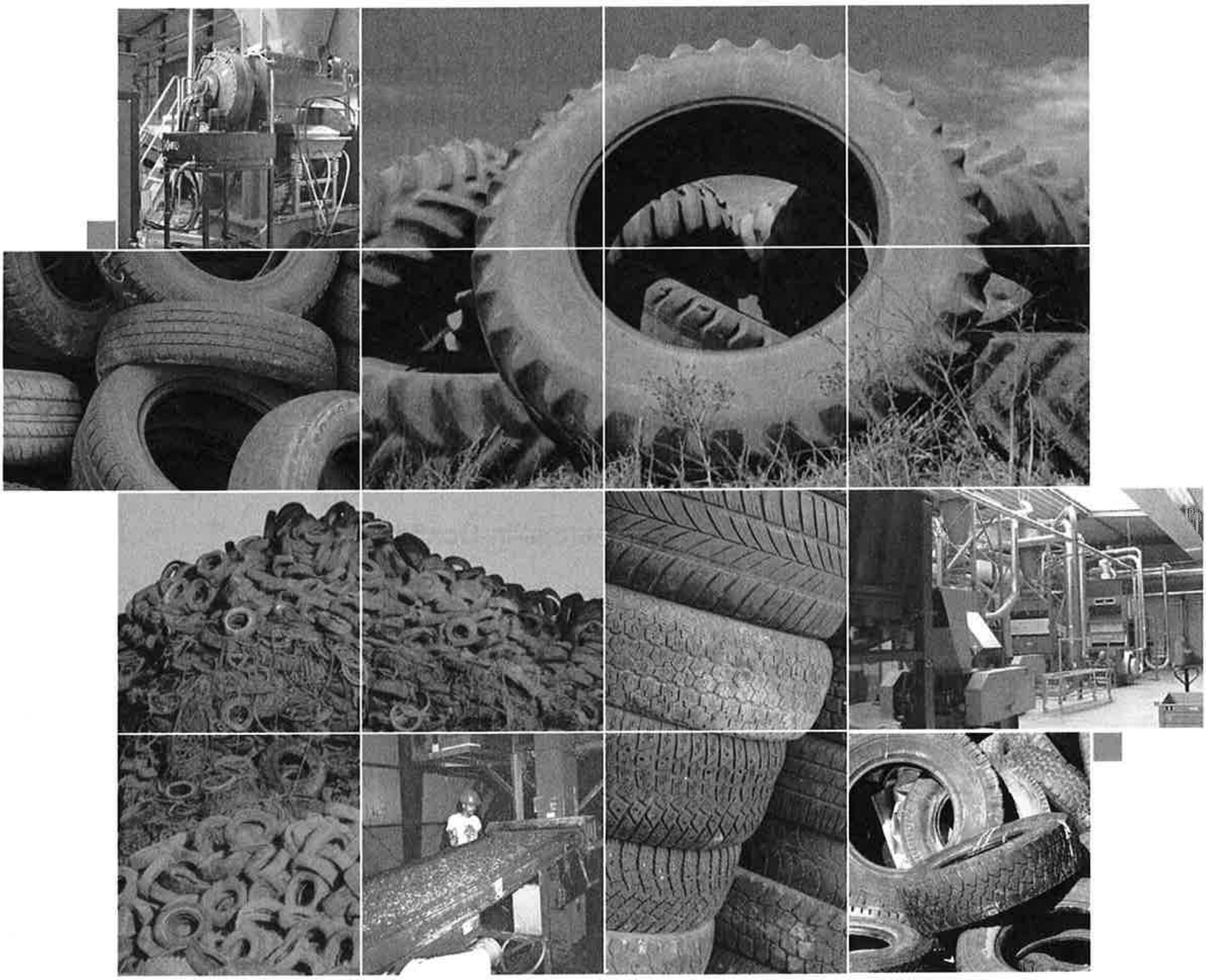
FINAL REPORT

Financial and Economic Analysis of the Proposed Used Tyre Product Stewardship Scheme



