MINING INDUSTRY

Off The Road Used Tyre Analysis

FINAL REPORT
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Prepared for Tyre Stewardship Australia
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in association with Brock Baker
Environmental Consulting

TyreStewardship AUSTRALIA

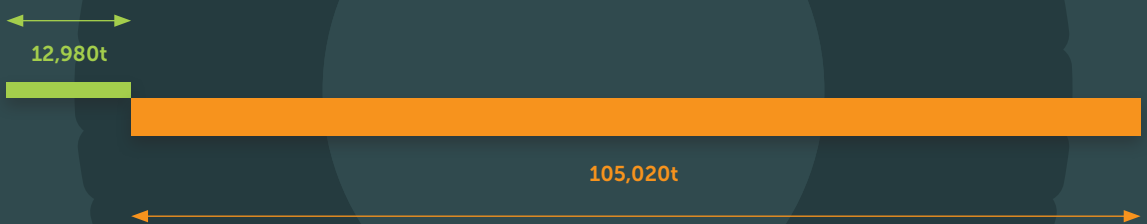
Contents

Introduction

In 2019, Tyre Stewardship Australia engaged Randell Environmental Consulting in association with Brock Baker Environmental Consulting to complete an analysis of the consumption and fate of mining industry Off-The-Road tyres

This analysis followed the completion of the report commissioned by Tyre Stewardship Australia titled ***End-Of-Life Tyres Supply Chain and Fate Analysis*** *(REC 2019)* by Randell Environmental Consulting

REC 2019 identified the need to better understand OTR tyre consumption and fate given the estimated **recovery rate in 2018/19 was just 11%**



The remaining 89% were not recovered (with 81% assumed to be disposed onsite at mining, farming or similar sites)

Basde on 118,000 tonnes of used OTR tyres in 2018/19.

Outline

Section 1 of this report begins by providing a detailed profile of all OTRs in Australia

- The profile includes analysis of OTR types and the industry sectors that generated the estimated 118,000 tonnes of used OTR tyres in 2018/19
- This section also provides analysis of the fate of all types of OTR tyres (i.e. what happens to the used OTR tyres)

Section 2 onwards, provides focused analysis of the mining portion of the used OTR tonnages

The 'deep-dive' into mining includes:

- A profile of the mining industry across Australia, including mine types
- Mapping of the mining industry sites and current used tyre processing sites, that enables analysis of travel times to used tyre processing facilities for different areas of Australia
- The historical and current management and fate of used mining tyres[2]
- Analysis of the technical feasibility of used mining tyre repair, re-treading, recycling or energy recovery
- A discussion of international best practice for used mining tyre management
- Analysis of the financials of used mining tyre recovery versus the current management practices
- Analysis of options to improve the recovery rates of used mining tyres

Project Scope

This report is intended to provide the foundation for further engagement with the mining sector

Much of the analysis is preliminary and intended to provide an understanding of the core issues.

The report does not provide 'the answers' to improved used mining tyre recovery, however, it will enable more informed discussions.

Scope 1

OTR tyre consumption and used tyre generation

- Detailed Material Flow Analysis (MFA) for OTR tyres that will detail OTR consumption, use, used tyre generation and fate by OTR tyre type
- Profile OTR tyre consumption and used tyre generation by industry sector (i.e. mining, agriculture, civil construction, other)

Scope 2

Mining industry sector analysis

- Provide a profile of the mining industry across Australia including mine types to enable analysis of the management of used tyres (based on mine type)
- Provide mapping of the mining industry sites to enable assessment of travel times to used tyre processing facilities for different areas of Australia
- Targeted consultation with state and territory regulators, a few mining companies, and used tyre recycling industry to confirm the historical and current management and fate of used mining tyres

Scope 3

Used mining tyres recovery analysis

- Analyse the technical feasibility of used mining tyre re-treading, recycling or energy recovery
- Analyse the financials of used mining tyre re-use, recycling or energy recovery, compared with current management practices
- Literature review of international best practice for used mining tyre management

Scope 4

Preliminary options analysis to improve recovery of used mining tyre

- Provide analysis of options to improve the recovered rates of used mining tyres
- The options analysis to include discussion of system wide reforms (product stewardship options) and, where appropriate, specific infrastructure investments that need to be implemented to enable used mining tyre recovery
- This options analysis is intended to provide the foundation for further engagement with the mining sector

Off-the-road tyre consumption, used tyre generation and fate

This section provides the detailed Material Flow Analysis (MFA) for all OTR tyres imported into Australia, including OTR tyre consumption, used OTR tyre generation and fate by tyre type and generating industry sector.

OTR tyre consumption

1.1

To profile OTR tyre consumption, OTR imports (both loose and fitment) were categorised by tyre type and then allocated to the assumed industry sector (that uses the OTRs). Table 1 provides the OTR tyre categories and related industry sectors derived for the project analysis.

Table 1. OTR tyre categories and industry sector allocations

OTR tyre category	Industry
Tractor (note 1)	Agriculture
Aircraft	Aviation
Grader, Bobcat and tractor	Construction
Solid and Fork lift	Manufacturing & trade
Earth mover	Mining

Note 1: Tractor small and large were split between Agriculture (80%) and construction (20%)

Table 2 provides the estimated OTR consumption by industry sector from 2014 till 2019 and the five-year average, in tonnes.

Table 2. OTR tyre consumption by industry sector 2014-2019 and five-year average (tonnes)

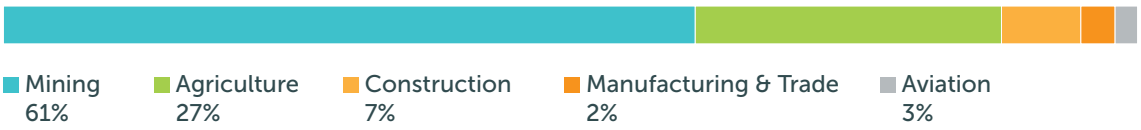
Industry	2014	2015	2016	2017	2018	2019	5-Yr. Ave.
Agriculture	46,300	38,800	36,100	39,000	37,300	33,800	37,000
Aviation[3]	2,200	2,800	2,200	4,500	3,500	3,700	3,400
Construction	14,100	10,600	10,400	10,400	9,300	8,500	9,800
Manufacturing & trade	36,700	55,700	21,700	2,400	8,600	2,900	18,200
Mining	62,200	44,600	58,500	67,600	80,800	76,900	65,700
Total	**161,500**	**152,400**	**128,800**	**123,900**	**139,600**	**125,800**	**134,100**

Over the past five years Australia has consumed an average of around 134,000 tonnes of OTR tyres.

On a tonnage basis, the mining and agriculture sectors have dominated consumption over the past 5 years, representing around 75% of the tonnages of OTR tyre consumption.

