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:
NON-PROCESSING REUSE OPTIONS

February 2022

This booklet will explore several potential uses of ELT in that do not require mechanical or thermal processing. The options presented here provide preliminary information designed to assist countries to understand immediately available opportunities.

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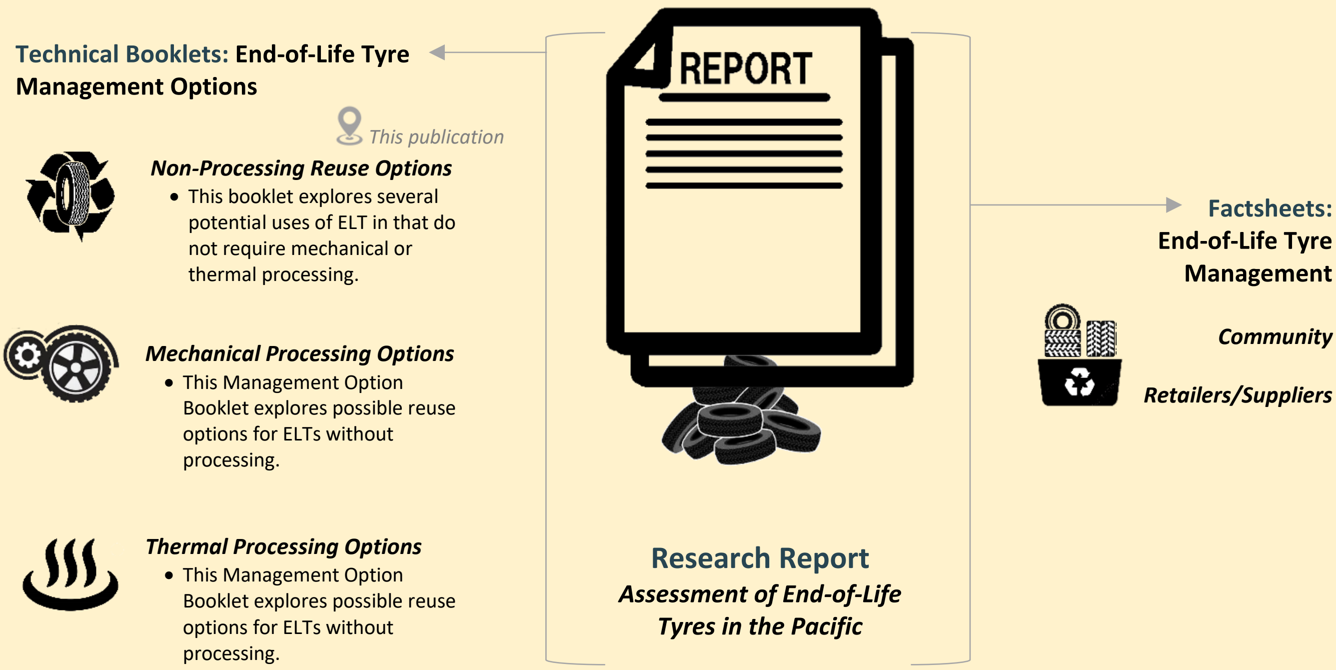
Our vision: A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures.

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



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

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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.

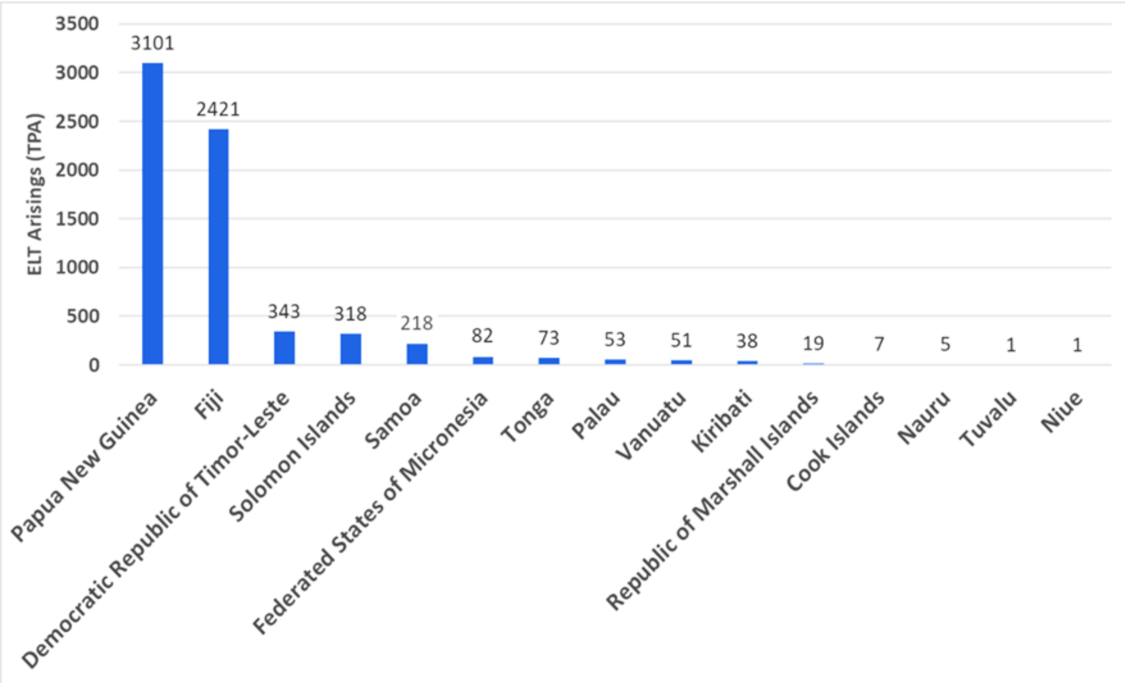
Some of these risks include:

- 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, SO_2 emission was found to be 102–820 g/kg, while NO_2 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**).

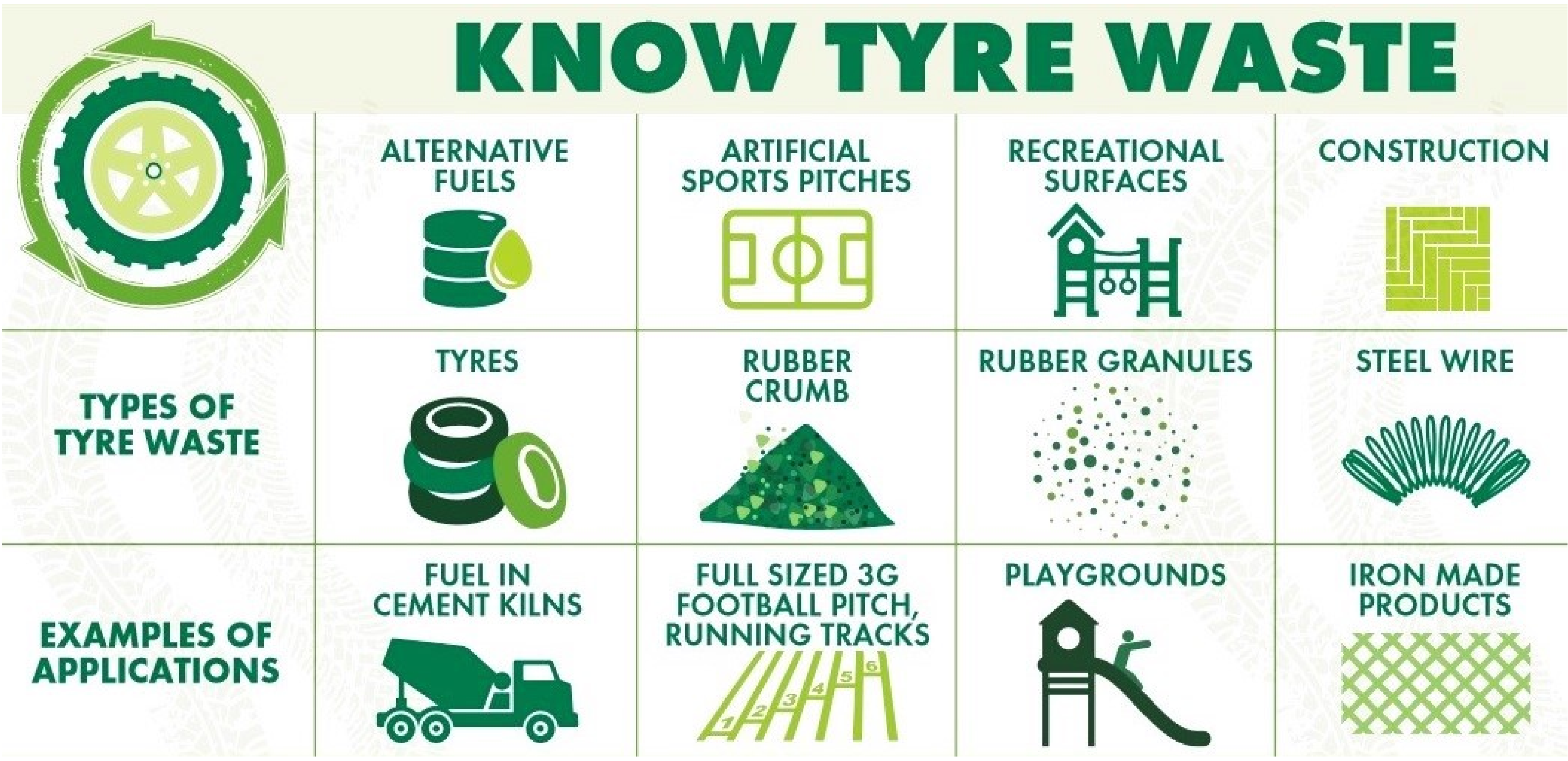
Figure 1 Estimated generation of ELT in PIC per year