~~COMMERCIAL-IN-CONFIDENCE~~

Prepared for ATMA / ATIG

December 2005

URS

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43167265

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Acronyms

ABS	Australian Bureau of Statistics
APEC	Asia-Pacific Economic Cooperation
ARF	Alternative Fuels and Raw Materials
ARF	Advanced Recycling Fee
ATDRA	Australian Tyre Dealers and Retreaders Association
ATIG	Australian Tyre Importers Group
ATMA	Australian Tyre Manufacturers Association
BCA	Benefit Cost Analysis
CATRA	Canadian Association of Tire Recycling Agencies
CIF	Cement Industry Federation
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department of Environment and Heritage
EB	Enhancement Benefit
EPA	Environmental Protection Agency
EPHC	Environment Protection and Heritage Council
EPR	Extended Producer Responsibility
EPU	Equivalent Passenger Unit
ETRA	European Tyre Recycling Association
GNP	Gross National Product
HNRV	Highest Net Resource Value
IWRP	Industry Waste Reduction Plan
JWGT	Joint Working Group on Tyres
NTDA	National Tyre Distributors Association (UK)
OEM	Original Equipment Manufacturer

OTR	Off The Road
PED	Price Elasticity of Demand
PMB	Polymer Modified Binder
PRO	Producer Responsibility Organisation
PVC	Polyvinyl Chloride
R&D	Research and Development
RIS	Regulatory Impact Statement
SBR	Styrene-Butadiene co-polymer
SMA	Sydney Metropolitan Area
SPT	South Pacific Tyres
TC	Transformation Category
TDF	Tyre Derived Fuel
TDP	Tyre Derived Product
URS	URS Australia Pty Ltd

Definitions

AFR	Means alternative fuels and raw materials that can be used as a source of fuel in energy generation (waste products such as end-of-life tyres, demolition timbers, waste oil, carbon anode dust, aluminium spent cell liners, solvent based fuels can be used as AFR in cement kilns) (Geocycle – Environmental Solutions for Industry 2001, p.3).
ARF	The Advanced Recycling Fee under the proposed National Used Tyres Product Stewardship Scheme, which is the fee that is proposed to be charged to the originators of new tyres entering the Australian market (importers and manufacturers of loose and fitted tyres).
Buffings	Rubber removed from tyre cases (both from the tread only and tread and tyre shoulder) to prepare them for retreading or during finishing of the tyres after the retreads are applied (Atech Group 2001, Pt.1, p.65).
Casing	A whole used tyre (NSW EPA 1998, p.4).
Collector	See 'Transporter'.
Ambient grinding	Refers to the mechanical grinding process that operates at room temperature and literally tears the tyre material apart; is a method of end-of-life tyre transformation into TDPs.
Cryogenic processing	Is the freezing process where used tyres are frozen at very low temperatures by liquid nitrogen, and then shattered similar to breaking glass; is a method of end-of-life tyre transformation into TDPs.
Disposal	The permanent disposal of end-of-life tyres. Disposal options for end-of-life tyres include a sanitary landfill (that receives other solid waste) and a tyre monofil (MWH New Zealand Ltd 2004, p.19).
Deemed Market Value of TDP	The market values of TDPs are to be determined by the PRO at the beginning of the Scheme; to be referred to as deemed market values. It is suggested that benefits are paid to transformers based on the TDP deemed market values. If the market value of a TDP changes over the Scheme operating period, the deemed market value can still be used to determine benefit payments.
End use market	Refers to the end markets that use Tyre Derived Products as inputs; the market that end market producers operate in (See 'End market producer').
End market producer	Means a producer of products that use Tyre Derived Products as inputs; essentially the demanders and users of Tyre Derived Products, e.g. flooring specialists, road surfacing companies, and retaining wall producers.
End-of-life Tyre	A used tyre that cannot or is not reused for its originally intended purpose and is not retreaded. Such tyres may have a further use as a raw material for other processes or