Figure 1 includes the 2018-19 OTR consumption by industry sector, in tonnes. It shows mining OTRs made-up 61%, followed by agriculture at 27% and construction, manufacturing and trade at around 10% and aviation tyres which made-up about 3%.

Figure 1. **2018-19 OTR consumption by industry sector (tonnes)**



3. Aviation tyre tonnages are likely to be an over-estimate as a single weight of 100 kgs per new tyre has been applied to all aviation tyre imports (as they are all under one import code) and that weight is too high for smaller aviation tyres.

Used OTR tyre generation 1.2

Following OTR tyre consumption and use, used OTR tyres are generated. The tonnages of used OTR generation relate to the consumption tonnages from the previous years. The tonnages of used tyres are lower than new tyre consumption from previous years due to tyre wear and the weight difference between a new and used tyre.

Table 3 provides the estimated used OTR generation by industry sector from 2014 till 2019 and the five-year average, in tonnes.

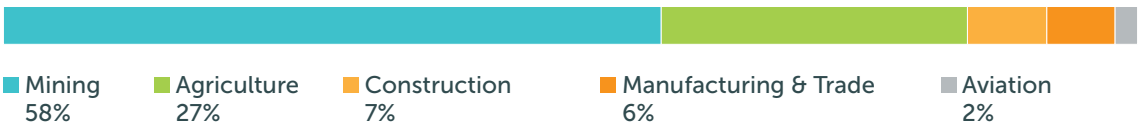
Table 3. **OTR used tyre generation by industry sector 2014-2019 and five-year average (tonnes)**

Industry	2014	2015	2016	2017	2018	2019	5-Yr. Ave.
Agriculture	38,300	39,000	32,700	30,400	32,900	31,400	33,300
Aviation	1,800	1,900	2,300	1,900	3,800	3,000	2,600
Construction	11,700	11,900	9,000	8,800	8,800	7,900	9,200
Manufacturing & trade	30,300	30,900	46,900	18,300	2,000	7,300	21,100
Mining	51,500	52,400	37,500	49,200	56,900	68,000	52,800
Total	**133,600**	**136,000**	**128,400**	**108,500**	**104,400**	**117,600**	**119,000**

Over the past five years an average of around 120,000 tonnes of OTR tyres have been generated.

Figure 2 includes the 2018-19 used OTR generation by industry sector, in tonnes. It shows mining OTRs made-up 58%, followed by agriculture 27% and construction, manufacturing and trade at around 13% and aviation tyres were presented about 2%.

Figure 2.
2018-19 used OTR by industry sector (tonnes)



Used OTR tyre fates 1.3

This section provides analysis of the fate (i.e. what happens to the used tyres) for Australia's used OTR tyres. The fate categories are based on those adopted in *REC 2019*, as listed below. All fate categories apart from 'export overseas for processing' refer to local on-shore fates.

Casings & seconds	Refers to used tyres that are **re-treaded** for reuse. It does not include OTR mining tyres that are repaired due to a sidewall puncture, for example.
Civil engineering	Refers to the use of used tyres in the construction of retaining walls or similar.
Crumb, granules and buffings	Refers to the highly processed rubber products that are made from used tyres for a wide range of uses from improving the performance of asphalt in road construction to tile adhesives.
Pyrolysis	Refers to the heating of tyres in the absence of oxygen to decompose and separate various organic components to generate end products including char, oil, syngas and steel.
Kilns/boilers/ furnaces	Refers to used tyres that are used as a fuel supplement in cement kilns or similar industrial facilities.
Stockpiles (>40 t, 5,000 EPU)	Refers to more than 40 tonnes of used tyres (5,000 equivalent passenger units, EPU) stockpiled for more than 12 months that are untreated and unprocessed to product specification. Stockpiles refer to large, typically illegal, piles of used tyres as opposed to dispersed dumping of tyres in small quantities, or onsite disposal of used tyres at mine sites or similar.
Landfill	Refers to used tyres sent to a legal landfilling site that is permitted by state or territory environmental regulators.
Onsite disposal (mining, other OTR)	Refers to the onsite disposal of OTR tyres (only) within a mining void or onsite on farms or similar.
Dumping dispersed	Refers to small incidental dumps, of several tyres, across Australia
Exported for processing	Refers to the used tyres that are not managed in Australia and are exported for re-treading and reuse, recycling or energy recovery.

Consultation with state and territory regulators and the used tyre recycling industry has been completed to enable analysis of the historical and current management and fate of used OTR tyres.

Table 4 and **Table 5** include the estimated proportions of each OTR tyre category sent to each of the local or export fates, listed above, as a percentage of total used OTR generation detailed in Table 3. Each of the fate category allocations are discussed below.

Table 4. **Used OTR tyres assumed local and export fate proportions by tyre category, 2018-19 (%)**

Fate	Agriculture	Aviation	Construction	Manufacturing & trade	Mining
Casings & seconds (re-treading)	–	–	–	–	–
Civil engineering	1%	–	1%	1%	1%
Crumb, granules & buffings	–	–	1%	1%	–
Pyrolysis	–	–	–	–	1%
Kilns/boilers/furnaces	–	–	–	–	–
Stockpiles (>40 t, 5,000 EPU)	2%	–	2%	2%	2%
Landfill	4%	4%	4%	4%	3%
Onsite disposal (mining, other OTR)	90%	10%	10%	10%	93%
Dumping dispersed	3%	3%	3%	3%	–
Export for processing	–	83%	79%	79%	–
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5. **Used OTR tyres assumed local and export fate proportions by tyre category, 2018-19 (tonnes)**

Fate	Agriculture	Aviation	Construction	Manufacturing & trade	Mining	Total	%
Casings & seconds (re-treading)	-	-	-	-	-	**-**	0%
Civil engineering	300	-	100	100	700	**1,200**	1%
Crumb, granules & buffings	-	-	100	100	-	**200**	0%
Pyrolysis	-	-	-	-	700	**700**	1%
Kilns/boilers/furnaces	-	-	-	-	-	**-**	0%
Stockpiles (>40 t, 5,000 EPU)	600	-	200	100	1,400	**2,300**	2%
Landfill	1,300	100	300	300	2,000	**4,000**	3%
Onsite disposal (mining, other OTR)	28,300	300	800	700	63,300	**93,400**	79%
Dumping dispersed	900	100	200	200	-	**1,400**	1%
Export for processing	-	2,500	6,200	5,700	-	**14,400**	12%
Total	**31,400**	**3,000**	**7,900**	**7,200**	**68,100**	**118,000**	**100%**

Figure 3.