***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.

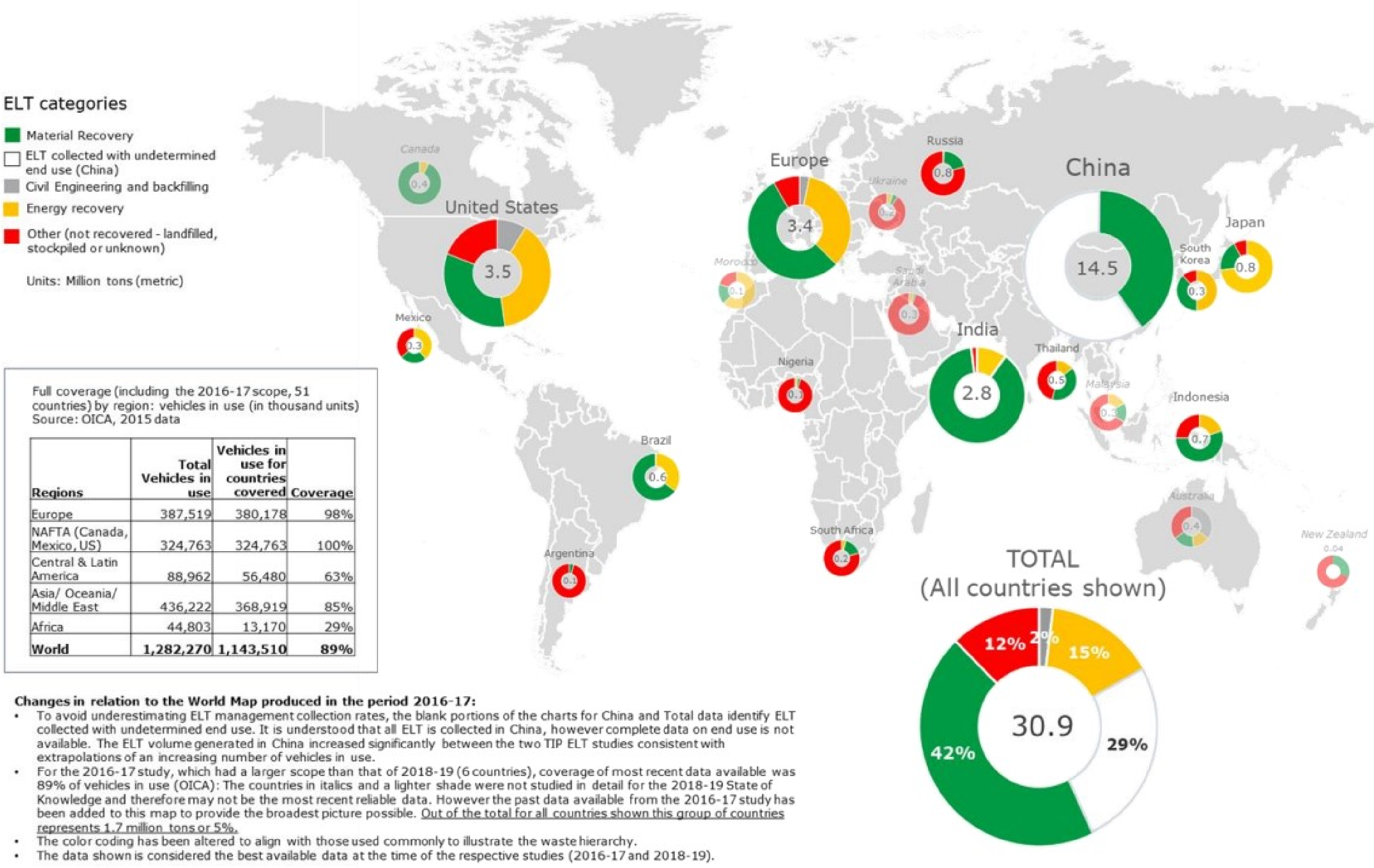
According to World Business Council for Sustainable Development (WBCSD) data, covering 13 countries plus Europe, 26 million tonnes out of a total ELT of 29 million tonnes generated is recovered. The largest quantities of recovered ELT are in China, USA, and Europe.

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: ELT Recovery in 13 countries and the European Union