	be destined for final disposal. [Note: End-of-life tyres are called "scrap tires" in the United States.] (MWH New Zealand Ltd 2004, p.4).
EPU	An equivalent passenger unit, the weight of tyre equal to an average passenger tyre, 9.5kg (NSW EPA 1998, p.4).
HNRV	Defined as the net present value of a Tyre Derived Product, involving the calculation of all costs, expenditures, and the net benefits of a resource to determine the value of resource value recovered.
Motor vehicle	Means any motor car, motor carriage, motor cycle or other vehicle propelled upon any public street wholly or partly by any volatile spirit, steam, gas, oil, or electricity, or by any means other than human or animal power, and includes a trailer, but does not mean or include any vehicle used on a railway or tram way (other than a light rail vehicle).] [Note: This includes any sedan, utility van, panel van, van, truck, articulated vehicle, trailer, caravan, bus, agricultural vehicle, agricultural trailer or mining vehicle and includes such vehicles when not used on public streets.] (NSW EPA 1998, p.4).
Processor	Any person who is not a retreader or a recycler, who processes used, rejected or unwanted tyres. [Note: This includes any person who shreds, cuts or de-walls tyres for disposal.] (NSW EPA 1998, p.4).
Producer	Refers to the originators of new tyres, essentially the manufacturers and importers of new tyres (loose and fitted tyres) that begin the flow of tyres into a market.
Product stewardship	"Product Stewardship is an approach that recognises that manufacturers, importers, governments and consumers have a shared responsibility for the environmental impacts of a product throughout its full life cycle" (EPHC) 2004a, p.2).
Recycler	See 'Transformer'.
Retreader	Any person who processes used, rejected or unwanted tyres for sale as a motor vehicle tyre (NSW EPA 1998, p.4).
Shredding	Shredding of tyres involves cutting and tearing the waste tyre mechanically with shredders using a series of various sized rotating knives (Monitor Tire Disposal Transformation 2005, p.1).
Transformer	Any person who processes used, rejected or unwanted tyres into a saleable product that is not a motor vehicle tyre (NSW EPA 1998, p.4).
Transporter	Any person who transports used, rejected or unwanted motor vehicle tyres in any part of Australia (NSW EPA 1998, p.4).
Dealer	A person or company that sells tyres to consumers for use on motor vehicles.

TDF	Refers to the use of tyres as a fuel substitute for fossil fuels within purpose built furnaces for cement kilns, power stations, smelters or paper mills (ARRB Transport Research 2004, p.40).
TDP	Refers to the point at which tyre waste becomes a 'product'. Means a saleable product manufactured directly from used, rejected or unwanted tyres that is used as a raw material for another manufacturing process. According to the Tyres Roundtable, an end-of-life tyre must undergo "substantial transformation" before it is classified a TDP. [Note: This refers to whole tyres, cut tyres, chip, granulate, buffing, crumb, steel and textile that are used for energy recovery (See 'TDF'), material recovery and civil engineering end use markets.]
Tyre category	Means the six common categories of tyres including Off The Road (OTR) tyres, truck and bus tyres, light and medium commercial tyres, specialty tyres, passenger tyres and motor cycle tyres.
Tyre monofil	A sanitary landfill, or portion of a landfill, that receives only end-of-life tyres. The landfill has an appropriate liner, cover, leachate collection system and monitoring system (MWH New Zealand Ltd 2004, p.19).
UEPU	A used tyre based on an equivalent passenger unit, the weight of used tyre equal to an average used passenger tyre, 8kg. Equivalent to a passenger tyre casing (See 'Casing').
Used tyre	A used, rejected or unwanted motor vehicle tyre, that can be reused for its originally intended purpose, retreaded, transformed, recycled, or that may be destined for final disposal. [Note: Used tyres are divided into two sub-categories depending on their appropriateness for reuse or recycling: (1) Waste tyres or (2) End-of-life tyres] (MWH New Zealand Ltd 2004, p.4).
Used tyre operator	Means any person, who buys, sells, exchanges, stores, transports, imports, exports, reuses, retreads, recycles, processes, bales, consigns for transport, accepts, disposes of to landfill, or otherwise disposes of used, rejected or unwanted tyres (NSW EPA 1998, p.4).
Used tyre transaction	Means the buying, selling, exchanging, storing, transporting, importing, exporting, reusing, retreading, recycling, processing, baling, consigning for transport, accepting, disposing of to landfill, or otherwise disposing of used, rejected or unwanted motor vehicle tyres in Australia (NSW EPA 1998, p.4).
Waste tyre	A used, rejected or unwanted motor vehicle tyre that can not be reused, retreaded, recycled or transformed. It is destined for final disposal.