Used OTR tyres assumed local and export fate proportions, 2018-19 (%)

- Onsite disposal (mining, other OTR) 80%
- Export 12%
- Landfill 3%
- Stockpiles (>40t, 5,000EPU) 2%
- Civil engineering 1%
- Dumping dispersed 1%
- Pyrolysis 1%

Onsite disposal (mining, other OTR) – 80%

Stakeholder consultation found that onsite disposal was the main fate for used OTR tyres in Australia, particularly for the mining and agricultural sectors, that generated about 85% of the used OTR tonnage in 2018-19. An estimated total of 93,400 tonnes of used OTRs were disposed onsite in Australia in 2018-19. Across Australia mining sites have been allowed to dispose used OTR tyres into mining voids, see Section 3.2 for further discussion.

Replacement agricultural OTRs are typically fitted on-farm by the tyre retailer. Industry commented that the cost of back loading and disposing of agricultural OTRs (around $120 per used OTR tyre) means that most used agricultural OTRs stay on-farm and are stored, repurposed or dumped on-farm in erosion gullies or similar.

Export for processing overseas – 12%

An estimated 14,400 tonnes of used OTR tyres were exported overseas for processing in 2018-19. Around 2,500 tonnes of aviation tyres were exported. Large aviation tyres would be re-treaded and refurbished and returned to Australia for continued use. Other smaller used aviation OTR tyres, that cannot be re-treaded, would be exported as shredded tyre derived fuel or baled. The remaining, around 12,000 tonnes, of OTR exports would likely be used OTR tyres from the construction and manufacturing and trade sectors that have been sectioned into manageable sized pieces for export.

Landfill – 3%

Most jurisdictions do not allow landfilling of any whole tyres and landfill operators typically would not want to accept large used OTR tyres for landfilling as they are very poor use of airspace and difficult to handle/compact. Landfilling of shredded OTRs is also unlikely given the high costs of shredding an OTR and the additional cost of landfilling gate fees. Some more remote, unmanned or less tightly controlled landfills would have used OTR tyres disposed onsite. A total of 4,000 tonnes of used OTR tyres were estimated to have been sent to these more remote, less controlled landfills in Australia in 2018-19.

Stockpiles _ 2%

Industry consultation found that stockpiling, that excludes onsite disposal, of OTRs in large, typically illegal stockpiles was not common in 2018-19. An estimated total of around 2,300 tonnes of used OTRs were disposed into stockpiles in Australia in 2018-19.

Civil engineering – 1%

Industry consultation found that the use of used OTRs in civil construction is not a significant fate for used OTRs. A total of 1,200 tonnes of used agriculture, construction, manufacturing and trade and mining OTRs were estimated to be used in civil engineering in Australia in 2018-19.

Dispersed dumping – 1%

The mapping and drive-time analysis of all Australian landfills and transfer stations, presented REC 2019, shows that 97% of Australians live within a 30-minute drive of a landfill or transfer station. The remaining 3% of the population are assumed to have no used tyre drop-off service in their area (due to being very remote) and are not likely to drive more than 30 mins to access a disposal point, and therefore the used tyres are likely to be dumped in diffuse small dumping events. For used OTR tyres where onsite disposal is allowed (i.e. mining OTRs) diffuse dumping is unlikely to occur and the used tyres would be kept onsite. Based on the method outlined above, an estimated total of 1,400 tonnes of used OTRs were illegally dumped across Australia in 2018-19.

Pyrolysis – 1%

TSA participants recovered a small amount, around 700 tonnes, of used OTR tyres via pyrolysis in Australia in 2018-19.

Crumb, granules and buffing – >1%

TSA participants processed a very small amount, around 200 tonnes, of used OTRs in Australia in 2018-19.

Cement kilns, industrial boilers or furnaces – 0%

No used tyres of any kind were sent to cement kilns, industrial boilers or furnaces in Australia in 2018-19.

Casing and seconds (re-treading) – 0%

Industry consultation found that re-treading of used OTR is not practiced in Australia, currently, except for aviation OTRs. Larger aviation OTRs (greater than 15 inch in diameter) are commonly re-treaded up to six or seven times once a set number of landings have been completed, to extend the life of the tyre. Australia exports all large aviation OTRs for re- treading off-shore to specialist facilities that provide complete refurbishment of the tyres before sending tyres back for continued use, see tonnages reported under ‘export for processing overseas’ below.

Key finding:

This report's more detailed used OTR tyre category and fate analysis came to essentially the same conclusion as *REC 2019*, **with an estimated 84% of used OTR tyre tonnages not recovered and 80% being disposed onsite at mining sites, farms or similar.**

Mining industry sector analysis

This section provides a profile of the mining industry across Australia including mine types, mapping of mining sites and used tyre processing facilities for different areas of Australia.

Australian mining sector profile

2.1

Geoscience Australia's OZMIN database (last updated Feb 2015) provides useful information about the profile of mining sites in Australia. Table 6 provides a summary of the number of operational mines in Australia by mine type and jurisdiction. Mining industry consultation has also informed the type of mining voids that are used for each mine type in Australia.

Table 6. Australian mining sites by mine type and by state

Mine type	NSW	NT	QLD	SA	TAS	VIC	WA	Total	%	Void type and % split[4]
Coal	61		52	1	4	5	2	125	31%	Open cut
Gold	10	7	5	2	2	7	74	107	26%	Open cut and underground 50/50
Other	6	4	6	6	6	2	15	45	11%	Rare earth mines mostly open cut 70/30
Iron ore	1	1	1	2	1		38	44	11%	Open cut
Copper	6	2	10	3			6	27	7%	Mostly underground 80/20
Nickel							23	23	6%	Mostly underground 70/30
Zinc	4	1	6	1	3			15	4%	Mostly underground 70/30
Bauxite		1	2				3	6	1%	Open cut
Opal	2			3				5	1%	Underground
Lead	1		1				2	4	1%	Mostly underground 70/30
Uranium		1		2				3	1%	Underground
Total	91	17	83	20	16	14	163	404		

Some 400 mines were operational in Australia in 2015. Coal mines, mostly in NSW and Qld, make up around 30% of mining sites in Australia. Gold mines, mostly in WA, make-up around 26%. Rare earth, iron ore, copper, nickel and zinc make up around 40%.

[4] *Source: mining industry consultation, pers. comm.*

By the number of sites, most of the mines in Australia are open pit mines, that would utilise large ridged and articulated haul truck tyres.

Whilst there will be significant amount of smaller mining OTRs used in underground mining, the above analysis illustrates the need for any used mining tyre recovery program to be able to cater for large bulk haul truck tyres, which will be the main tyre type/tonnages that would require processing.

Used mining OTR tyre disposal practices 2.2

This section analyses the historical and current used mining tyre disposal practices in Australia. The analysis is based on consultation with the key mining jurisdictions WA, Qld, NSW and NT environmental protection agencies and some industry consultation.

