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PacWastePlus PACIFIC WASTE MANAGEMENT

This initiative is supported by **PacWastePlus**-a 72 month project funded by the European Union (**EU**) and implemented by the Secretariat of the Pacific Regional Environment Programme (**SPREP**) **to sustainably and cost effectively improve regional management of waste and pollution.**

End of Life Tyre Management:

OPTIONS FOR MECHANICAL PROCESSING

February 2022

This Management Option Booklet explores possible reuse options for ELTs without processing. The options presented here provide preliminary information designed to assist countries to understand immediately available opportunities.

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Our vision: A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures.

Acronyms

BaP	Benzo(a)Pyrene
ELT	End of Life Tyres
EU	European Union
TDF	Tyre Derived Fuel
CO	Carbon Monoxide
SOx	Sulfur Oxides
NOx	Nitrogen
VOCs	Volatile Organic Compounds
PAHs	Polynuclear Aromatic Hydrocarbons
SPREP	Secretariat of the Pacific Regional Environment Programme
PICs	Pacific Island Countries
OTR	Off The Road Tyres

Contents

End-of-Life Tyre Management Publication Series

Technical Booklets: End-of-Life Tyre Management Options

Non-Processing Reuse Options
- This booklet explores several potential uses of ELT in that do not require mechanical or thermal processing.

This publication

Mechanical Processing Options
- This Management Option Booklet explores possible reuse options for ELTs without processing.

Thermal Processing Options
- This Management Option Booklet explores possible reuse options for ELTs without processing.

Research Report
Assessment of End-of-Life Tyres in the Pacific

Factsheets: End-of-Life Tyre Management

Community

Retailers/Suppliers

The PacWastePlus Programme

The Pacific – European Union (EU) Waste Management Programme, PacWastePlus, is a 72-month programme funded by the EU and implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) to improve regional management of waste and pollution sustainably and cost-effectively.

About PacWastePlus

The impact of waste and pollution is taking its toll on the health of communities, degrading natural ecosystems, threatening food security, impeding resilience to climate change, and adversely impacting social and economic development of countries in the region. The PacWastePlus programme will generate improved economic, social, health, and environmental benefits by enhancing existing activities and building capacity and sustainability into waste management practices for all participating countries.

Countries participating in the PacWastePlus programme are: *Cook Islands, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu*.

KEY OBJECTIVES

Outcomes & Key Result Areas

The overall objective of PacWastePlus is “to generate improved economic, social, health and environmental benefits arising from stronger regional economic integration and the sustainable management of natural resources and the environment”.

The specific objective is “to ensure the safe and sustainable management of waste with due regard for the conservation of biodiversity, health and wellbeing of Pacific Island communities and climate change mitigation and adaptation requirements”.

Key Result Areas

- **Improved** data collection, information sharing, and education awareness
- **Policy & Regulation** - Policies and regulatory frameworks developed and implemented.
- **Best Practices** - Enhanced private sector engagement and infrastructure development implemented
- **Human Capacity** - Enhanced human capacity

Learn more about the PacWastePlus programme by visiting

https://pacwasteplus.org/

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PacWastePlus PACIFIC WASTE MANAGEMENT

Introduction

An estimated one billion tyres worldwide (about 17 million tonnes) reach the end of their useful lives every year. This number has been growing steadily and this trend is expected to continue.

While there are efforts by governmental authorities, the tyre industry, and individual manufacturers to manage end-of-life tyres (ELTs), there is still much to be done.

This Management Option Booklet explores possible reuse options for ELTs without processing.

Several end-use markets exist to manage ELT such as Energy generation whereby ELT are used either whole or shredded straight into the kiln. shredded and used as fuel (TDF). ELT are also recycled in the Infrastructure Sector whereby ELT are used whole, shredded, or grounded and used as embarkment, asphalt, and synthetic field turf.

ELTs that do not enter an end-use market are usually landfilled, burnt, or illegally stockpiled posing several environmental and social risks.

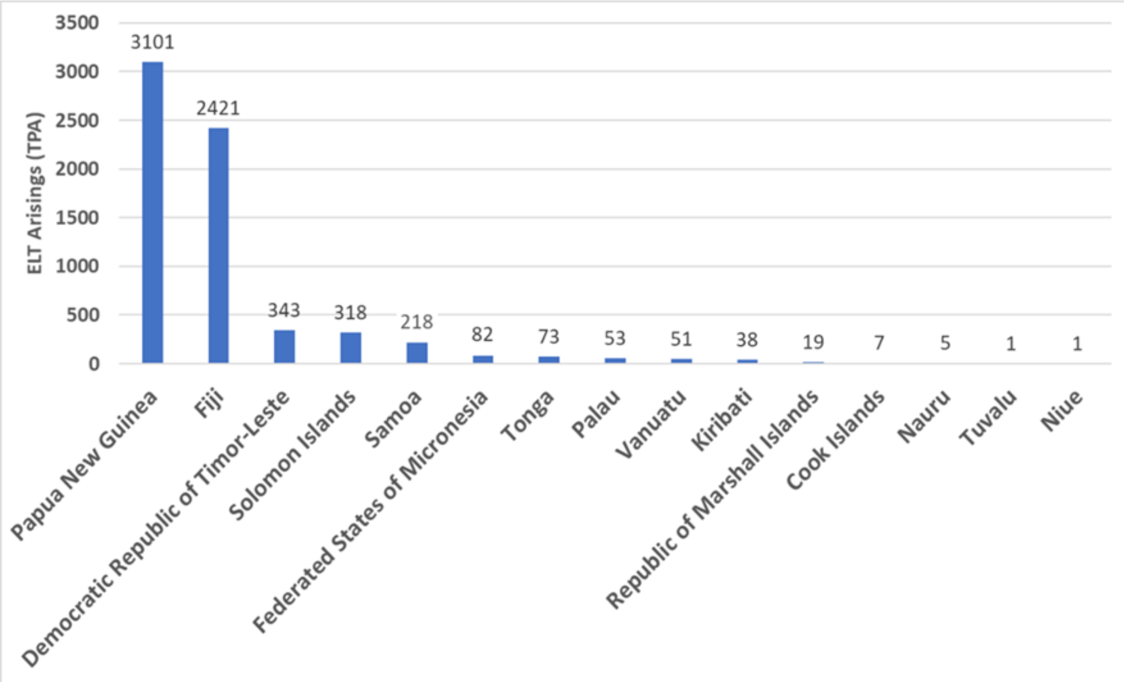
Some of these risks include:

- Incubation of mosquito larvae due to the ability of whole tyres to hold water. This presents a biosecurity risk of the spread of mosquitos as non-native species, and the associated risk for disease such as malaria and dengue fever. In drier regions, dust settles within tyres with the associated risk of transfer of seeds, insects, and other vermin associated with export of baled tyres.
- Emission of several types of classified pollutants, such as particulates, carbon monoxide (CO), sulfur oxides (SOx), oxides of nitrogen (NOx), volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs); and metals such as arsenic, cadmium, nickel, zinc, mercury, chromium, and vanadium.
- Tyre fires, apart from intense heat, give off black carbon with CO gas emission. Research has reported that the emission levels of CO from different type of tyres were 21–49 g/kg, SO2 emission was found to be 102–820 g/kg, while NO2 emission was 3–9 g/kg. Among metals, ZnO and CO have been found to be 21 and 92 times higher than an area far from the open fire.
- Emissions from an open tyre fire can represent significant acute (short-term) and chronic (long-term) health hazards to firefighters and nearby residents. Depending on the exposure time and concentration, these health effects could include irritation of the skin, eyes, and mucous membranes, respiratory effects, central nervous system depression, and cancer. There are 16 PAH types known to be emitted from tyre fires, including several compounds known to be carcinogenic including benzo(a)pyrene (BaP).
- Illegally dumped ELTs will degrade overtime due to exposure. ELTs are sensitive to UV light (the sun) and temperature, and over time, will leach toxins such as zinc and manganese into the surrounding environment.

The generation of ELTs is high in most Pacific Island countries and territories due to limited control over the quality of tyre imports, often resulting in the importation of large quantities of second-hand tyres (re-treads).

It is estimated that some 6,700 tonnes, or approximately 670,600 tyres, reach end of life annually across all PICs (**Figure 1**).