Executive Summary

Background

In 2004/05 240,000 tonnes of used tyres or 29.7 million used EPU casings (UEPU)[1] became end-of-life tyres and entered the waste stream in Australia. More than 75 percent of these tyres were disposed of, with the majority going to landfills.

URS Australia Pty Ltd (URS) was engaged by the Australian Tyre Manufacturers Association (ATMA) and Australian Tyre Importers Group (ATIG) to conduct a financial and economic analysis to determine the feasibility and practicality of a proposed National Used Tyre Product Stewardship Scheme (the Scheme) that aims to overcome this waste tyre problem. The Scheme was initiated by ATMA and ATIG, the representative groups for new tyre producers (of both domestic and imported tyres), and supported by the Federal Government and the broader tyres industry through the Department of Environment and Heritage (DEH) and the Tyres Stakeholder Roundtable.

The Scheme is proposed to establish tyre product stewardship through an extended producer responsibility (EPR) framework, with the aim to address the current market failure where the majority of end-of-life tyres are disposed to landfill and discarded illegally, or used for applications that may not represent their highest net resource value. It is proposed that the Scheme be national, industry-led and co-regulatory, and involve an Advanced Recycling Fee (ARF) to fund a benefit system. New tyre manufacturers and importers of loose and fitted tyres (referred to collectively as 'producers') will be responsible for payment of the ARF, the collection and allocation of which will be managed by a Producer Responsibility Organisation (PRO). The funds collected are to be used to fund a range of market development and waste management strategies, including the payment of benefits to transformers producing Tyre Derived Products (TDPs), and the payment of transport rebates for regional and rural tyre collection. A primary objective of the Scheme will be to recover the Highest Net Resource Value (HNRV) from end-of-life tyres, defined as the net present value of a TDP, which involves the calculation of all costs, expenditures, and the net benefits of a resource to determine the resource value recovered.

Methodology

A range of data was collected and has been analysed and augmented by URS for use in financial and economic modelling. Data collection, via previous studies and stakeholder consultation, covered a range of information including volume, financial, demand, growth and international data relating to tyres. Research was structured to encompass four key areas relevant to the Project:

- Supply side information;
- Demand side information (including an assessment of barriers to industry development);
- Processing and logistics; and

1 Based on 1 used EPU = 8 kg with use losses

- Scheme costs.

The financial and economic modelling was based on principles of benefit cost analysis (BCA), and used a discounted cashflow model that was linked with a model to describe biophysical flows. The financial analysis was used to determine the financial viability and feasibility of the Scheme, and the economic (benefit cost) analysis was used as a systematic means of analysing all of the financial, economic, environmental and social costs and benefits associated with the Scheme.

The combined financial and economic model has been used to determine Net Present Value (NPV) of the Scheme, and sensitivity and scenario analyses have been undertaken to examine demand-side issues such as current and potential size of end use markets, and to assess supply-side factors such as market growth potential, cost of logistics and processing, and industry leakages (to landfill and illegal dumping).

The modelling has been based upon an interlinked set of modules, which comprise the following:

- Tyre flows;
- Tyre location;
- Collection, transport, storage, transformation and disposal costs;
- End-of life tyre and transformed product composition;
- Value of transformation categories;
- Tyre derived product demand estimates; and
- Social and environmental values.