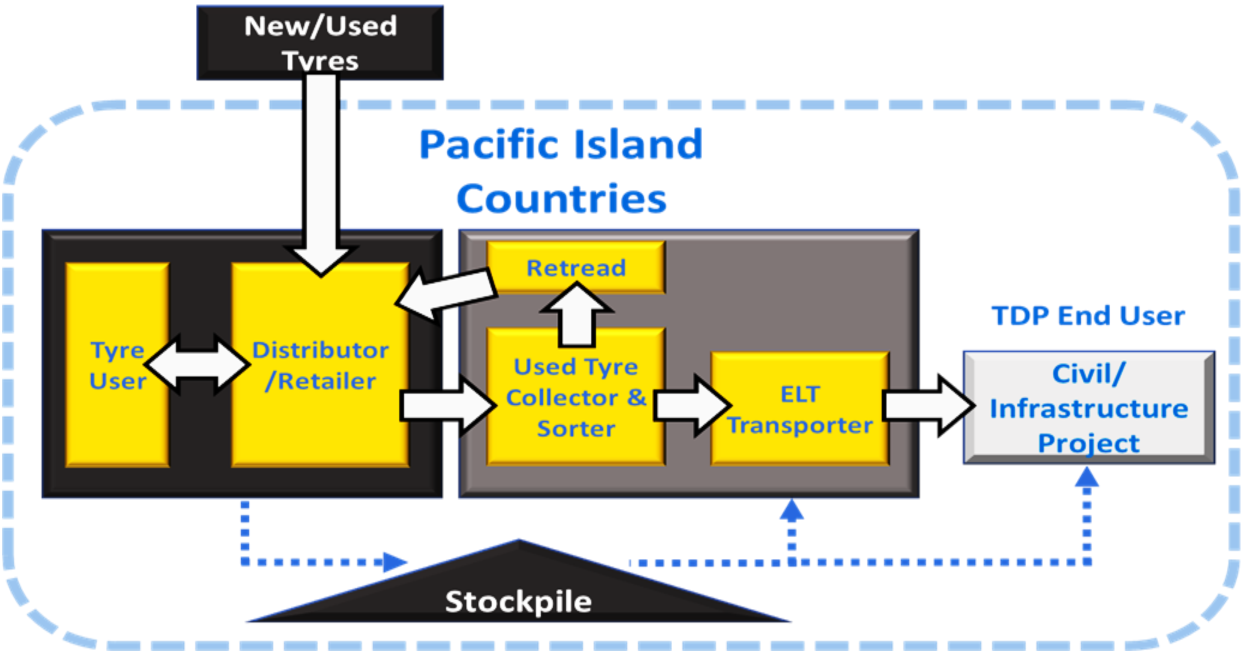
Regions	Total Vehicles in use	Vehicles in use for countries covered	Coverage
Europe	387,519	380,178	98%
NAFTA (Canada, Mexico, US)	324,763	324,763	100%
Central & Latin America	88,962	56,480	63%
Asia/ Oceania/ Middle East	436,222	368,919	85%
Africa	44,803	13,170	29%
World	**1,282,270**	**1,143,510**	**89%**

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

This booklet will explore several potential uses of ELT in that do not require mechanical or thermal processing. 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: ELT available opportunities for Pacific Island countries

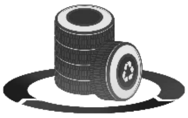


Social Benefits of Recovering End-of-Life Tyres

There are many social 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

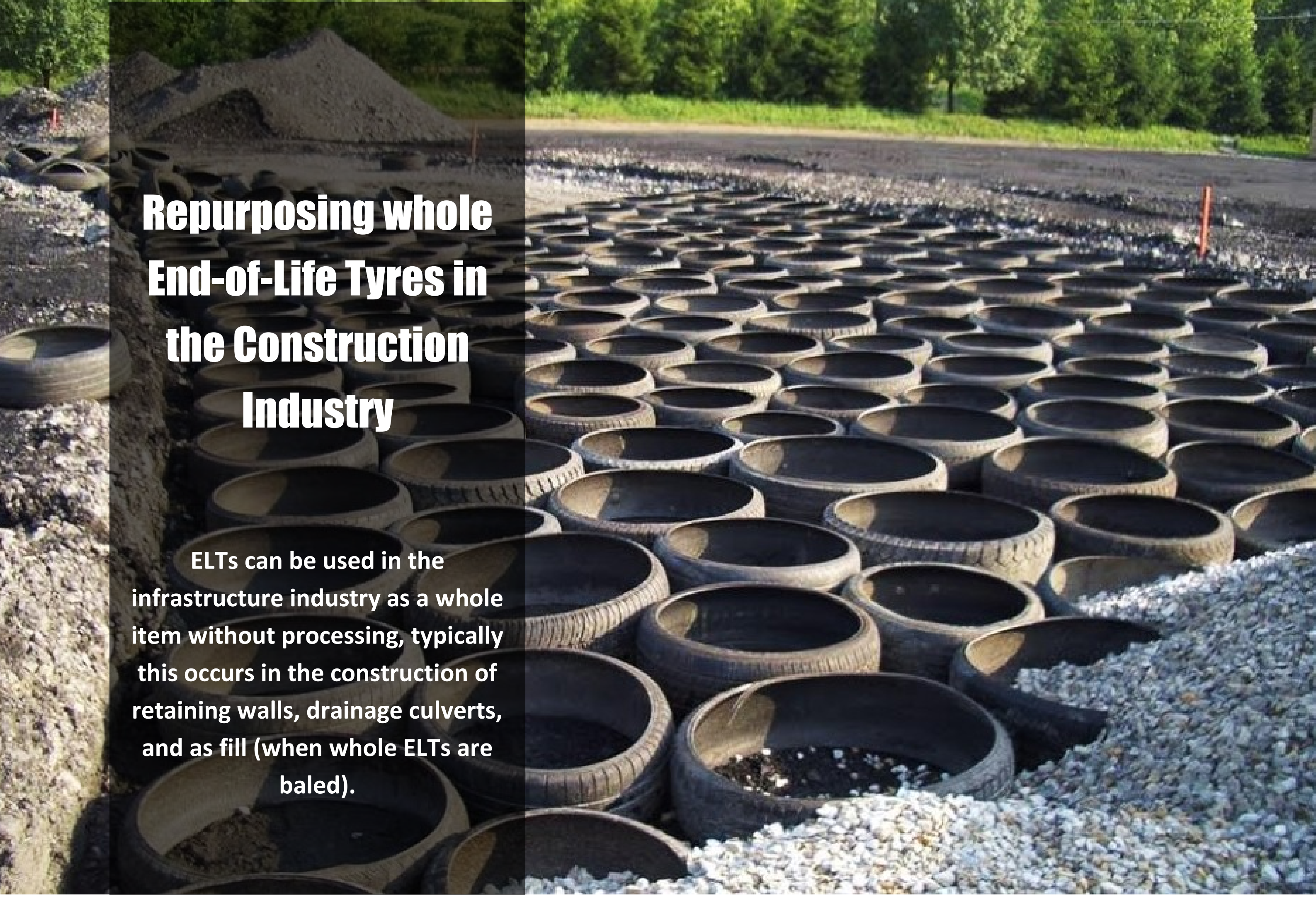
The establishment of tyre recycling industry will generate employment opportunities for local citizens. Employment opportunities will be created to facilitate collection, processing, recycling, and sales.