Western Australia 2.2.1

In WA used mining tyres are permitted to be disposed onsite in designated areas that are defined in the mining site environmental licence. WA licenses typically contain requirements for used mining tyre storage and onsite burial.

For example, the Newcrest Telfer Gold Mine licence, page 15, requires the following for storage:

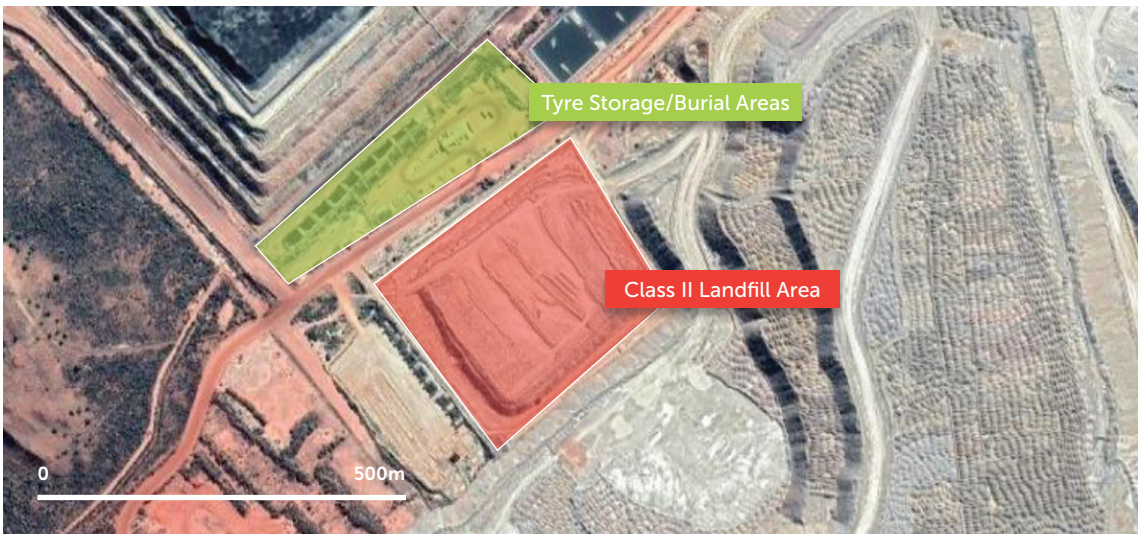
- Storage of tyres shall only take place within the tyre storage/burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3).
- Not more than 30,000 used tyres shall be stored at the premises at any onetime;
- Used tyre stacks shall not exceed 1000 tyres per stack and 5 m in height; and
- Used tyre stacks are to be stored no less than 4 m from any other tyre stacks

The licence also specifies the onsite burial requirements for used mining tyres as follows:

- Burial of tyres shall only take place within the tyre burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3 and Figure 4).
- Tyres shall only be land filled:
  a. in batches separated from each other by at least 100mm of soil and each consisting of not more than 40 cubic metres of tyres reduced to pieces;or
  b. in batches separated from each other by at least 100mm of soil and each consisting of not more than 1000 whole tyres.
- Cell locations where tyres are to be buried will be surveyed and the latitude and longitude recorded.

Figure 4 shows the 'landfill map area' referred to above, extracted from page 23 of the licence. Large storages of used tyres can be seen in separated piles awaiting burial.

Figure 4 **Example of permitted mining tyre storage and burial area at Telfer Gold Mine in WA.**



WA government are currently reviewing the practice of used mining tyre onsite disposal and the current licence allowances with a view to improve recovery rates of used mining tyres.

Queensland

2.2.2

In Qld used mining tyres are permitted to be stored and disposed onsite with no limits on quantities or location. The recently approved Adani Carmichael Coal Mine licence (EPML01470513) includes only the following requirement for used tyre disposal, see page 9:

- Scrap tyres are authorised to be stored awaiting disposal or disposed on the mining lease in a manner that minimises environmental harm. A record must be kept of the number and location of tyres disposed.

The Qld Department of Environment and Science have also published ***Operational policy, Mining, Disposal and storage of scrap tyres at mine sites*** (DES 2014). This policy states that new mining approvals should apply the 'waste hierarchy' in the management of used mining tyres by:

2.1 ***Avoidance***

When negotiating purchase agreements with new tyre suppliers, seek take-back clauses to maximise freight backloading opportunities.

2.2 ***Recycling***

Explore opportunities to recycle scrap tyres on-site and locally through use in impact-absorbing surfaces, bitumen and road construction, pastoral and agricultural use, and civil engineering applications.

2.3 ***Waste-to-energy***

Use existing opportunities in Queensland to recover the intrinsic energy value through waste-to-energy options.

2.4 ***Disposal***

a. *Tyres stored awaiting disposal—or transport for take-back and, recycling, or waste-to-energy options – should be stockpiled in volumes less than 3m in height and 200 square metres in area. Additional fire precautions should be taken, including removal of grass and other materials within a 10m radius of the scrap tyre store. Tyres should be stored in a manner that prevents water retention and minimises mosquito breeding events. Options may include holing side-walls, covering with tarpaulins, spraying with a non-persistent insecticide, or reducing the stockpile during rain events.*
b. *Disposing of scrap tyres in underground stopes is acceptable provided this practice does not cause an unacceptable fire risk or compromise mine safety.*
c. *Disposing of scrap tyres in spoil emplacements is acceptable, provided tyres are placed as deep in the spoil as possible but not directly on the pit floor. Placement should ensure scrap tyres do not impede saturated aquifers and do not compromise the stability of the consolidated land form.*
d. *Disposing of scrap tyres (and other wastes) on mine sites is a notifiable activity under Schedule 3 of the Environmental Protection Act 1994, and the locations of the disposal sites need to be recorded on the Environmental Management Register.*

Qld Department of Environment and Science noted that there has been discussions held at senior level of Government with the Minerals Council of Australia flagging the Department's expectation for the current management practices for used mining tyres to change as new processing options come online and that the Department would consider banning onsite used tyre disposal if industry do not pursue an alternative to onsite disposal.

New South Wales

2.2.3

Consultation with NSW EPA staff found that mining tyres are allowed by EPA to be stored and disposed onsite with no limits on quantities or location.

A review of mining licences such as the Mt Arthur Coal mine licence, one of NSW largest coal mines, found no reference to used tyres and no reference to onsite burial requirements.

EPA noted that if a farmer in NSW was to bury waste tyres on their farm it would be an offence. NSW EPA is likely to review the status of mining tyre onsite disposal in its annual review of regulations.

Northern Territory

2.2.4

Consultation with NT EPA and NT Department of mining staff found that mining tyres are allowed by EPA to be stored and disposed onsite with no limits on quantities or location. NT staff noted that licences in NT do not specify onsite burial requirements.