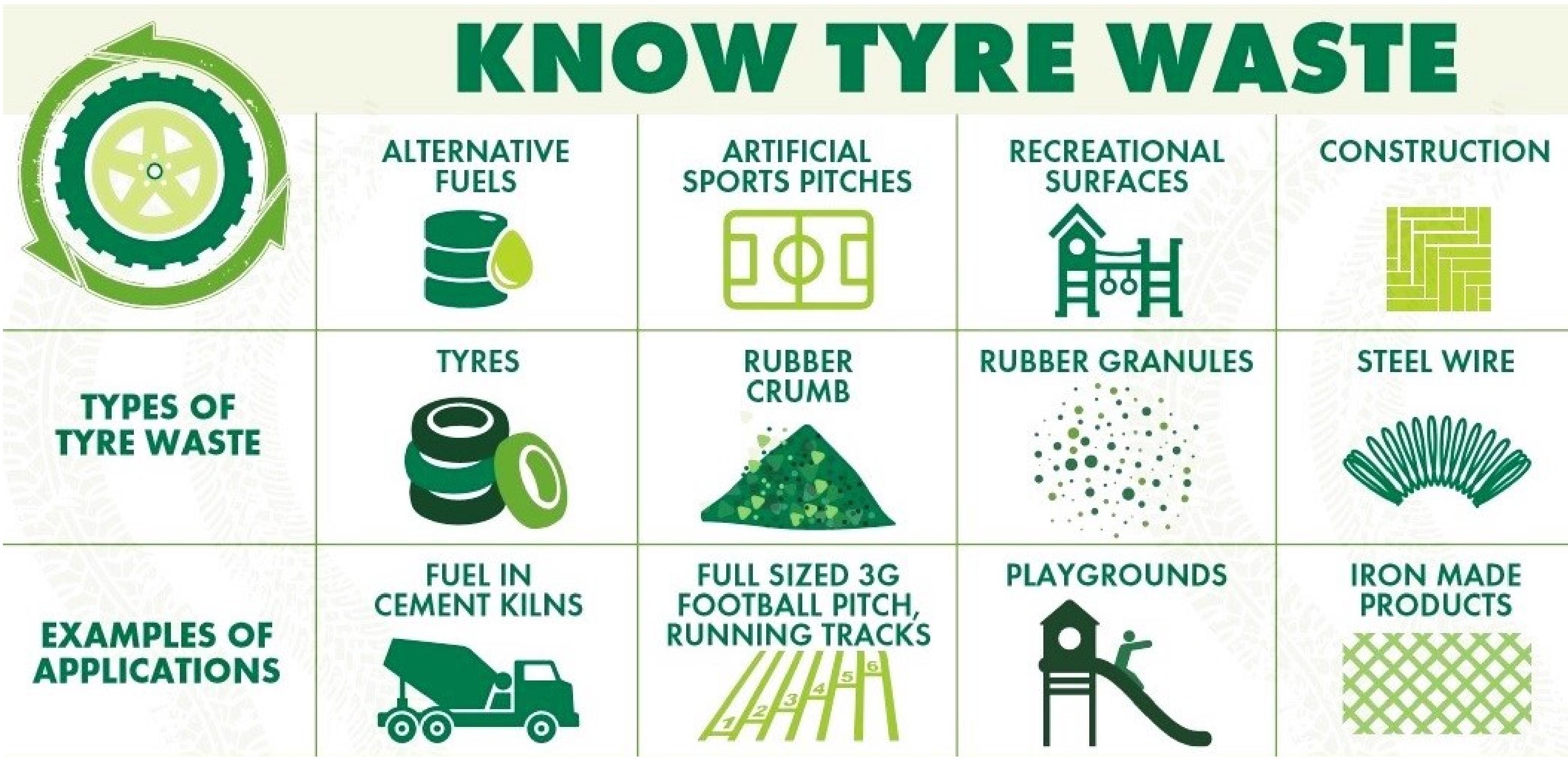
Figure 1 Estimated generation of ELT in PIC per year



***Source**: Hyder, Stocks & fate of end-of-life tyres, 2015*

Due to lack of international demand for ELTs as a commodity, shipping tyres to safe recycling or disposal in other remote countries is a costly exercise with limited opportunity for resale (currently).

In the absence of options for in-country ELT reprocessing, many ELTs are dumped, or landfilled consuming critical landfill space, which is already a major issue for atolls and small islands with limited land availability.



ELT Recovery Around the World

There are very few countries in the world recycling of ELT. Countries with successful ELT recycling programs often include regulatory restrictions. Energy recovery is commonly excluded from strictly regulated ELT management systems.

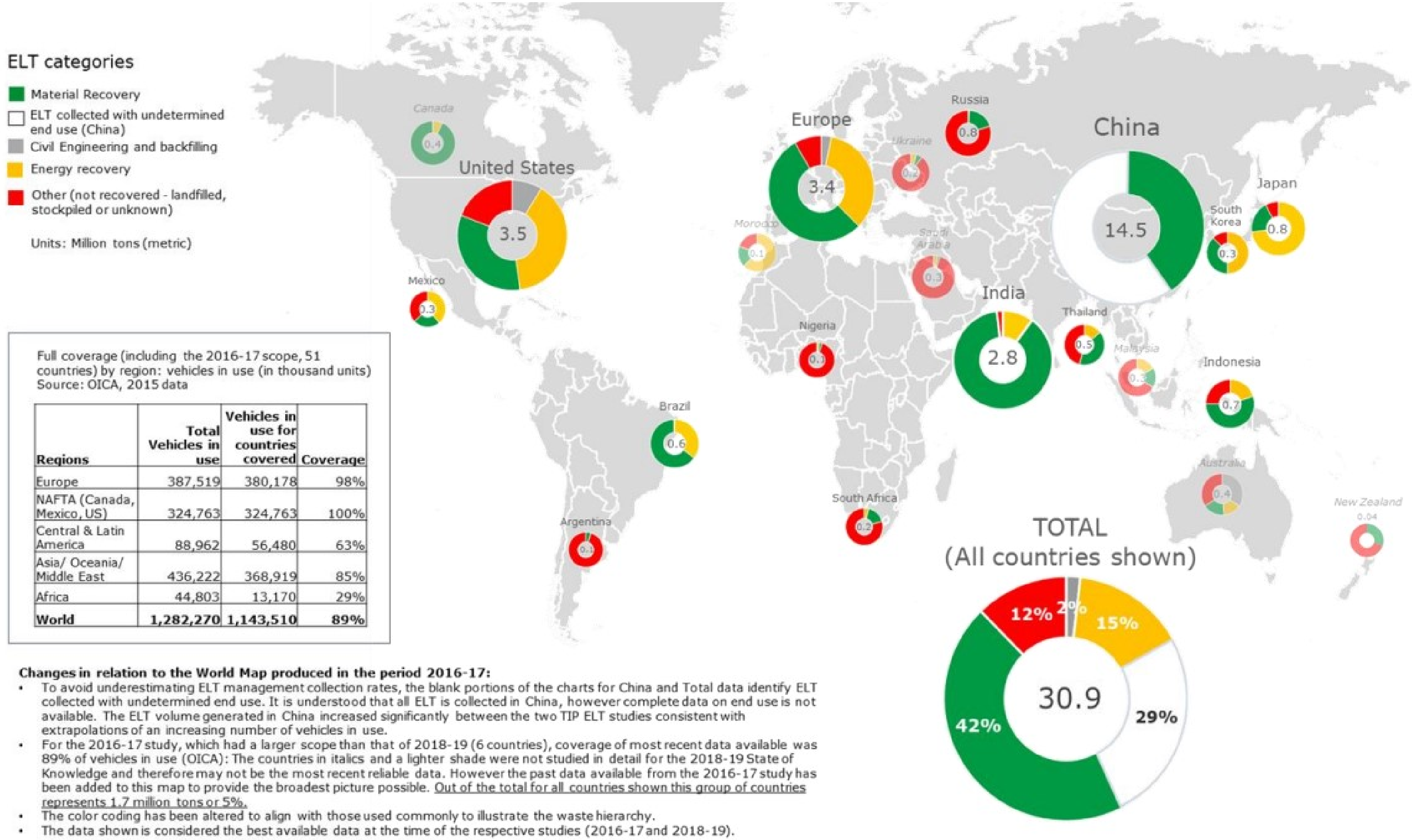
According to World Business Council for Sustainable Development (WBCSD) data, covering 13 countries plus Europe, 26 million tonnes out of a total ELT of 29 million tonnes generated is recovered. The largest quantities of recovered ELT are in China, USA, and Europe.

Europe has a greater drive for utilisation of all tyre resources, due to limited landfill airspace and strict resource recovery legislation which included a ban in landfilling tyres.

India and Brazil also report high recovery rates, although India's is a high proportion of informal (undocumented) recovery.

North America provides subsidies for the use of rubber granulate in high value applications, promoting material recycling. Africa, the Middle East, and Russia show high numbers of landfilled or non-recovered ELT.