Waste Education

Enhancing awareness of ELT waste management issues will benefit the community in general by demonstrating positive environmental results. ELT recovery may help to expand the concept of better utilisation of a valuable resource into other areas of positive influence in the waste sector.

Waste Management & Commodity Creation

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



Repurposing whole End-of-Life Tyres in the Construction Industry

ELTs can be used in the infrastructure industry as a whole item without processing, typically this occurs in the construction of retaining walls, drainage culverts, and as fill (when whole ELTs are baled).

ELT use in civil engineering typically involves replacing conventional construction materials (e.g. road fill, gravel, sand, or dirt) with whole tyres (see **Table 1**). Prior to using ELTs in any infrastructure or engineering project as a substitute for virgin construction materials, it is recommended that a design engineer is engaged to determine the appropriate use of whole ELTs in a particular application, to ensure the tyres do not pose a health or environmental risk. Prior to repurposing ELT, appropriate approvals should be sought as it can be subjected to national legislation.

For example, an Environment Impact Assessment (EIA) may be required prior to using ELT in construction projects.

Table 1: End use construction with whole tyres

End Use	Description	What is Involved
Embankments, retaining walls and housing foundations	ELTs may be banded together and partially or completely buried on unstable slopes. Estimated lifespan of more than 100 years where tyres are protected from weathering and combustion.	Strapping, covering tyres in geotextile membrane
Roadside crash barriers	Whole tyres can be easily stacked to form a protective roadside barrier to lessen impact of crashes, reducing the severity of driver harm. Tyres are stacked and may be fixed together but not fixed to the ground. Estimated lifespan with direct sun exposure is 10-20 years.	ELT are stacked and held together by fasteners.
Marinas and docks	Tyres used as barriers for vessels against dock and marina structures. Tyres are attached to jetty edges and support structures where there is potential for vessel impact. Estimated lifespan 5-10 years.	Strapping or fastening
Playground equipment	Use of whole tyres in playground equipment. Estimated lifespan 5-10 years.	Strapping or fastening
Tyre Bales are exported for other use	Whole tyres are baled using a tyre baling machine using approx. 100 tyres per ~1 tonne bale.	Tyre baler

Using ELT to Construct Retaining Walls

Retaining walls made from specially stacked tyres and may be encased in concrete, are used to form a strong and durable retaining wall system. Construction costs may be reduced up to 75% compared to the lowest cost alternatives such as rock, gabion, or concrete protection.

Process Overview

The retaining wall uses whole waste tyres, whose topside wall is removed, and then filed with cobble material (eg stone, gravel, soil, sand, lightweight aggregate, or other fill materials). Retaining walls using ELTs are usually designed so that the font portion of the wall is initially exposed. The wall may be left 'as is' or covered in concrete to increase the wall's durability.

Capacity (maximum and minimum throughput)

Potentially unlimited utilisation

CASE STUDY

The Texas Department of Transportation undertook research in 2020 to identify existing retaining walls constructed using scrap tyres. The research discovered a number of whole tyre retaining wall examples (see **Table 2**).