NT EPA would like to see the tyres recovered but, due to remote locations, on-site burial has always been seen as the only option.

Key findings:

- Any used mining tyre recovery program needs to be able to cater for large bulk haul truck tyres, which will be the main tyre type/ tonnages that would require processing.

- All jurisdiction consulted allow onsite disposal.

- WA is the only jurisdiction consulted with requirements for used mining tyre storage and disposal included in the mine licence (i.e. that are required)

- QLD, NSW, WA are all reviewing the current practice of allowing onsite disposal and Qld government have raised this issue with Minerals Council of Australia

- Historically onsite disposal has been allowed due to there being no alternatives. As this changes, mining companies should expect the allowance of onsite disposal to cease.

Mining sites and used tyre processing locations

This section provides analysis of mining site and used tyre processing locations around Australia and analysis of average travel distances.

Figure 6. Examples of lower and upper end of processing investment costs.

Photos by Tyrecycle and Pearl Global

Figure 7, overleaf, illustrates the location of Australian mining and used tyre processing locations. It also includes the 500 km distance 'circle' from each used tyre processor. The green shading for the 500 km distance circle also illustrates the density of processing sites in each 500 km area.

Important! Only a few of Australia's used tyre processors are currently able to receive large mining OTR tyres. **So Figure 7, is simply illustrating the current network of used tyre processing sites that could take used mining OTRs in future and most of these sites would require investment to be able to process large mining OTRs.** The extent of the investment would depend on the level of mining tyre processing to be done onsite. Investments could range from as little as $100,000 for excavator shears to simply section the tyres to allow enable transport or shipping for further processing in Australia or off-shore, through to multi-million-dollar investments to build full OTR tyre processing plants such as those recently established by Pearl Global in Queensland (see example photo above right).

Figure 7. Australian mine sites and current used tyre reprocessors (most without mining OTR capability)

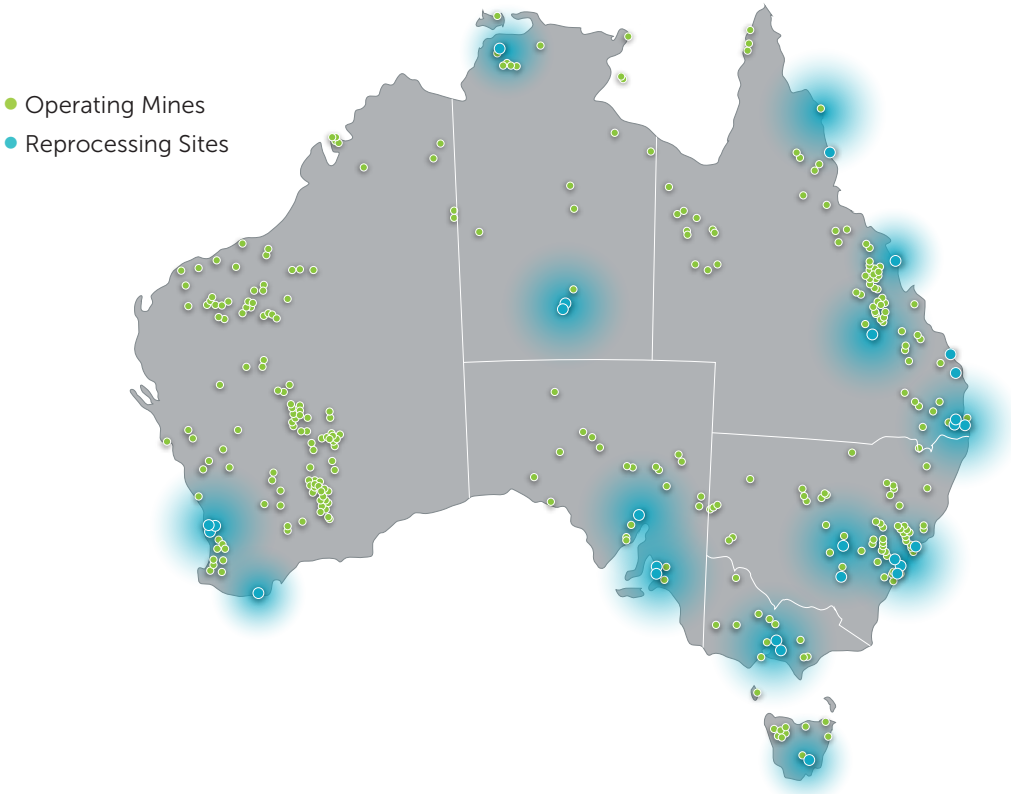


Table 7 provides the results of analysis for the distances between used tyre processors and mining sites.

Table 7. Distance between mines and used tyre processors by jurisdiction (kilometres)

Distance (kilometres)	NSW	NT	QLD	SA	TAS	VIC	WA
Average distance between mines and processors	183	442	449	327	268	168	832
Closest mine to a processor	7	53	21	49	62	56	101
Furthest mine to a processor	731	1,208	1,244	582	406	422	1,713

Vic, NSW and Tas have similar average distances of around 200 kms between mining and processing sites. Qld and NT both have average distances of around 400 kms. WA has by far the longest average distance of around 800 kms.

Table 8 provides the results of analysis for the proportions of mining sites within distance ranges to used tyre processors by jurisdiction and nationally.

Table 8. Proportions of mining sites within distance ranges to used tyre processors by jurisdiction (%)

Distance from nearest processor	NSW	NT	QLD	SA	TAS	VIC	WA	Australia
Within 500 km	98%	53%	73%	73%	100%	100%	13%	**57%**
Between 500 km and 1,000 km	2%	40%	12%	27%	0%	0%	62%	**30%**
Greater than 1,000 km	0%	7%	15%	0%	0%	0%	24%	**13%**

Key findings:

– Nationally, 57% of sites are within 500 kms of the used tyre processor, 30% are between 500 and 1,000 kms and 13% are more than 1,000 kms away from a processor.
WA, Qld and NT all have sites that are more than 1,000 kms from a processor site, but WA has by far the largest proportion with 24% of the mines more than 1,000 kms from a processor.

– Only a few of Australia's used tyre processors are currently able to process large used mining tyres. Most used tyre processors in Australia would require investment to be able to process large used mining tyres.

The extent of the investment would depend on the level of mining tyre processing to be done onsite. Investments could range from as little as $100,000 for excavator shears to simply section the tyres to allow enable transport or shipping for further processing in Australia or off-shore, through to multi-million-dollar investments to build complete mining tyre processing plants.

Section 4

Used mining tyre recovery analysis

This section provides analysis of the technical feasibility of large used mining tyre repair, re-treading, recycling or energy recovery.