Figure 2: Global ELT recycling



Full coverage (including the 2016-17 scope, 51 countries) by region: vehicles in use (in thousand units)
Source: OICA, 2015 data

Regions	Total Vehicles in use	Vehicles in use for countries covered	Coverage
Europe	387,519	380,178	98%
NAFTA (Canada, Mexico, US)	324,763	324,763	100%
Central & Latin America	88,962	56,480	63%
Asia/ Oceania/ Middle East	436,222	368,919	85%
Africa	44,803	13,170	29%
World	**1,282,270**	**1,143,510**	**89%**

Changes in relation to the World Map produced in the period 2016-17:

- To avoid underestimating ELT management collection rates, the blank portions of the charts for China and Total data identify ELT collected with undetermined end use. It is understood that all ELT is collected in China, however complete data on end use is not available. The ELT volume generated in China increased significantly between the two TIP ELT studies consistent with extrapolations of an increasing number of vehicles in use.
- For the 2016-17 study, which had a larger scope than that of 2018-19 (6 countries), coverage of most recent data available was 89% of vehicles in use (OICA): The countries in italics and a lighter shade were not studied in detail for the 2018-19 State of Knowledge and therefore may not be the most recent reliable data. However the past data available from the 2016-17 study has been added to this map to provide the broadest picture possible. Out of the total for all countries shown this group of countries represents 1.7 million tons or 5%.
- The color coding has been altered to align with those used commonly to illustrate the waste hierarchy.
- The data shown is considered the best available data at the time of the respective studies (2016-17 and 2018-19).

***Source**: WBCSD Global ELT Management – A global state of knowledge on regulation, management systems, impacts of recovery and technologies, December 2019*

The risks posed by various recovery methods to the environment and human health are critical to public authorities. For example, in China, the government and industry are trying to move away from polluting recycling methods by providing subsidies for “clean” methods.

ELT Recovery Methods in Key Countries

Table 2 presents data sourced from the WBCSD Global State of Knowledge

Table 1 Main ELT recovery methods in key countries around the world

Country	Annual ELT Recovery (t)	Method of Recovery
China	14,545,000	Reclaim rubber and granulation Low emission pyrolysis methods are under research and development
Europe	3,425,000	Rubber granules and powder (43%), cement kiln burning (38%) Use of ELT in asphalt and low noise surfaces and in plastics Research into pyrolysis
United States	3,700,000	Energy recovery (39%), material recovery (33%) of which most is granulated, and 9% civil/infrastructure use of ELT. Significant focus on environment and health related impacts of ELT recycling.
India	2,750,000	Material recovery process with a large part going to crumb rubber Research for ELT use in is steel production and rubber-modified concrete
Indonesia	684,000	Pyrolysis is the main recovery route, obtaining oil as TDF for industrial purposes ELT are also used in brick manufacture 15% goes to material recovery, mostly granulation
Japan	849,000	Mostly energy recovery (73%), with exemption of reporting and reduction objectives for energy from waste Material recovery of ELT is 19% Civil infrastructure use is 0.1%
Nigeria	113,000	Use as TDF for cooking (currently studies recommending against this practice) Civil/infrastructure applications (carpark barriers and marine jetties) Research into rubber granules absorbing oil spills
Thailand	515,000	Pyrolysis and cement kilns process around 54% of all ELT, creating issues around pyrolysis pollution Recent study by the government on a regulatory system for ELT Similar issues to PIC with little or no ELT collection infrastructure outside major cities

This booklet includes details on various ELT mechanical processing options. ELT's can be mechanically processed using specialised equipment to create outputs of whole tyres and the individual components of steel, nylon and various rubber forms.

Figure 3 provides an overview of Tyre Derived Products (TDP) from the traditional EOLT recovery market and their common applications.

ELT management is continually evolving present systems have been adapted over time as learning about ELT management has increased. Several of the references supplied in this report provide multiple options for further analysis, as PIC ELT systems develop and mature.

The options presented here provide preliminary information designed to assist countries to understand immediately available opportunities and does not reduce the need for more detailed assessment prior to implementation.

Figure 3: TDP from ELT to recovery markets and common application

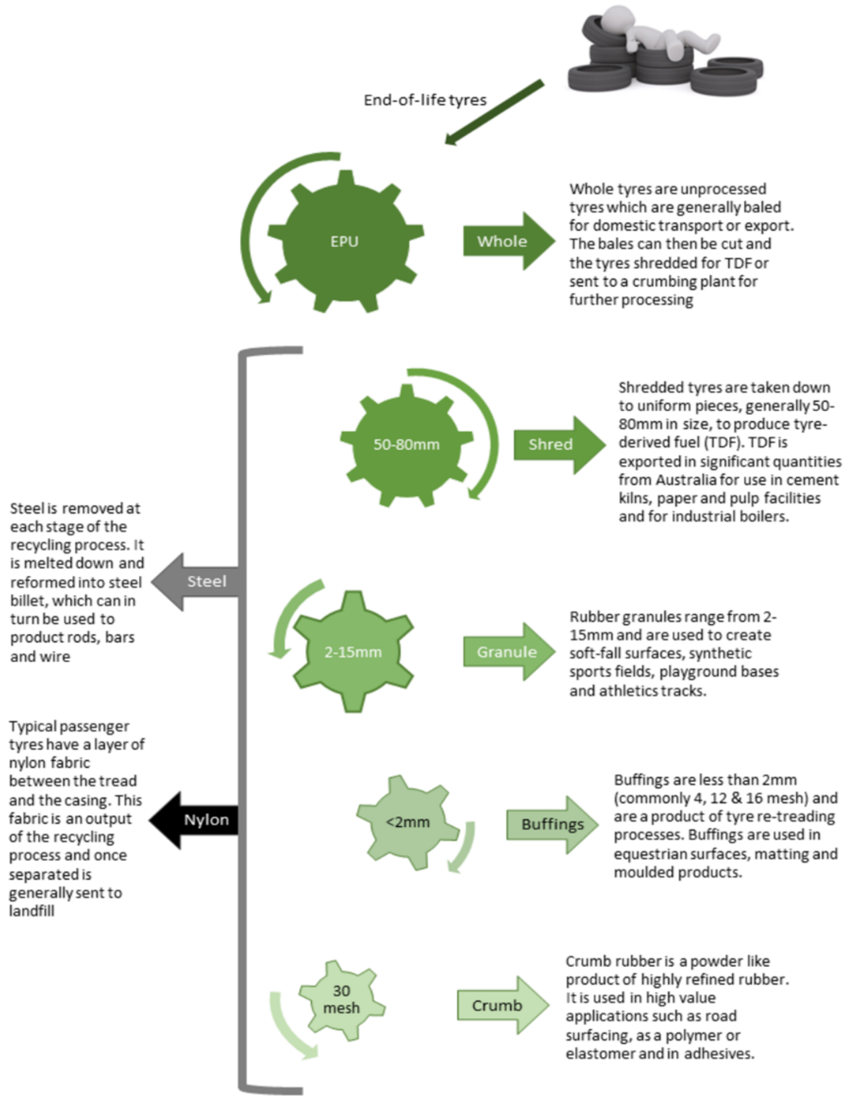
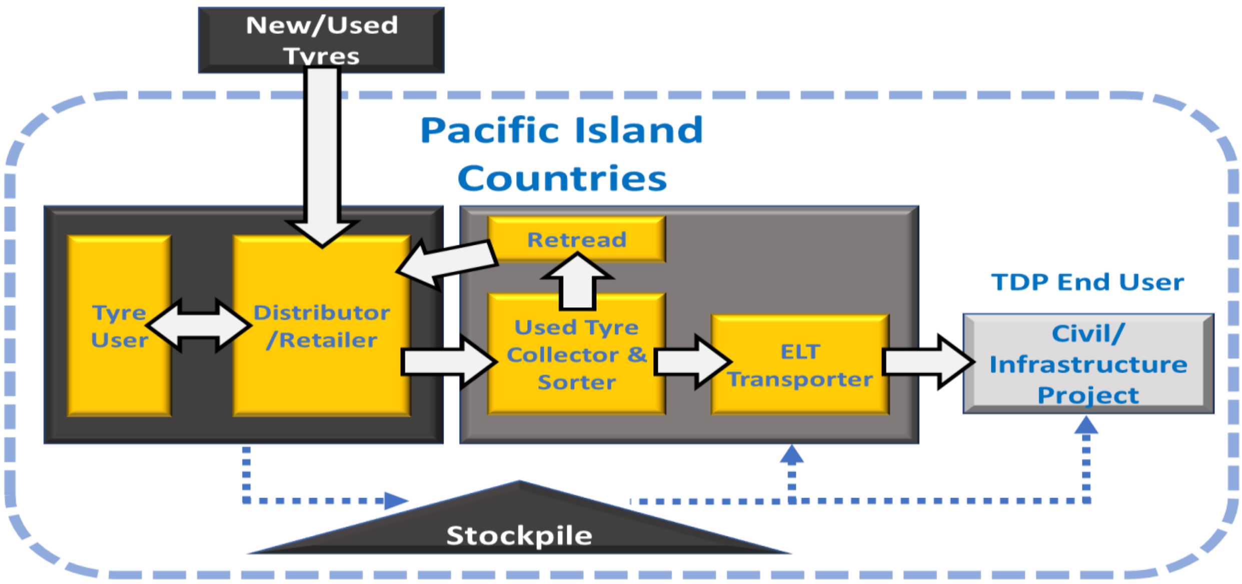