The base analysis completed in the study has included the following assumptions and model settings:

- Free rider rate of 5% is assumed i.e. the ARF is not collected from 5% of EPUs;
- ARF to be collected for a length of eight years over the ten year Scheme;
- ARF to be charged for three months prior to Scheme funding and benefit payments beginning, to enable amount of $6 million to be raised to back the Scheme; and
- Benefit paid based on 20% of the deemed market value of a TDP (determined by the PRO at the beginning of the Scheme and reviewed throughout Scheme operations, based on the market value that end market users pay for TDP, or the value of a TDP as a substitute for an equivalent input);
- Metal recovery benefit paid based on 15% of the deemed market value of each tonne metal recovered;
- Textile recovery benefit based on 15% of the deemed market value of each tonne of textile recovered;

- Benefit payments are made on total value of TDP sold on to end use market following onset of Scheme, not based on the difference between current levels and potential future levels (this option chosen due to ease of management and monitoring);
- Rural and regional collection and transport cost rebate to start in the second year of the Scheme and to run for five years; and
- Rural and regional collection and transport cost rebate is paid to bring costs down to a metro equivalent.

Results

On the basis of the above assumptions the base analysis was found to produce the following results:

- If the Scheme operates with an ARF of $0.85 per EPU applied across all tyre categories, and a 20% benefit rate on the PRO-deemed market value of transformed TDPs, then the BCA suggests a positive net present value for the Scheme of $7 million, indicating that the Scheme is financially feasible;
- With the Scheme target recovery of 90% of end-of-life tyres, in year ten of the Scheme, the number of tyres going to landfill is reduced to 7.7%. Likewise the level of illegal dumping is projected to decrease from 11% to 2.5% over the ten year period of the Scheme;
- The 20% benefit paid on the deemed market value of a TDP links directly to the objective of deriving the HNRV from used tyres. This benefit payment is directed at creating a demand for higher value products, with an anticipated outcome of the Scheme that used tyre resources will be viewed as having a positive value (as opposed to the current negative value as a waste) so that in the long-term benefit payments will no longer be required;
- By creating demand for end uses the proposed Scheme will work to 'pull' resources through the supply chain. Flow-on benefits should be created from end market users to transformers to collectors. The current system, where fees are collected by retailers from consumers to dispose tyres, tends to push used tyres towards the cheapest form of disposal;
- Sensitivity on altering the level of benefit paid to transformers showed that if benefit was paid on a higher proportion of TDP end market values, then a higher ARF is required, e.g. if the benefit was increased to 27.5% of the TDP deemed market value, then the ARF would need to be $1.00 per EPU (likewise decrease to 12.5% of TDP deemed market value would need an ARF of $0.70 per EPU);
- Analysis on ARF levels required to achieve lower used tyre recovery, showed that recovery of 70% of used tyres corresponds with a $0.60 ARF if a 14% benefit proportion was paid, and recovery of 80% of used tyres requires an ARF of $0.75 per EPU assuming benefit payment of 18.5% of TDP deemed value. With 90% recovery and an increased benefit payment to 22%, an ARF of $0.90 would be needed;

- Sensitivity on paying benefits based on both existing market growth and growth in terms of additional markets created (as in the base case), compared with only paying benefits for TDPs created in new markets, showed that close to $44 million could be saved or the ARF lowered to $0.61 if only new markets were paid incentives;
- Assessment on excluding rurally sourced tyres from the Scheme showed that $38 million is saved in Scheme operating costs, however the funds available for resource recovery benefits is reduced to $11 million, and additionally the 90% target recovery rate will not be reached after ten years if rural tyres are excluded for the entire length of the Scheme;
- Sensitivity on the exclusion of Off The Road (OTR) tyres from the Scheme shows that the value of resource recovery would be reduced by $23 million, a net social loss of $16 million would result, the ARF level would need to be increased to $0.91 per EPU, and the 90% used tyre recovery target could not be achieved in year ten;
- Analysis on freerider effects on ARF level showed that 50% freerider level would require ARF to be increased to $1.60;
- Sensitivity on freerider effect and Price Elasticity of Demand (PED) revealed that at 50% freerider level, producers of medium priced passenger tyres participating in the Scheme would see a 1.6% increase in the price of their tyres, resulting in a reduction in total market share of 1.8% or approximately $56.5 million.