Used mining tyre repair 4.1

Repairing of partly worn, but damaged, mining tyres is common in Australia. For example, Bridgestone Mining Solutions Australia (BMSA) have six mining OTR repair service centres located around Australia, as detailed here. Due to the cost of new mining tyres (around $40-50,000 for a large mining tyre) there is a strong financial driver to repair mining tyres where significant tread remains. Apart from repair, mine operators also put chains around worn tyres to get more life out of the tyre before disposal.

Used mining tyre re-treading 4.2

Industry consultation found that re-treading of mining OTRs is currently not happening in Australia and is unlikely to in future. Industry noted that there has been attempts to re-tread mining tyres in the past that have failed. This main cause of failure was wear/damage to the casing making the re-treaded tyre less reliable. The adhesive bond between the casing and the re-tread was not typically the cause of failure.

However, in contrast to this view, Kal Tyre promote a global mining tyre re-treading business that has been operating for over 45 years, here. Kal Tyre re-tread over 10,000 OTR tyres annually in the UK, West Africa, Canada, Chile and Mexico.

Used mining tyre recycling 4.3

Recycling of used large mining tyres by processing the tyres into crumbed rubber and steel is not currently happening in Australia, however, it is technically feasible and there are international examples such as those discussed below.

ELDAN recycling installed a mining tyre recycling plant in at the OK Tedi Mining Limited copper mine in Papua New Guinea. For this plant the mining tyres are pre-cut, and have the bead removed, by a heavy-duty demolition shear into pieces which fit the in-feed of the shredder, which is designed to process mining tyres. The tyre sections are processed into tyre shreds, and free steel wire is liberated and removed from the shreds by a powerful magnet. The tyre shreds are then further processed in a granulation and separation plant. Depending on the customer specific requirements a high-quality rubber granulate and clean steel wire can be produced.

Companies such as Eco Green Equipment are marketing processing equipment purpose built to recycle large used mining OTR tyres, as demonstrated here. This equipment is purpose built to cut the remaining rubber from the three outer sites of the tyre and then remove the steel bead from the mining OTR before sectioning and shredding the casing for rubber and steel recovery.

Tyrecycle are the main company in Australia that are currently marketing the recycling of mining tyres into rubber and steel, as shown here. However, it is understood that all mining OTR processing is occurring at overseas facilities, with only primary size reduction happening onshore.

The recycling of used mining tyres is an energy intensive process that requires multiple stages of size reduction which adds to the processing costs.

Used mining tyre recovery via pyrolysis 4.4

There are several pyrolysis plants that are either built, commissioning, under construction or in the planning stages of establishing in Australia with the intention of targeting used mining tyres as one of the primary feedstocks.

The Pearl Global facility in Stapylton, Qld has recently completed commissioning, is operational and is receiving large mining tyres. The processing units can be housed in a 40-foot ISO frame so it is portable and scalable and can be located in proximity to tyre generating sites.

The stated time to replicate the facility is 16 weeks. With six processing units operating at one site, 18,000 tonnes of tyres could be processed per annum. The processing units require the tyre to be shredded down to two-inch feedstock before processing.

Southern Oil is considering a pyrolysis facility designed to be able to process whole large used mining tyres or baled tyres and will provide oil that can be further refined.

Tytec Recycling is a collaboration between Tytec Group and Green Distillation Technologies Corporation (GDTC) and is planning to build a pyrolysis system for whole used mining tyres processing also to be located in Qld. They anticipate the plant to be operational by mid-2021.

Sister company, Tytec Logistics, currently specialise in delivering new OTR tyres to mining sites in purpose-built trailers, that maximise payload, and service large portions of the mining industry, including remote sites. Tytec Recycling recognise the significant backloading opportunity for used tyres using the same transports, see photos below.

Photos by Tytec

Used mining tyres are also being processed in pyrolysis plants overseas at plants such as the Titan Tyre Recycling Facility in Canada, that started operating in 2016.

Canadian company Kal Tyre are set to open their first major mining tyre pyrolysis facility in Chile, South America to service the vast copper mines. The plant will have two kilns and capacity to process 7,500 tonnes of rubber. Two kilns will enable 24/7 operation of the plant. Similar to the Pearl Global proposition, the Kal Tyre units are to be built close to mine sites and be scalable and relatively easy to replicate.

Used mining tyre energy recovery (TDF)

4.5

The shredding of mining tyres for use as a fuel supplement, or tyre derived fuel (TDF), in industrial kilns is also technically feasible. Tyrecycle is the main company in Australia that is currently marketing the collection of mining tyres to produce TDF, as shown here.

The process for TDF production is the same as the first stages of recycling (i.e. de-beading, tyre sectioning and shredding). Once the material is shredded to the appropriate size, it is exported to kilns located in Asia and used to supplement coal, mostly in cement kiln firing. As noted in Section 1.3, no used tyres are sent to the cement kilns in Australia, that operate in NSW, SA, Qld and Tas.

Key findings:

- The repair of large mining tyres that are partly worn and damaged is a well-established industry in Australia, currently.
- Re-treading of fully worn large mining tyres is not happening in Australia currently and some do not think re-treading is a viable option for large mining tyres. However, companies such as Kal Tyre have an international network of mining tyre re-treading sites.
- The recycling of used large mining tyres into crumbed rubber and steel is technically feasible, however, energy intensive and currently the only reported recycling is by Tyrecycle who cut the tyres into manageable sections and export the tyres for recycling overseas where overhead costs are lower.
- It is technically feasible to produce a TDF from large used mining tyres, however, in Australia this is understood not to be happening in significant tonnages due to the energy intensive processes required to shred large mining tyres for export as TDF.
- Recovery of large used mining tyres by pyrolysis is technically feasible and several pyrolysis plants are either built, commissioning, under construction or are in the planning stages of establishing in Australia with the intention of targeting used mining tyres as one of the primary feedstocks.
- Historically, large used mining tyres have been allowed by regulators to be disposed of into mining voids. With the development of onshore options for recovery by pyrolysis and several providers tyring to establish onshore operations to target large used mining tyres, it is an appropriate time for regulators to review if this practice should be allowed to continue.

Section 5

Used mining tyre best practice management

This section provides results of the literature review of international best practice for used mining tyre management.

Whilst there are several examples of what could be termed 'best practice' mining tyre **recovery**, that have been discussed above, the literature review found little information on best practice used mining tyre management (i.e. examples of mining tyre governance and resulting recovery rates).

Literature such as ***Investigating global best practice waste tyre management***, L. O'Keefe, 2016, available here, provide detailed review of global approaches to used tyre management. However, the focus of such studies is, understandably, on passenger and truck tyres with limited discussion of mining tyre management best practice.

The review found that onsite disposal of used large mining tyres is wide spread, globally.