Table 2: Examples of retaining walls constructed with whole used tyres

Location of Tyre Wall	Description
Tyre- faced earth-reinforced wall, built by USDA, Forest service, Northern California	3m high wall, IH:4V face batter used; soil reinforcement with slit-film geotextile used at 19 to 38 cm vertical spacing; Tyres filled with local backfill; Tyres staggered one-half diameter for each successive layer; face settlement of 1ft measured after 5 years.
Granite aggregate filled rubber tyre retaining wall, Batam, Indonesia	7 ft high wall to support a hill slope adjacent to a 328 ft high microwave transmission tower; rubber tyres filled with granite aggregates and quarry waste; Woven geofabric to resist lateral earth pressure.
ECOW ALL highway noise abatement barrier, Vienna, Austria	Designed and built by Econtract company in Austria; Tyre cavities filled with earth; Tyres are perforated and planted with creeping vines or other local flora.
Reinforced-earth tyre retaining wall, Santa Barbara, CA	Whole tyres used to construct wall face; Tyres were split into two along the treads and used for soil reinforcement, Tyre halves were anchored into backfill using rebars, Tyre halves were also tied to each other using ropes; Cost around $27 per sq ft.

Source: *www.cedengineering.com*

Structural Safety Concern

Prior to construction of tyre retaining walls, a structural engineer should determine suitability of project site for the construction of tyre walls and determine any specific construction specifications. Testing of the heigh and width of a tyre wall will determine safety against overturning, base sliding, bearing failure and internal shear failure are likely to be undertaken.

Pacific tropical conditions can result in overheating of exposed tyres in retaining wall. To address with this, wall design may include the installation of a fire resistant geofabric to cover the exposed portion of the tyres. Once covered, the wall can then be covered with a variety of products, including vegetation, timber, or concrete panels.

Environmental Considerations

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. Tiny shrimp placed in runoff water suffered no noticeable health consequences.

Financial Considerations

When planning to construct a retaining wall, funds will need to be available for capital purchase, labour, and maintenance. **Table 3** provides details of the minimum items that are likely to attract charges.

Table 3: Financial Consideration for using ELT for the construction of Retaining Wall

Capital Cost	Operating Costs	Maintenance Costs
Funds will be required to purchase the following materials (at a minimum)*. • Volume of ELTs required for the construction of the retaining wall. • Fire Retardant Geosynthetic fabrics. • Wall facing elements such as sheeting timber, timber or concrete panels, vegetation facing. • Cobble materials for filling of tyres once topside wall is cut and removed.	Funds will be required to contract the following services (at a minimum)*. • Labour – project dependent • Utilities • Consumables – ELT, fittings, fastenings are project dependent. • Administration – visual monitoring of exposed ELT	Funds will be required to undertake the following activities (at a minimum)*. • Monitoring of wall • Repair to any exposed tyres • Subsidence repairs

** Costs cannot be accurately provided as this will be dependent upon supply of materials, height and length of wall, and numerous other specific factors associated with the planned construction.*

Using ELT to Construct Floating Marine Infrastructure

ELTs filled with foam can be used to float marine devices such as marinas and docks. Tyre floats cost is cheaper than alternative foam filled plastic In the United States, uses 30,000 to 50,000 tyres are used as breakwaters and flotation devices in a year.

Process Overview

Several ELTs are fastened together using plywood, plastic or other material which are fitted over the sidewall openings on either side of scrap tyre. Expandable plastic foam material such as urethane, polystyrene or other is injected and expands to fill the tyre cavity. Bolts or other fasteners are used to to secure several of these to provide a floating platform.

CASE STUDY

A unique 40 metre floating jetty constructed for the Gove Boat Club in the Northern Territory, Australia from tyres filled with polyurethane. Recycled plastic Enduroplank™ was chosen as the ideal material to use for the decking as it needs no painting or maintenance and is flexible enough to transition with the tide. The floating jetty also acts as a breakwater against waste and wind making boarding boat easier and safer.

Source: https://www.exploroz.com/places/113751/nt+gove-boat-club

Environmental Considerations

- Weathering of ELT and binding materials from constant water actions may result in structural damage with components polluting the marine environment.
- Constant wave actions will result in the release of chemicals from ELT, including plastic foams and sealants. Weathered ELTs will, overtime, release chemicals into the marine environment.
- It is recommended that an environmental impact assessment be conducted before widescale use.

Financial Considerations

When planning to construct floating marine infrastructure, funds will need to be available for capital purchase, labour, and maintenance. **Table 4** provides details of the likely minimum items to include in the budget.

Table 4: Budget Item Details

Capital Cost	Operating Costs	Maintenance Costs
Funds will be required to purchase the following materials (at a minimum)*. • Volume of ELTs required. • Plastic Foam • Planks • Sealant	Funds will be required to contract the following services (at a minimum)*. • Labour – project dependent • Utilities • Consumables – ELT, fittings, fastenings, sealants are project dependent. • Administration – visual monitoring of ELT.	Funds will be required to undertake the following activities (at a minimum)*. • Any ongoing maintenance costs will include monitoring and repair of degraded structure overtime, and/or checking for subsidence. • Recovery and disposal of ELT from damaged floating device.