Summary

The outcome following ten years of the Scheme should be industries operating with security of TDP supply and surety of the quality of the product they purchase. Networks should be well developed, investments made in new processing equipment, and efficiencies should be created for achievement of improved economies of scale.

An important role of the operation and monitoring of the Scheme by the PRO will be an ongoing assessment of the number and value of tyres sourced from all areas of the market. Improved market intelligence will be necessary basis for any revisions of incentive that may need to be undertaken during Scheme operation to maximise sustainable use for used tyre resources from all areas.

1.1 Client and Stakeholders of the Project

URS Australia Pty Ltd (URS) has been engaged by the Australian Tyre Manufacturers Association (ATMA)[2] and Australian Tyre Importers Group (ATIG)[3] to conduct a financial and economic analysis determining the feasibility and practicality of the proposed National Used Tyre Product Stewardship Scheme (the Scheme), and to suggest alternatives and options as required to ensure achievement of the Scheme's objectives. The Scheme has been initiated by ATMA and ATIG (the 'Client'), the original tyre manufacturers (of both local and imported tyres), and supported by the Federal Government through the Department of Environment and Heritage (DEH) that represents combined federal and state government interests and that will ultimately be called on to sanction a final scheme. There are a number of industry and government stakeholders represented on the Tyres Stakeholder Roundtable, which is the main vehicle for collaboration between the stakeholders in scoping and developing a possible national scheme (see Appendix A for a list of Roundtable representatives).

1.2 Project Background

The purpose of the Scheme is to establish product stewardship through an extended producer responsibility (EPR) framework. The Scheme aims to systematically address the current situation in Australia where the majority of end-of-life tyres are disposed to landfill, discarded illegally, or used for applications that may not in all instances represent their potential value. This is despite end-of-life tyres being a significant resource for a number of products and markets. According to an industry discussion paper published by the Environment Protection and Heritage Council (EPHC) (2004a, p.2):

> Product Stewardship is an approach that recognises that manufacturers, importers, governments and consumers have a shared responsibility for the environmental impacts of a product throughout its full life cycle [and] Product Stewardship schemes establish a means for relevant parties in the product chain to share responsibility for the products they produce, handle, purchase, use and discard.

To initiate this Scheme the Client Brief[4] (2004) for the Financial and Economic Analysis identifies a national, industry-led and co-regulatory scheme involving an Advanced Recycling Fee (ARF) and benefit system to address the prevailing market failure. This report aims to present the economic and financial appraisal of the proposed Scheme, to confirm and verify its efficiency and cost effectiveness to achieve the agreed objectives, and to suggest amendments, improvements and recommendations for further actions.

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2 ATMA Members: Bridgestone Australia Ltd and South Pacific Tyres (Client Brief 2004, p.14).

3 ATIG Members: Bear Cat Tyres, Bridgestone Earthmover, Hankook Tyres, Haulmark Tyres, Kumho, LD Wholesale Tyres, Michelin Australia Pty Ltd, Pirelli Australia, Toyo Tyre and Rubber Australia Ltd, Transport Tyre Sales, Tyres 4U, and Yokohama Tyre Australia Pty Ltd (Client Brief 2004, p.14).

4 The Client Brief was devised by ATMA, ATIG and the Tyres Roundtable to reflect the desired outcomes of industry stakeholders from the proposed Scheme.

Stakeholder Roundtable Agreed Scheme Principles

1. To establish a scheme that will address the end-of-life used tyre issue in Australia for the optimal economic, social and environmental outcome;
2. To develop a scheme, which is in effect a direct or proactive market intervention, such that it has clearly defined objectives, scopes and timelines;
3. To develop a scheme that will aim to recover the optimum resource value from end-of-life used tyres in Australia; and
4. To develop a scheme that manages inclusively, transparently and accountably.