The ELDAN recycling system installed at the OK Tedi Mining Limited copper mine in Papua New Guinea, discussed in Section 4.3, provides an example of an onsite solution for large used mining tyres. However, it is unclear how successful the onsite recycling plant has been and what ongoing markets have been established for recycled products.

An example that is worth noting is new legislation in Chile, that includes a ban on the onsite disposal of mining tyres onsite. The *Extended Product Liability and Recycling Promotion* legislation was passed in 2016. The regulation will come into force with the 'supreme decrees' that will establish collection and valorisation goals for each priority product (including tyres). **For used mining tyres, the legislation states that by 2026, 100 per cent of collection and recovery must be achieved.**

The legislation differentiates tyre recycling goals according to their size, above and under 57 inches, projecting that larger mining tyres should be completely reused in 2026, while those less than 57 inches, should attain a 98 per cent recycling rate by 2028. Source: Tyre and Rubber Recycling, New Chilean Plan for Mining Tyres, Jan 2019.

Key findings:

- The review found that onsite disposal of used large mining tyres is wide spread, globally.

- Chile has implemented legislation that requires 100 per cent recovery of mining tyres by 2026. The implementation of this legislation has been key to enabling Kal Tyre to invest in, develop and build their new mining tyre pyrolysis facility.

- While mining companies are allowed to stockpile or dispose of used mining tyres onsite, which they can do at effectively no cost, the recovery of mining tyres is unlikely to be wide spread.

Used mining tyre recovery financials

This section provides analysis of the financials of large used mining tyre recycling or energy recovery compared with current management.

Stakeholder consultation found that onsite disposal was the fate of almost all used large mining tyres in Australia. Whilst there would be some handling involved in shifting and burying the used tyres, this is all assumed to be within normal site operations. There would be no external costs associated with onsite mining tyre disposal. The costs for onsite disposal are therefore assumed to be zero.

The tyre recovery industry has been consulted to inform the analysis below.

The financials presented below are for large used mining tyres with an assumed weight of three tonnes. There are some heavier mining tyres (up to 4.5 tonne) and some lighter. As discussed in Section 2, large bulk haul truck tyres will be the main tyre type/tonnages that would require processing and these are assumed to have an average weight of three tonnes.

Table 9 Estimated cost range for collection of used large mining tyres for offsite processing (total costs to the waste generator) ($/tyre)

Mine site	Lower		Upper		Comments
	$/unit	$/tonne	$/unit	$/tonne	
Regional	$1,000	$333	$1,800	$600	Collection costs vary by distance travelled. 'Regional' collections typically allow for up to 500 kms from processor.
Remote	$1,400	$467	$2,300	$767	Collection costs vary by distance travelled. 'Remote' collections typically allow for up to 1,000 kms from processor.

Table 9 provides the estimated cost range for the collection of used large mining tyres for the off-site processing from regional mines (up to 500 kms from processing site) and remote mines (up to 1,000 kms from processing site).

Mining companies located in regional areas could expect to pay from $1,000 to $1,800 per three tonne used mining tyre (collection and processing costs). Mining companies located in remote areas could expect to pay from $1,400 to $2,300 per three tonne used mining tyre (collection and processing costs).

Assuming an average new tyre cost of $45,000, these costs present 2-4% of a new tyre cost in regional area and 3-5% of a new tyre cost in remote areas.

Table 10 provides the estimated processing cost ranges for a tonne of used large mining tyres. It shows processing costs are highest for recycling back into crumbed rubber, followed by pyrolysis and then energy recovery (via shredding and TDF export). Whilst processing costs are higher for recycling and pyrolysis, it is important to note that these processes will generate revenue from recycled products.

Table 10 Estimated processing cost ranges for used large mining tyre ($/tonne, excluding freight)

Process	Lower	Upper	Comments
	$/tonne	$/tonne	
Recycling (crumbed rubber - onshore)	$600	$800	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Crumbing costs are typically $400 -$600 per tonne.
Recovery via pyrolysis (oil, syngas, act. carbon - onshore)	$300	$500	Costs are for whole mining tyres processing.
Energy recovery (tyre derived fuel - exported)	$285	$300	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Typical costs for TDF exports are around $85 to $100.

Where mining tyre recovery facilities are located very close to mining sites, the collection costs in Table 9 would decrease (due to reduced transport costs) and would be closer to the processing cost ranges listed in Table 10.

Key findings:

- Mining companies located in regional areas could expect to pay from $1,000 to $1,800 per three tonne used mining tyre (collection and processing costs). Mining companies located in remote areas could expect to pay from $1,400 to $2,300 per three tonne used mining tyre (collection and processing costs).

- Assuming an average new tyre cost of $45,000, these costs present 2-4% of a new tyre cost in regional area and 3-5% of a new tyre cost in remote areas.

- For remote sites, where mining tyre recovery facilities are located very close to mining sites, the costs to the mining company could reduce significantly (due to reduced transport costs).

Improving recovery of used mining tyres

Considering the analysis that is presented in the sections above, the items below discuss a range of ways to improve the recovery of used mining tyres in Australia. This discussion does not provide 'the answer,' however, it will aid in further engagement with the mining sector.

Mining tyre importers become members of the current Tyre Stewardship Scheme(TSS)

7.1

If mining tyre importers were to join the current TSS, around $100 dollars (per large mining tyre imported and sold into Australia) would be collected, or 0.2% of the sale price for a $45,000 mining tyre.

As the analysis in Section 6 illustrates, the costs to recover large used mining tyres is estimated to be 10-23 times more than the TSS fees that would be collected.

Membership of the scheme would fund TSA to provide support to mining tyre manufacturers, importers and mining companies to:

- Build upon research such as that included in this report to development an industry strategy for mining tyre recovery
- Investigate and identify areas of the country with needs for additional recovery infrastructure, to support industry to make funding applications to Governments (for example)
- Support market development for products derived from used mining tyre recovery.

Co-regulatory or mandatory product stewardship to fund recovery

7.2

The Australia *Product Stewardship Act* is currently under review. It is possible that used mining tyres could be included under a **co-regulatory or mandatory product stewardship** scheme under this review. There are numerous possibilities as to how this could unfold.

If used mining tyres are included under a co-regulatory or mandatory scheme, the key outcome would be the payment of part or all of the recovery costs for used mining tyres (by tyre manufacturers/importers). This would likely see a significant increase in used tyre recovery infrastructure capacity and capability around Australia.

Ban on onsite disposal of mining tyres in all jurisdictions

7.3

Following Chile's lead, jurisdictions around Australia could implement a ban on the onsite disposal of used mining tyres. A lead time of at least several years (Chile gave a 10-year lead time) would allow time for the establishment of the required recovery infrastructure around the country. All states and territories should implement the ban to ensure used tyres are not simple shifted to a mine in another jurisdiction. A will structured national ban for onsite disposal would provide the used tyre recovery industry with the feedstock security that has been lacking historically.