** Costs cannot be accurately provided as this will be dependent upon supply of materials, height and length of wall, and numerous other specific factors associated with the planned construction.*

Using ELT to Construct Playground Equipment

There are numerous ideas on using ELT as playground equipment. Tyres makes interesting dividers, fences, and enclosures in the outdoor play areas.




Process Overview

Tyres are used to create big and small climbing, balance, and coordination challenges for children. Children will go through tyres, on top of or just for balance.

Capacity (minimum and maximum throughput)

Dependent on Area size and design of playground.

Environmental Considerations

- Careful inspection of ELT is required prior to use in playgrounds to ensure there are no steel wires sticking out. Worn out rubber and exposed wires can pose a serious hazard to children
- Tyres without proper drainage tend to collect water which can be a breeding ground for mosquitos. In areas of malaria prevalence, this can be a be a dangerous problem.
- Repurposing of ELT in playground will still require a final disposal management approach once tyres are no longer suitable for use in the playground.
- Weathering of tyres may result in the release of zinc into the environment.

Financial Considerations

When planning to construct playground equipment, funds will need to be available for capital purchase, labour, and maintenance. **Table 5** provides details of the minimum items that are likely to attract charges.

Table 5: Financial Costs when using ELT to construct Playground Equipment

Capital Cost	Operating Costs	Maintenance Costs
Funds will be required to purchase the following materials (at a minimum)*. Volume of ELTs required. • **Consumables – ELT, fittings, fastenings, are project dependent.**	Funds will be required to contract the following services (at a minimum)*. • Labour – project dependent • Utilities	Funds will be required to undertake the following activities (at a minimum)*. • Any ongoing maintenance costs will include monitoring and repair of degraded structure overtime, and/or checking for subsidence. Administration – visual monitoring of ELT. • Recovery and disposal of damaged tyres.

Baling End-of-Life Tyres

Whole ELTs can be baled for use in construction projects or exported for further processing if they cannot be repurposed in country.

The baling of tyres compresses the airspace in between the tyres to increase the mass per volume, increasing capacity for tyre transport and storage by approximately 50%. Compacting tyres reduces volume and costs associated with tyre transportation.

This option could be utilised at regional ports prior to. The presence of a baling machine in every PIC port could reduce transportation costs to a centralised shredding and granulation facility, or the planned cement plant in PNG.

Table 5 provides and overview of financial costs when using ELT to construct playground equipment.

Figure 3: Model V85 tyre baler, Smart Waste Australia

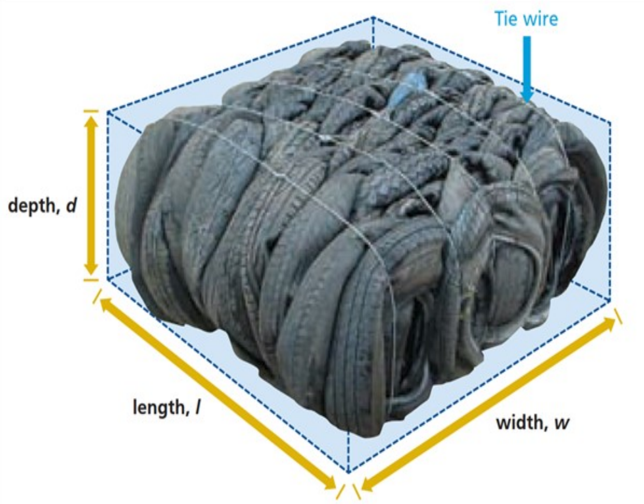


Figure 4: Reference sketch of tyre bale

Table 5: Financial Costs when using ELT to construct Playground Equipment

Process Overview	Final Product Descripton	Capacity (Maximum and Minimum Throughput
Tyres are collected and stacked into a baling machine. This machine compacts the tyres. A high tensile strap is then threaded around the tyres to hold them together.	Compressed whole tyre bales	Capacity varies between machines. Throughput can vary between 9-140 passenger car tyres per bale with approximately 1-6 bales per hour.

Financial Considerations

When planning to bale ELT for further processing overseas, funds will need to be available for capital purchase, labour, and maintenance. **Table 6** provides details of the minimum items that are likely to attract charges.

Table 6: Financial Costs for Baling of ELT

Capital Cost	Operating Cost	Maintenance Cost
Funds will be required to purchase the following materials (at a minimum)*. • A simple tyre baling arrangement starts at~AU$30,000. • The baling of tyres increases the capacity for tyre transport and storage by around 50%. **Site Selection and Land Purchase** • Rural, or industrial land acceptable. • Sufficient buffer to be allowed for stockpile purposes (maximum 2000 tonnes recommended). **Machinery Procurement** • Baler. • Bales can be more than 1 tonne each (depending on number of tyres) therefore further transportation equipment such as a forklift is required to move the bales. **Machinery Installation** • Installation of these machines is typically on a standard reinforced concrete slab. Noise attenuation housings are an optional provision. Utilities requirements vary by size of machine.	Funds will be required to contract the following services (at a minimum)*. • Labour – 1 to 2 operations staff (FTE). • Utilities – Electricity to run Hydraulic power pack. • Consumables – Fuel (generator), hydraulic oil, wear surfaces. • Administration – Minimal reporting required. • By-Products Disposal – Nil.	Funds will be required to undertake the following activities (at a minimum)*. Baling Machine parts replacement due to wear and tear over time.