Figure 4: Chain from the creation of ELT to repurposing

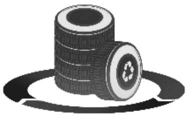


Social Benefits of End-of-Life Tyre Processing

There are many benefits to ELT processing

Improved Environment

Having a market that can accept and repurpose ELTs will enable PICs to collect ELTs effectively and provide a cleaner environment for their communities. This will also reduce pollution through less burning, dumping, and landfilling.



Socio-economic Outcomes

The establishment of tyre recycling industry will generate employment opportunities for local citizens. Employment opportunities will be created to facilitate collection, processing, recycling, and sales.

Waste Management

Processing ELTs would redirect tonnes of ELT usually illegal dumped, burnt or landfilled into emerging industry sectors to increase business activity in the country.

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Using shredded tyres instead of these materials may be beneficial as it reduces the density of materials, promoting improved drainage and better thermal insulation.

Additionally, when used under roads and rail tracks, shredded tyres reduce noise and vibration that can affect nearby buildings and communities.

Table 1 describes the various applications suitable based on the size of the shredded tyres.

Table 1: End-use options for shredded tyres

End Use	What is Involved	Technology Required
Used as filler in construction projects	Tyre shreds are used in place of clean fill materials as a structural material in civil applications	Primary Shredder (6-inch shred size)
Landfill construction	Tyre shred can be added to landfills as a medium for gas extraction. Vertical pipe placed into the landfill where the tyre shred is located for gas to be extracted and used for energy.	Primary Shredder (6-inch shred size)
Utilised as substitute for drainage materials	Tyre shreds are used in place of gravels or rocks as a drainage medium in civil applications. Tyre shreds can replace gravel in septic systems, acting as a permeable layer for drainage, while reducing the mining demands for alternative materials	Primary Shredder (3-inch shred size)

Shredding Technology

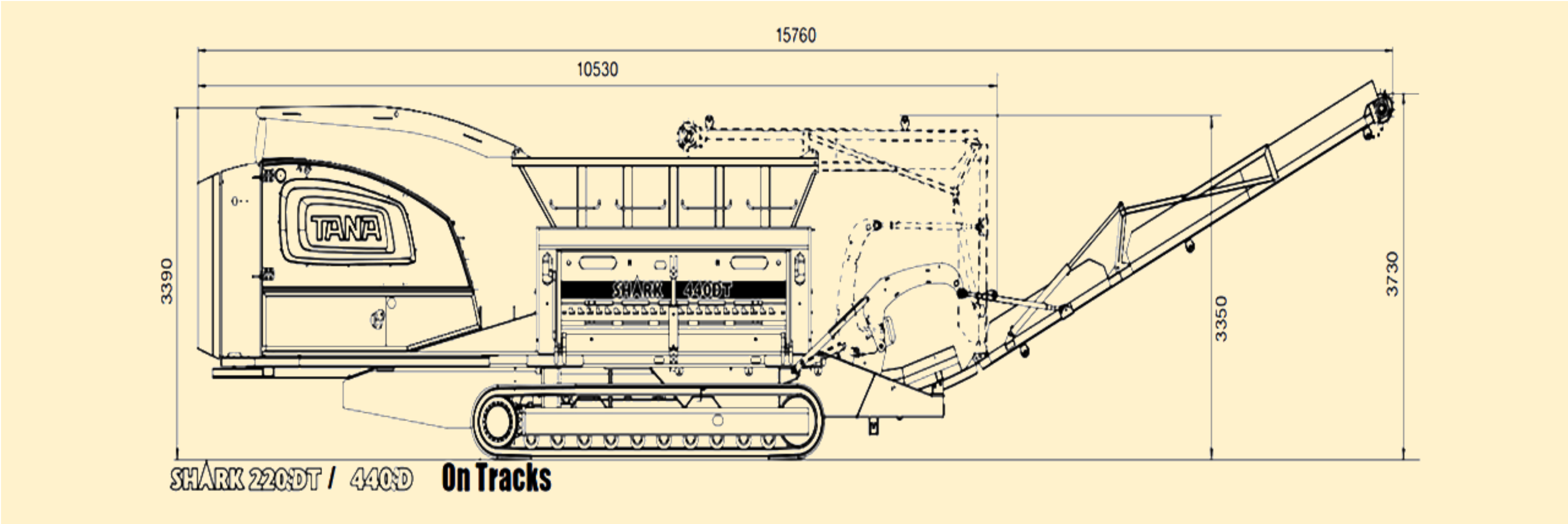
The shredding of tyres requires heavy duty bladed machines for processing. Machinery types are dependent on tyre type and volume and desired shred size. The size of product exiting the shredder is determined by the width of the cutters.

Single shaft shredders are used more for general waste for low-duty applications and are top loading. Twin shaft shredders come in top loading and through feed format and are typically used in first-pass size-reduction applications where output sizes are not critical.

Shredders can be either high or low speed and usually have a perforated screen which governs the final shredded product size by not allowing product through until it has been shredded small enough by the rotating cutters.

A small scale shredder can shred up to 250 car tyres per hour, a medium scale shredder can proces 600-800 tyres per hour while aarge scale shredder can process both car and truck tyres (1000 car tyres per hour and up to 200 truck tyres per hour.

Figure 5: Example of a Tyre Shredding Machine with built in Conveyor and magnetic separator



Installation of these machines is typically on a reinforced concrete slab. Vibrations are damped by internal mounting plates. Noise attenuation housings are an optional provision. Utilities requirements vary by size of machine. Electrical or diesel motors are used to drive rotating gearing.

Mobile shredder options are available on self-moving caterpillar tracks or mounted on a semi-trailer for relocation to stockpile location.

Financial Considerations

Capital Costs

- Small-scale shredders typically cost around US$20,000, with high capacity shredders ranging from US$230,000 to over US$1 million.
- Used machines are regularly available.

