 000	×	\checkmark
Polytrade	Grafton	80 000	\checkmark	\checkmark
Polytrade	Rydalmere	Unknown	\checkmark	\checkmark
Victoria				
Australian Paper	Maryvale	130 000	×	\checkmark
Australian Paper Recovery	Truganina	85 000	\checkmark	\checkmark
Australian Paper Recovery	Hallam	70 000	\checkmark	\checkmark
Visy Recycling	Springvale	Unknown	\checkmark	\checkmark
Visy Recycling	Heidelberg	Unknown	\checkmark	\checkmark
Visy Recycling	Coolaroo	Unknown	\checkmark	\checkmark
Queensland				
Visy Recycling	Carrara	Unknown	✓	✓
Visy Recycling	Murarrie	Unknown	\checkmark	\checkmark
Visy Recycling	Gibson Island	220 000	\checkmark	\checkmark
Tasmania				
Cleanaway	Derwent Park	60 000	\checkmark	\checkmark
Veolia	Spreyton	40 000	\checkmark	\checkmark
South Australia				
North Adelaide Waste Management Authority	Edinburgh	180 000	√	✓
Visy Recycling	Wingfield	Unknown	✓	\checkmark
Western Australia				
Cleanaway	Perth	160 000	\checkmark	\checkmark

Facility operator	Facility location	Capacity (tonnes/year)	Accepts MSW	Accepts C&I
Southern Metropolitan Regional Council	Canning Vale	75 000	√	√
Northern Territory				
Cleanaway	Darwin	Unknown	\checkmark	\checkmark
ACT				
Re.group	Hume	Unknown	✓	✓

Note: Figures provided in the tables are estimates and should be used with caution.

 $Source: Industry {\tt Edge \ communication; \ http://www.re-group.com/services/.}$

Plastic

G.3 Number of plastic repressor facilities by jurisdiction in 2017-18

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Total
Number	0	14	0	9	6	2	25	2	58 <mark>a</mark>

^a Excludes ~8 facilities known to be operating in 2017-18 but no data was available.

Note:

Source: Envisage Works 2019, Plastics infrastructure analysis update - Project report, Table 15 November, p. 25

G.4 Top ten Australian plastics reprocessing facilities by throughput

Facility operator	Capacity (tonnes/year)	Accepts MSW	Accepts other
NSW			
Visy Recycling	Unknown a	\checkmark	\checkmark
Astron Sustainability	Unknown a	×	\checkmark
Dunlop flooring	Unknown a	×	\checkmark
Martogg group of companies	Unknown ^a	×	\checkmark
Polytrade	Unknown a	\checkmark	\checkmark
Victoria			
Advanced Circular Polymers	70 000	\checkmark	\checkmark
Astron Sustainability	Unknown a	×	\checkmark
Cryogrind	Unknown a	×	\checkmark
Dunlop flooring	Unknown a	×	\checkmark
GT recycling	Unknown a	×	\checkmark
Martogg group of companies	Unknown ^a	×	\checkmark
Olympic Polymer Processors	Unknown a	×	\checkmark
Polymer Processors	Unknown ^a	×	\checkmark

Facility operator	Capacity (tonnes/year)	Accepts MSW	Accepts other
Queensland			
Astron Sustainability	Unknown ^a	×	✓
Action products	Unknown ^a	×	\checkmark
Martogg Group of Companies	Unknown ^a	×	\checkmark
Resitech Industries	Unknown ^a	×	\checkmark
South Australia			
Recycled plastics Australia	20 000	\checkmark	\checkmark

a >2 500 tonnes per year.

Note: List excludes multiple smaller facilities with output less than 2 500 tonnes per year in 2017-18.

Sources: Envisage Works 2019, Plastics infrastructure analysis update – Project report, Table 15 November, p. 30; https://astronsustainability.com/resin/; https://www.dunlopflooring.com.au/about/; https://olympicpolymers.com/; https://www.polymerprocessors.com.au/; https://www.rtigroup.com.au/about-us/;

Glass

G.5 Glass beneficiation facilities

Facility operator	Facility location
NSW	
SKM a	Sydney
Victoria	
SKM ^a	Melbourne
Visy recycling	Melbourne
Polytrade	Melbourne
Queensland	
Owens Illinois	Brisbane
South Australia	
Visy recycling	Adelaide

^a SKM recently went into administration. The ownership arrangements are unknown.

Source: APCO (2020): Towards the 2025 Targets: Evidential companion report to Our Packaging Future.

G.6 Glass re-processing facilities

Facility operator	Facility location	Capacity (tonnes/year)
NSW		
Owens Illinois	Penrith	Unknown a
Victoria		
Owens Illinois	Melbourne	Unknown a
Alex Fraser	Clarinda	200 000

Facility operator	Facility location	Capacity (tonnes/year)
Downer	Melbourne	20 000
Queensland		
Owens Illinois	South Brisbane	Unknown ^a
South Australia		
Orora	Adelaide	350 000
Owens Illinois	West Croydon	Unknown ^a
Tasmania		
Nil		
Western Australia		
Nil		
Northern Territory		
Nil		
ACT		
Re.Group	Hume	Unknown

^a Total production across all Owens Illinois facilities was 650 000 tonnes in 2017-18. Individual site capacity is unknown. Source: APCO (2020): Towards the 2025 Targets: Evidential companion report to Our Packaging Future

Tyres

G.7 Tyre re-processing facilities

Facility operator	Main activities
NSW	
Bandag	Re-treading
BSV Tyre Recycling Australia	Baling, shredding and crumbing
Ecoflex International	Civil works
JLW Services	Shredding and crumbing
Ray Johnson Scrap Tyre Disposals	Casings
Green Distillation Technologies	Pyrolysis
Victoria	
Oz Tyre Recyclers	Baling, shredding and crumbing
Tyre Crumb	Shredding and crumbing
Queensland	
Australian Tyre Processors	Shredding
BG & JM Barwick	Shredding
Chip Tyre	Shredding and crumbing
Ozcom Recycling	Casings
Seven Star Rubber Crumb	Shredding and crumbing

Facility operator	Main activities
Tyre End	Casings
Green Distillation Technologies a	Pyrolysis
Western Australia	
Elan	Pyrolysis
Lomwest Enterprises	Civil works
Pearl Global	Pyrolysis
National	
Tyrecycle (ResourceCo)	Shredding and crumbing

^a Not operational. Toowoomba facility in development approval stage.

Note: Excludes an unknown number of companies specialising in baling and exporting of, most likely to Asia for TDF applications. An estimated 258 000 tonnes of tyre waste is exported annually for this purpose.

Source: Envisage Works 2019, Tyre flows and recycling analysis: Final Report, October, pp. 21-22; https://www.gdtc6.com/tyre-recycling/; REC, et. al., 2019, End-of-life tyres supply chain and fate analysis, November, pp.37-40



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