Environmental and Health Impacts of Technology/Process

Some residual water in tyres may still provide opportunity for insect breeding, where bales are left in the open for extended periods.

Shipping Requirements

While ELT can be shipped easily in containers, the following considerations should be explored when exporting ELTs:

- Biosecurity legislation or policies of the importing countries
- The maximum stock levels at wharf storage space
- Ensuring that baled tyres are stored securely to prevent breeding of pesticides.
- Implementing appropriate fire safety measures.

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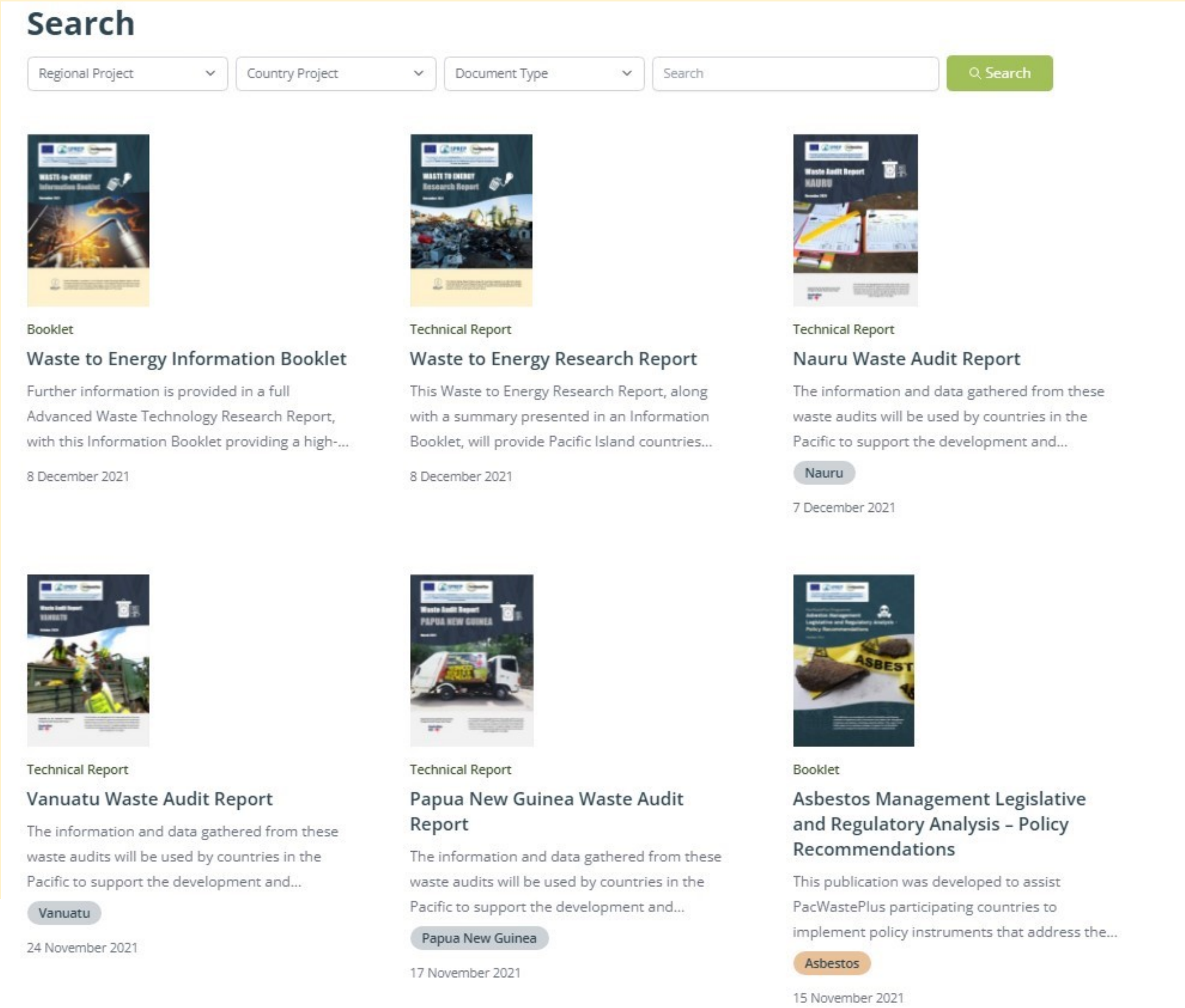

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