Operating Costs

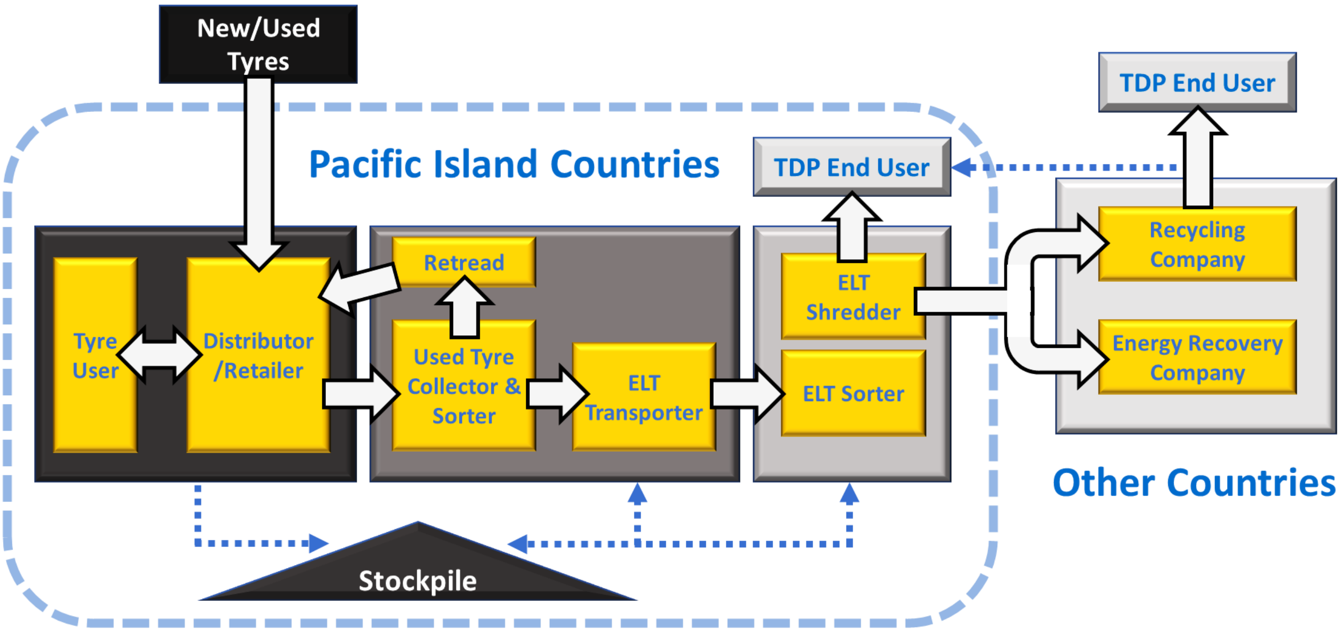
Labour (day operation only)	Utilities requirements	Consumables	Administration	By-Products Disposal
2 FTE (Shredder, including supervisor) **2 FTE (loading and stockpile maintenance)**	11kW for a Debeader 37kW for a small shredder 75kW for a Medium Shredder 110kW for a Large Shredder 370kW for a Mobile Terex Ecotec TDS820 (includes conveyor) 2 x 160kW motors for a Stationary Tana Shark 440EM electric version 10kW each for a Feed and product Conveyors	Fuel for generator (if not mains electricity supply) Blades (may be bolted, or welded into place on rotating shaft) Lining, where wear plates are sacrificial Grease and oil for bearings and rotating parts.	Logging incoming and outgoing volumes or weights Maintenance logs and scheduling Stockpile management and reporting.	Recycling of steel beading (approx 20% of tyre mass) Recycling of machine oil where possible Recycling of undersize rubber flakes in Crumb Rubber or Rubber Powder facilities (if available) - Landfill disposal if not.

Maintenance Costs

- Wearing components on shredders have hard faced welded surfaces. Hard facing needs to be reworked from time to time depending on machine usage.
- Cutting tips for shredders have a service life of around 10 months for a set of cutting tips. When cutting tips are changed, wear will be evident on the securing nuts, bolts, and washers so these will also require replacement.
- Parts required each year, based on 5 days per week running 12-hour operation:
  - 2 x set Tungsten Carbide cutting tips (1 x Rotor, 1 x Stator)
  - 1 x set cutter spacers
  - 1 x set rotary cutting tip holder
  - 1 x set fixed blade holder
  - 1 x set of wedge/cover plates
- Additional parts in year 2
  - 1 x full set of rotor bearings
  - 1 x rubber belt for Conveyor
- Additional parts in year 3
  - 1 x full set of rotor bearings
  - 1 x rubber belt for Conveyor
- Budgetary costs:
  - Year 1 – US$54,000 Parts, Labour extra
  - Year 2 – US$58,000 Parts, Labour extra
  - Year 3 – US$62,000 Parts, Labour extra

Governance Consideration

The following high level governance model describes ELT Shredding:



Using Shredded ELT in Landfill Engineering

Landfill construction and operation is a growing market that can utilise shredded tyres.

Figure 6: Shredded ELT as bottom drainage layer in landfill

ELT as Bottom Drainage Layers

Tyre shreds can replace other construction materials that would have to be purchased and can be used as both a liner and/or a cover for landfills. To be used as bottom drainage layer in landfill construction, ELT are shredded to 50 -100 mm, the following minimum standards are recommended[1]:

- Shredded tyres should not be placed on the side slopes.
- The bead wire should be removed prior to shredding to ensure that liners are not punctured. If bead wire cannot be completely removed, then a sand layer should be placed on membrane liners before tyre shreds are added.
- All tyre shreds are to be free of flammable contaminants.
- A filter layer is required to be placed above the shredded tyres that form the leachate collection system drainage layer to minimize the clogging of the drainage layer and the perforations in the leachate collection system pipes.

ELT as Backfill Material in Venting Layers

Tyre shreds can also be used in landfill gas extraction as backfill materials in venting layers. Tyre shreds have hydraulic and gas conductivity values comparable to or higher than coarse aggregate, which makes them acceptable for use in landfill gas collection systems. When designing landfill gas collection systems that use shredded tyres as a backfill material, the size of the shredded materials is important.

Typically, a 3-inch size is ideal for landfill gas extraction. Gas is extracted through vertical perforated pipes where a well is drilled with an auger with a diameter of 50 – 100 centimetres (cm). After drilling, a perforated polyethylene pipe with a diameter of 10 – 15 cm is placed in the middle of the hole, and gravel is filled in around the pipe.

Vertical extraction wells are typically placed 40 – 80meters (m) apart, depending on the landfill. Shredded ELT may be used as a lightweight backfill in gas venting systems replacing gravel (see **Figure 9**).

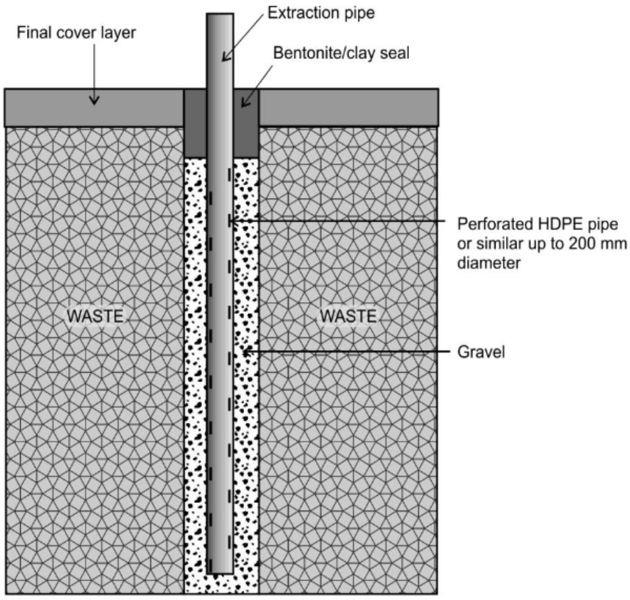


Figure 7: Typical LFG Extraction well

Figure 8: ELT replacing gravel in LFG extraction well

Horizontal collectors with shredded tyre backfill have been designed and installed at three landfills in southern Florida and Louisiana.

In southern Florida, these installations total 10,000 feet of tire chip-backfilled horizontal collectors.

Eleven of the collectors that were installed in 2001 are now under approximately 70 feet of waste and are still in operation today. Construction cost savings exceeded $10,000 for these 11 horizontal collectors[1].

When designing landfill gas collection systems that use shredded tyres as a backfill material, the most important considerations are shred size, permeability, compaction, and compressibility.

ELT as Final Landfill Cover

Tyres have high drainage capacity and has potential to be used as landfill cover. Landfill cover design generally consists of three layers: the barrier layer, the drainage layer, and the cover soil layer.

The purpose of the drainage layer is to allow any infiltrated water to drain from the overlying cover soil layer so that it is prevented from seeping into the underlying barrier layer and the waste. The drainage layer minimizes the generation of leachate in the landfill and prevents water build-up within the cover.

Shred size ranging from 0.5 inches to 5.5 inches can possess satisfactory properties to serve as the drainage material in landfill covers.

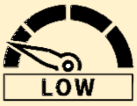
Figure 9: Shredded ELT as Landfill cover

However, site-specific testing using the actual tyre shreds is recommended to accurately determine the engineering properties of available tyres and to design an effective and inexpensive final cover. The interface strength between shredded tyres and other materials within landfill cover systems, such as soils and geosynthetics, is important to ensure slope stability.

Tyre shreds are susceptible to volume change given its high porosity and high rubber content; this should be closely due to the pressure created in a landfill environment.

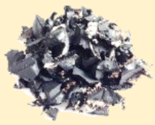
Using Shredded ELT as Filling Materials in the Infrastructure Sector

Tyre shreds possess interesting technical properties that could be beneficially used in civil engineering applications.



Density

Stiffness



Characteristic properties of tyre shred materials

Shredding of scrap tyres produce chunks of rubber ranging in size from large shreds to smaller chips.

Thermal Insulation Capacity

Elasticity

Drainage Capacity

Shredded ELT in Road Making

Tyre shreds have been used as lightweight fill materials for roadway embankments and backfills behind retaining walls. The shreds can be used “as is” or blended with soil.

Embankments containing tyre shreds are constructed by surrounding the shreds with a geotextile fabric and placing at least 0.9 m (3 ft) of natural soil between the top of the scrap tyres and the roadway.