Establishing a network of used tyre processing sites in close proximity to new mining tyre distribution locations

7.4

Transport costs are a significant part of mining tyre recovery costs, especially while used mining tyre processing facilities are not available as a network of sites across the country.

Backloading of used tyres when delivering new tyres may be the best means of reducing transport costs. However, if there is no used tyre processing facility in proximity of the new mining tyre distribution locations, significant additional freight costs would still be incurred.

Establishing a network of used tyre processing sites in close proximity to significant mining areas

7.5

Another approach to reducing transport, and overall recovery costs, could involve establishing a network of used mining tyre processing facilities in close proximity to significant mining areas with a significant tonnage of used mining tyres.

These facilities could be setup to provide full processing of mining tyres, as is proposed by the Pearl Global and Kal Tyre technologies or be a far more basic facility that is set-up to section the tyres and load them for efficient transport to Australian or export markets (Tyrecycle's current model).

Tyre retailers lease mining tyres rather than sell them

7.6

Mining tyre importers/retailers could set-up contracts with miners that include leasing of the tyres rather than purchasing. This would allow for drop-off and pick-up of mining tyres at the same time and build the used tyre processing costs into the leasing fees. This would also allow the mining company to resolve tyre supply, pick-up and processing costs within one contact. It would also provide the mining company with assurance that the used tyre is sent to an appropriate facility for processing.

Develop on-shore energy recovery markets for TDF

7.7

Australia currently exports significant tonnages of shredded used tyres as TDF to Japan and Korea. Currently, no Australian used tyres are sent to local industrial kilns/boilers/furnaces as a fuel (i.e. brown coal) supplement.

There has been very little incentive for Australian coal fired kilns/boilers/furnaces operators to install the required infrastructure to utilise TDF as Australia has access to huge reserves of cheap coal.

Used mining tyres could be processed into TDF and used to offset coal use in future, as pressure increases for the reduction of coal fired energy production.

Glossary of terms / abbreviations

Term / abbreviations	Description
TSA	Tyre Stewardship Australia
BBEC	Brock Baker Environmental Consulting
REC	Randell Environmental Consulting
Material flow analysis (MFA)	MFA is an analytical method to quantify flows and stocks of materials in a well-defined system. MFA is used to study material flows across different industrial sectors. When combined with an assessment of the costs associated with material flows this business-oriented application of MFA is called *material flow cost accounting*. MFA is an important tool in establishing a circular economy.
Stockpile	The following definition of used tyre stockpile was adopted for the report analysis: 1. More than 40 tonnes (5,000 EPUs) in storage onsite 2. More than 12 months storage 3. Untreated, unprocessed to product specification.
Casings	The rigid, inner of a tyre upon which a tread is placed. Typically, tyres good enough for re-tread or resale as seconds are referred to as casings.
Civil engineering	Engineering discipline that deals with the built environment, including works like roads, bridges, canals, dams, and buildings.
Crumb rubber	A highly-refined rubber product, typically less than 1mm in diameter, made from recycled tyres.
Domestic recycling	Activities that occur to recycle or reprocess waste tyres within Australia.
Dispersal to the open environment	The dispersal of rubber from in-use tyres to the open environment (land, waterways, etc.) due to wear of the tyre tread.
Used tyre fates	What happens to Australian used tyres when they reach the end of their useful life (either in Australian or overseas) including re-use, recycling, energy recovery, and disposal fates.
Used tyres	A tyre that is deemed no longer capable of performing the function for which it was originally made.
Energy recovery	The use of used tyres in a thermal process to recover energy for electricity generation or industrial process.
Equivalent passenger units (EPUs)	A standard measure, based on the typical weight of a standard passenger tyre (9.5 kgs).
In-use	Tyres that are in demand for the purpose for which they were originally made.
Off-the-road (OTR) tyre	Tyres for mining sites and heavy industry applications.
Recovery	Broadly refers to used tyres that are collected and either reused, recycled or recovered for embodied energy (energy recovery) either in Australia, or overseas.
Recycling	Process to recover constituent materials from end-of-life tyres and use those materials to manufacture other products either in Australia or overseas.
Resource recovery	Refers to used tyres that are collected and either reused recycled or recovered for embodied energy (energy recovery) either in Australia or overseas.
Re-treading	The preparation of used tyres for reuse by replacing the outer tread.
Reuse	The use of tyres for the purpose for which they were originally made, including use of re-treaded tyres and second-hand tyres.
Rubber granule	A refined rubber product, typically 2mm – 15mm, made from recycled tyres.
tpa	Tonnes per annum
Tyre Derived Fuel (TDF)	Shredded tyres prepared to a specification for use in energy recovery.
Tyre Stewardship Australia (TSA)	The not-for-profit organisation established to deliver the National Tyre Product Stewardship Scheme.
Tyre-derived aggregate (TDA)	Shredded tyres prepared to a specification for use as aggregate in civil engineering applications.
Tyre-derived products (TDPs)	Any product produced from rubber, steel, textiles or other material recovery from the recovery of used tyres.

About TSA

Tyre Stewardship Australia (TSA) was established in 2014 to implement the national Tyre Product Stewardship Scheme (the Scheme) which aims to promote the development of viable markets for end of life tyres. The Scheme's objectives are to:

- increase resource recovery and recycling and minimise the environmental, health and safety impacts of end of life tyres generated in Australia; and
- develop Australia's tyre recycling industry and markets for tyre derived products.

TSA accredits participants, including tyre retailers, manufacturers, recyclers and collectors, who are committed to supporting the objectives of the Scheme. TSA also invests in market development initiatives including research and development, and commercialisation, of new productive uses for end of life tyres.

TSA's work helps to drive the transformation of a waste product into a useful commodity, creating new industries and employment opportunities while also reducing the environmental harm caused by the illegal dumping of old tyres. TSA envisions a circular economy for tyres, where resources from end of life tyres are used and reused, such as through recycling, recovery and/or repurposing, ultimately boosting new industries and eliminating tyres from the waste stream.

TSA's Purpose, Vision and Mission

TSA's purpose is to drive sustainable outcomes for end of life tyres.

TSA's vision is to create a circular economy for end-of-life tyres which contributes to a sustainable society.

TSA's mission is to collaboratively ensure the sustainable management, recycling and productive use of end of life tyres.

TSA aims to build awareness and facilitate the commercialisation of better opportunities provided by end of life tyres, provide accreditation and stimulate innovation, in order to advance circular economy principles within the sector.

Mining Industry
Off-The-Road Used Tyre Analysis

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Report Disclaimer

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