The use of tyre shreds for the construction of embankments provides several advantages. The most obvious advantage is that of reduced unit weight, which is especially beneficial in situations where an embankment is to be constructed over an area with low bearing support.

Additionally, tyre shreds have good drainage characteristics, being as permeable as a coarse granular soil.

In the United States of America, states that have used shredded tyres in embankments are California, Colorado, Indiana, Maine, Minnesota, New Jersey, North Carolina, Oregon, Pennsylvania, South Carolina, Vermont, Virginia, Washington, Wisconsin, and Wyoming. Oregon uses the largest volume of shredded tyres known to date where 580,000 scrap tyres were shredded and used in a landslide correction project. In Colorado, between 400,000 and 450,000 scrap tires were used to construct an embankment containing tyre chips on a section of interstate highway.

However, site-specific testing using the actual tyre shreds is recommended to accurately determine the engineering properties of available tyres and to design an effective and inexpensive final cover. The interface strength between shredded tyres and other materials within landfill cover systems, such as soils and geosynthetics, is important to ensure slope stability.

Tyre shreds are susceptible to volume change given its high porosity and high rubber content; this should be closely due to the pressure created in a landfill environment.

Design Considerations

While tyre shreds can be mixed or blended with soil, as the percentage of soil is increased, the unit weight of the blend increases. A maximum 50:50 tyre chip to soil ratio is suggested so that tyre chip usage is not reduced too greatly. However, if the unit weight of the fill is not a concern, then even small percentages (10 to 25 percent) of tyre chips can be blended into the soil. This could improve the compatibility of the fill.

Since tyre shreds are unlike conventional materials, special design procedures are required, including shred containment, shred particle size distribution, particle shape, type of belt, compacted density, and whether soil will be mixed with the tyre shreds. To contain tyre shreds, a geotextile fabric should be placed beneath the shreds and wrapped around and above them. The geotextile must completely enclose the tyre shreds to provide the necessary containment.

A major concern in the use of tyre shreds in an embankment are the comparatively large settlements (about 10 to 15 percent of the height of the tire layer) that have been observed in various field studies. There is little information available on the tolerable settlements of highway embankments. The detrimental effects of settlements in this range can be reduced by using flexible pavement over scrap tyre fills, by inducing some of the postconstruction settlement during construction. This can be done by placing a thicker soil cap or a surcharge earth loading over the embankment, or by using stage construction. Another possible means of mitigating scrap tyre embankment settlements is to use a rubber-soil mix to construct the embankment, instead of using tyre shreds alone.

Shredded ELT in Septic System

The conventional septic system consists of two main parts: a septic tank and a soil absorption system, also known as the drain field. The drain field provides the final step in the wastewater treatment process.

A standard field is a series of trenches, or a bed lined with crushed stone or gravel and buried one to three feet below the ground surface.

Perforated pipes or drain tiles run through the trenches to distribute the wastewater onto the aggregate.

Figure 10: Standard design of Septic Tanks

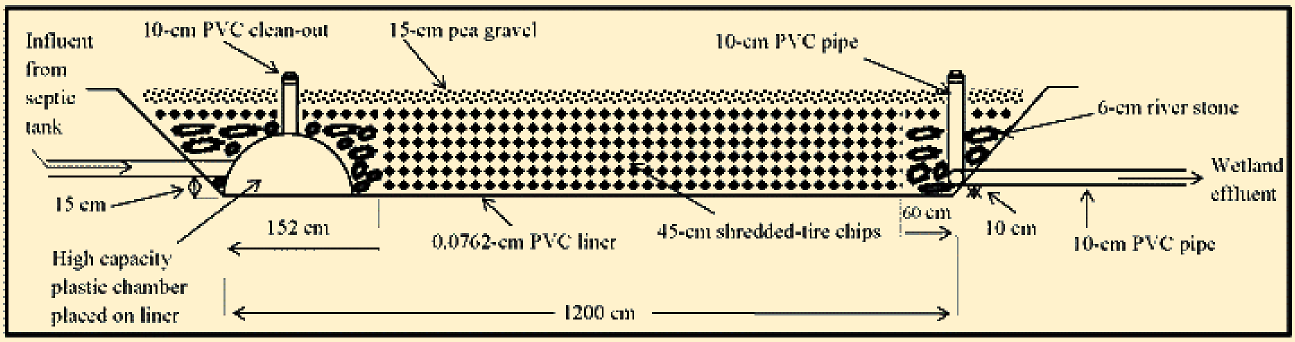


Figure 11: ELT used as drainage material in Septic Tanks

While gravel is a typical drainage material, there are regions where gravel is scarce, therefore expensive, and existing supplies are being used up by the construction industry, thus the hunt for alternative materials for use with onsite systems. Shredded tyres can replace crushed stone or gravel as porosity was found to be higher with tyre chips than stone.

Tyre chips increases drain field storage capacity by 30 percent because the void space between the tyre chips is greater than the void space for gravel (60 percent for tire chips; 40 percent for stone).

Tyre chips can also hold more water than stone and can be transported more easily due to their light weight. Challenges to using tyre shreds in drain fields is that the tyre chips must be clean cut and be of uniform size and in some areas, stone is abundant and cheap.

Environmental Considerations

Preliminary assessments indicate that the combustion process may have been initiated by heat released either by the presence of organic soils and microbial degradation, the oxidation of exposed steel wires, or microbes consuming liquid petroleum products that could have been spilled on the tire shreds during construction. The crumb rubber in the presence of air may have ignited when exposed to the heat generated in the embankment, initiating the combustion process.

Some minor leaching of zinc and PAH to the environment. Tests undertaken on ELTs indicate minimal leaching of iron and manganese into groundwater at levels which were below health concerns.

End Use	Environmental Concern
Utilised as substitute for drainage materials	Some potential risk to the environment of products, through the transfer of zinc and organic substances such as phenols or phthalates by leaching into ground soils due to weathering and water runoff.
Used as filler in construction projects	
Landfill engineering	
Septic systems (drainage)	

Tyre Granulation

Granulation is the process of converting tyre shreds into tiny particles of rubber (a few millimetres in diameter to a few microns), otherwise known as "crumb". Rubber crumb is a powder like substance also referred to as crumb rubber or rubber powder.

Steel and tyre cords are removed from discarded tyres, and the remaining rubber is reduced to a granular consistency. Some applications for crumb rubber include rubberized asphalt, playground flooring, welcome mats, anti-fatigue mats and vehicle mud guards. This option requires significantly more investment and coordination of ELT stockpile access to ensure a centralised facility can be effective and sustainable. It is suggested that a commercial imperative such as local authorities stipulating a certain limited use of virgin materials in all road projects in favour of a higher percentage of recycled products (glass, plastic, tyres) would be an effective incentive.

Option Description

To create smaller rubber pieces from the shredded tyres as described above, the rubber pieces must enter a secondary grinding process and be reduced to the desired size. A three-stage grinding process is used to separate rubber, fabric, and steel to produce the crumb rubber.

- In the first stage, tyres are fed into a tyre shredding machine.
- Following shredding, the rubber pieces travel by a fabric separator and screener to separate them from fabric and steel. Depending on the amount of other material present, this separating process may need to be repeated.
- The crumb producing process then utilises a rubber powder producing machine containing a feeder, grinding wheels and a vibrating screen to return oversize pieces back to the grinding section for further breaking down and separation.

There are alternative methods to the above process such as cryogenic processing which provides a higher quality output of recycled rubber. However, these other methods require expensive and specialised equipment that is not deemed to be appropriate for PICs at this stage.

Applications include:

- Road surfacing (crumb rubber asphalt);
- Sporting fields;
- Soft fall playgrounds and other soft fall surfaces.

Granulation Technology

The following section assesses two granulation plant types:

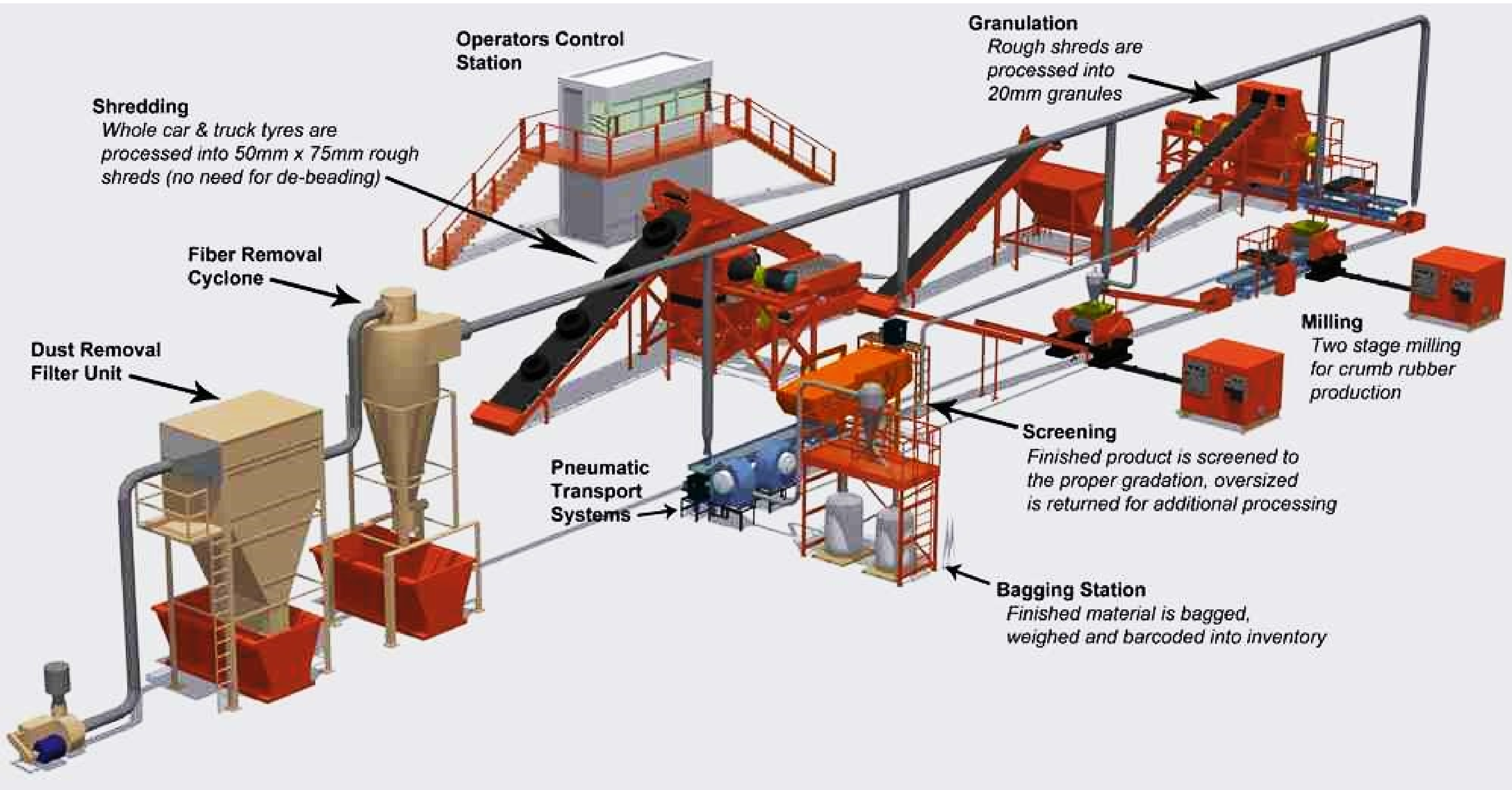
- A shredding facility containing multiple units for the shredding of tyres to approximately 40mm size
- A secondary granulation and fine grinding facility processing tyre shreds into rubber mulch/crumbs and rubber powder, with separation of clean steel wires and nylon threads as recyclable by-products.

A typical ambient temperature multi-step processing technology is shown below. It uses a series of machines (typically operating in series) to separate the rubber, metal, and fabric components of the tyre.

Magnetic separators are included at various points to remove steel. Because of the fine nature of the final products, a dust collector is required.

The lighter nature of nylon fibres means the dust collector is also used as a separation device.

Figure 12 Typical ambient ELT complete processing technology

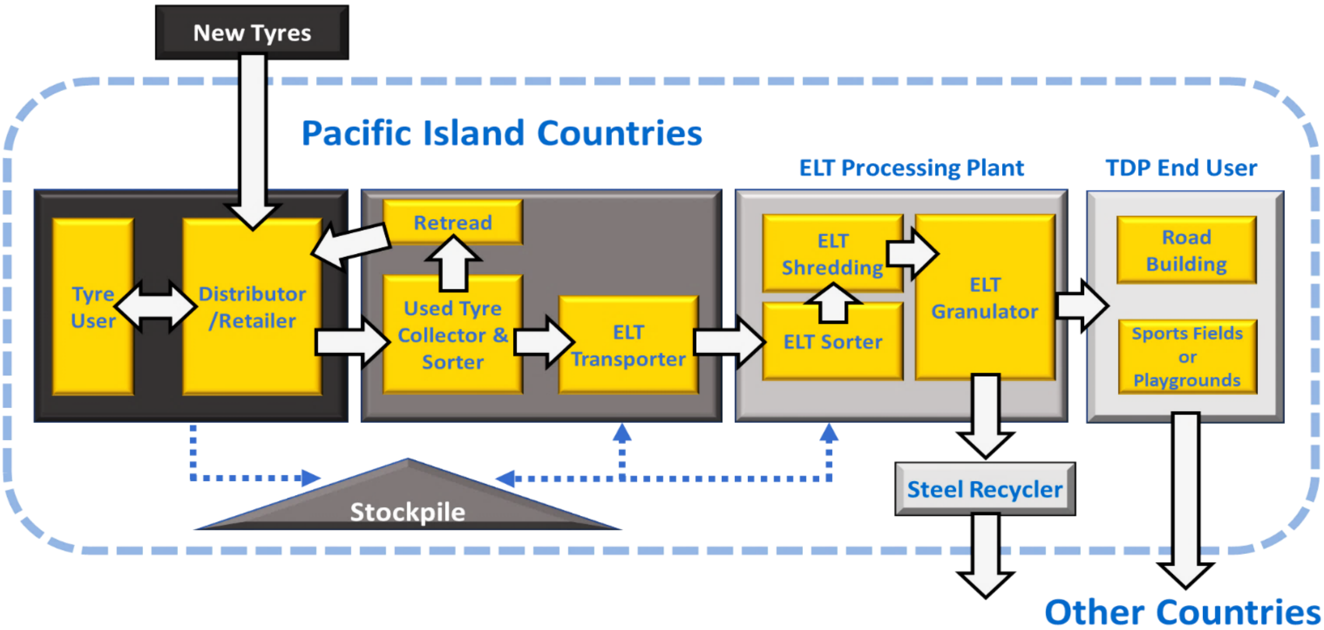


Capital Costs

- DeBeader and Shredder: refer to Section **Error! Reference source not found.** pricing
- Secondary Shredder: US$300,000 to US$600,000
- Crumb Rubber Plant: Granulators US$420,000 to US$600,000
- The typical investment for even a modest rubber crumbing facility is likely to exceed US$1.8 million or US$9.5 million for a larger scale plant.

Governance Model

The following high level governance model describes a ELT Granulating operation



Using Tyre Crumbs in Road Surfacing

Road construction is a common market for tyre crumb. When crumb is added to asphalt, it dramatically increases the asphalt's viscosity. The addition of rubber to road construction materials provides increased binding strength and elasticity, and. Crumb rubber ischemically treated to rapidly blend into asphalt. Carbon present in rubber acts as an anti-oxidant and prevents asphalt from ageing and oxidizating.

Scrap tyre rubber can be incorporated into asphalt paving mixes using two different methods (a wet process or a dry process). The initial step in the production of crumb or granulated scrap tyre rubber is shredding, the rubber is processed, the particle sizing is reduced, steel belting and fiber reinforcing are separated and removed from the tyre shred before crumbing. In the wet process, crumb rubber acts as an asphalt cement modifier, while in the dry process, granulated or ground rubber and/or crumb rubber is used as a portion of the fine aggregate.

Figure 13: Rubber Crumbs used in Asphalt

The use of waste crumb rubber in road construction as a pavement surface has a better skid resistance, fatigue crack resistance and increased pothole resistance. Other benefit of using tyre crumbs in road construction includes:

- Reduced noise pollution from the road by about 50 – 70%. This allows building roads closer to residential buildings. Sometimes an innovative canvas eliminates the need for a fence.
- Increased service life of the road by 5 – 10 years, which allows significant savings on road repairs.
- The road’s surface is more resistant to deformation. Bitumen with the addition of crumb rubber gives elasticity to the road surface, as a result of which the surface becomes more durable, the coefficient of adhesion of tires to the asphalt surface increases, which is especially important in rainy weather.
- Improving the drainage properties of the road surface prevents damage to the road during rains.
- Increased service life of car wheels by slow tread wear.

An Environment Impact Assessment should be undertaken prior to use in any construction project including road making. This will ensure the minimisation and management of potential negative environment and social impacts. The operation of a granulation facility willl need to comply with National Air Emission standards.

Use of Tyre Crumbs in Sporting Facilities

Rubber coating creates favorable conditions for training or competition. The load on joints and knees is significantly reduced, and the risk of injury is also reduced. Rubber crumb coating is durable, easy to install, has a long service life. The coating can be used in any climatic conditions.

Figure 14: Use of Rubber Crumbs in Running Tracks

Stadiums with rubber coatings are waterproof and water-permeable. In the first case, the rubber coating allows water to pass through it, and, in fact, playing can resume right after a rainy spell.

The crumb rubber floor coating also have a porous structure that allows water to pass through it; before liquid is collected in specially designated places (water collectors) before final discharge into storm water drain.

Gym rubber flooring is a fundamental component for the comfortable and correct operation of a gym.

Sports rubber flooring in the gym is primarily needed to protect the gym floor, reduce maintenance costs, cushion shock, and absorb noise caused by heavy equipment.

Rubber flooring is highly durable and comfortable to walk and train on

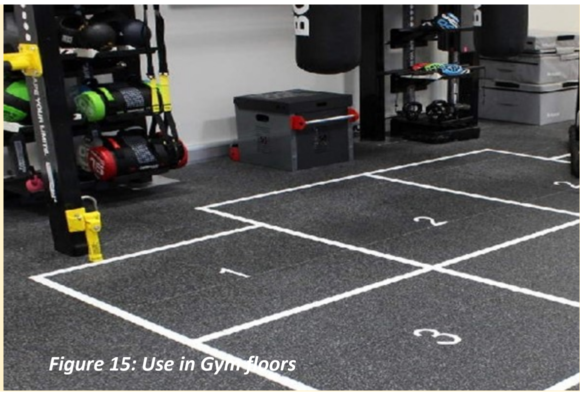


Figure 15: Use in Gym floors

Rubber Crump Coating for Children's Playground and Territories

Rubber crumb coatings for playgrounds have many advantages:

- Suitable for long-term and all-season use
- Reliability and durability of the rubber base
- An elastic and flat surface provides safety and prevents injuries and bruises when falling (this is especially important for children)
- Beautiful and stylish design can transform any territory, zone, or site allotted for arrangement
- A big variety of shades allows to create geometric patterns or perform in a single-color version

Figure 167: Rubber crumb coatings for playgrounds

Environmental Considerations

Some potential risk to the environment of products, through the transfer of zinc and organic substances such as phenols or phthalates by leaching into ground soils due to weathering and water runoff. A French Agency review indicated low concentrations of heavy metals, plasticizers, additives, and volatile organic components (VOCs), all below reference toxicological values, in artificial turf infill and playgrounds. The studies consider the risk of carcinogenicity as low or negligible due to low emission levels

Conclusion

ELTs are a source of substitute products that can replace virgin raw materials and help conserve natural resources. The challenge and opportunity for all stakeholders is to create an ELT system where ELT are considered as a resource available for useful and sustainable markets.

PIC volume of ELT is approximately 7,000 tonnes per year. Existing ELT stockpiles are unknown actual volume due to incomplete record keeping, but are estimated to be around 125,000 tonnes, based on import/export data.

Current efforts at reducing ELT stockpiles appear to be sporadic at best, with waste tyre burning still a common occurrence. Ideally, the use of ELT in forms that utilise their physical material properties makes more sense than incineration, both environmentally and economically.

When shredded, ELT can be used to replace conventional construction material, such as road fill, gravel, crushed rock, or sand. Using shredded tyres instead of conventional construction materials is beneficial due to a reduced density, improved drainage properties, and better thermal insulation. The shredding of tyres requires heavy duty bladed machines for processing. Machinery types are dependent on tyre type and volume and desired shred size.

Shredded tyres can be used in PICs with advanced civil infrastructure as:

- Filler in Construction Projects
- Landfill constructions
- Substitute for drainage materials

Some of the properties of ELT that make it ideal for use in local infrastructure sector are particle size and shape, specific gravity, compacted unit weight, shear strength, compressibility, permeability, and combustibility. Due to the differences between tire shreds or chips and stone or soil-like embankment materials, physical characterization of tire shreds or chips represents a specific challenge to the tire user.

Shredded tyres can be converted into tiny particles through the process of granulation whereby size is reduced to a few millimetres in diameter to a few microns of rubber, known as “crumb”.

Applications of tyre crumbs in the infrastructure sector include:

- Road surfacing (crumb rubber asphalt);
- Sporting fields.
- Soft fall playgrounds and other soft fall surfaces.

Some potential risk to the environment of products, through the transfer of zinc and organic substances such as phenols or phthalates by leaching into ground soils due to weathering and water runoff.

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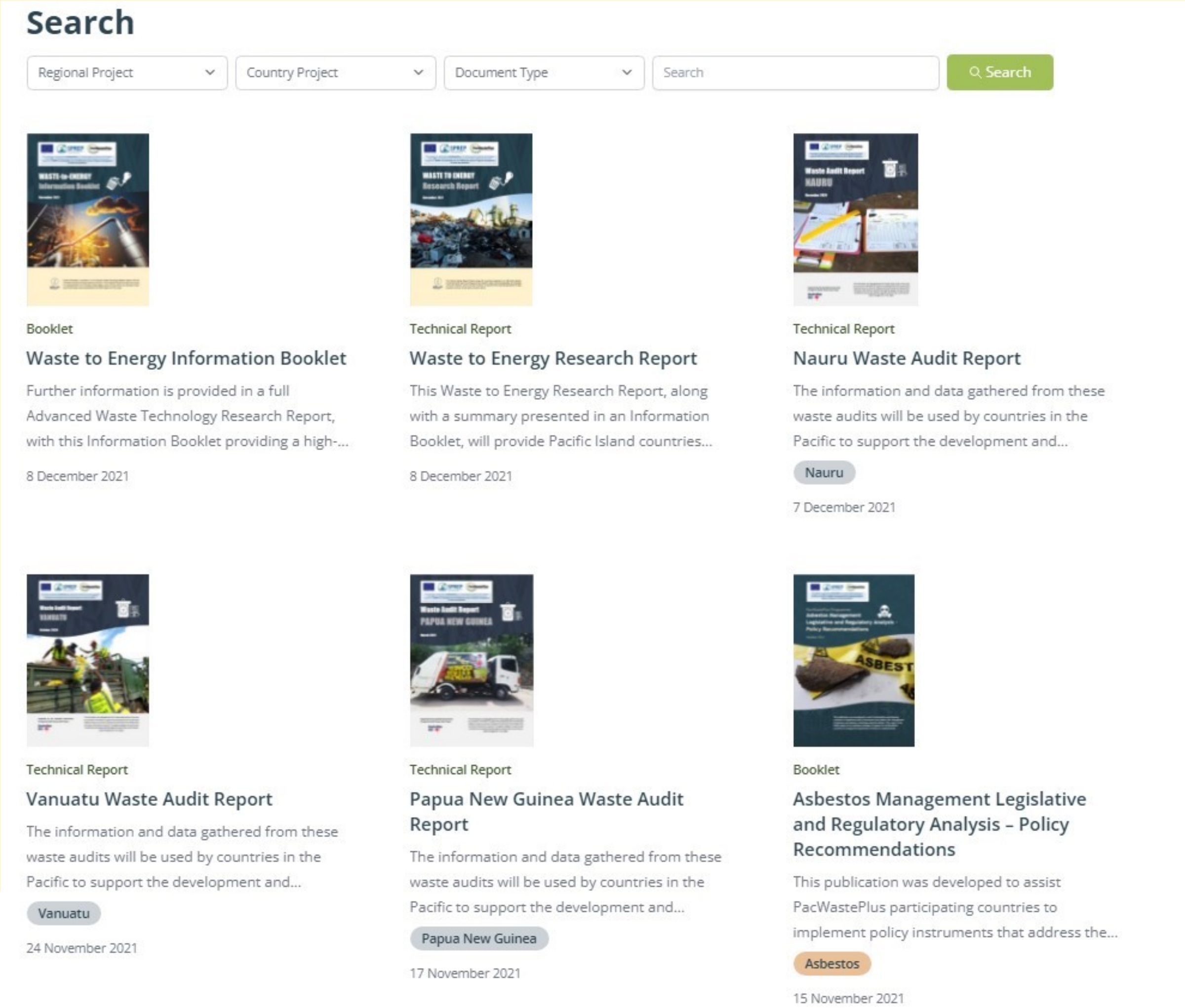

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