Source: Client Brief 2004, p.9

1.3 Requirements

Based on requirements specified in the Client Brief, this report will include economic and financial models of the existing situation for the tyre industry in general and the end-of-life used tyre sector in particular, with the sustainable, optimum resource value recovery scenario as the eventual goal.

The report will compare the feasibility of the proposed Scheme versus a 'do nothing' or 'without Scheme' approach. The brief does not require this report to investigate alternatives to the proposed co-regulatory scheme (as would be required in a Regulatory Impact Statement (RIS)), such as 'voluntary' or 'full-regulatory' options.

1.3.1 Highest Net Resource Value

The Agreed Scheme Principles identify the aim of the proposed Scheme to "develop a scheme that will aim to recover the optimum resource value from end-of-life used tyres in Australia" (Client Brief 2004, p.9). Highest Net Resource Value (HNRV) is one of the underlying concepts for this analysis, as it focusses on the aim to prevent resources being directed to markets or uses with negative values. HNRV can be defined as the net present value of a Tyre Derived Product (TDP), involving the calculation of all costs, expenditures, and the net benefits of a resource to determine the value of resource value recovered. As such this study aims to analyse the TDPs that realise the highest net value of used tyre resources.

HNRV is not the only basis for analysis of a scheme such as this. Other areas of assessment include a scheme's effects on employment, the environment or landfill.

1.3.2 Transformation Categories

A further important concept of the Scheme that is referred to throughout the report, is a set of Transformation Categories (TCs) that have been identified as different specifications of TDPs from end-of-life tyre recycling and resource recovery. The concept of TCs has been developed by the Stakeholder Roundtable for the purpose of identifying the levels of tyre recovery.

TCs are useful criteria for assessing the Scheme and its effectiveness, as it divides each product derived from tyres, into varying size levels and cost/value structures, enabling comparative analysis. In this report, TCs are split into Transformation Categories ranging from TC1 to TC5, generally representing decreasing sizes of particles, which in most cases coincides with increased production costs and often also increased market value[5]. A complete description of the different TCs is in Section 4.3 of the report below.

1.4 Previous Studies and Work on this Issue

Over the past five years, a number of developments have occurred in Australia regarding the topic of end-of-life tyres. This has included discussions, reviews and studies amongst industry and government stakeholders to identify issues and solutions to the waste tyre problem, and a number of the resulting reports have been used as data sources in this study.

In December 2000 a workshop of industry and government stakeholders took place to discuss the issues surrounding end-of-life tyres. The key outcome was agreement that a national approach to the management of end-of-life tyres is required (Client Brief 2004, p.3).

Following this workshop, Environment Australia funded a consultancy project in 2000/2001, *A National Approach to Waste Tyres*, which investigated and analysed the scope of the waste tyre problem and assessed policy options. In 2001 DEH commissioned a discussion paper, *A National Approach to Waste Tyres: Analysis of Policy Options*, which developed three product stewardship options for tyres as possible national approaches to the issue (Client Brief 2004, p.3).

In August 2002 after the release of this DEH paper, the specifically established Joint Working Group on Tyres (JWGT), comprising ATMA, ATIG, Cleanaway and Renewed Rubber, approached DEH with a proposal to develop a voluntary industry EPR scheme for end-of-life used tyres. In October 2002, Australia's Environment Ministers, meeting as the EPHC, considered this proposal and subsequently agreed that national action was required on end-of-life tyres, releasing the discussion paper *A National Approach to Waste Tyres: Policy Discussion Paper* (Client Brief 2004, p.3).

From this time DEH has been facilitating the development a national solution to the problem of used tyres through a series of Used Tyre Roundtable meetings that began in October 2003. As an initial reference DEH commissioned the consultancy project *Economics of Tyre Recycling* to analyse the economics of the existing used tyre sector and some aspects of the proposed scheme.

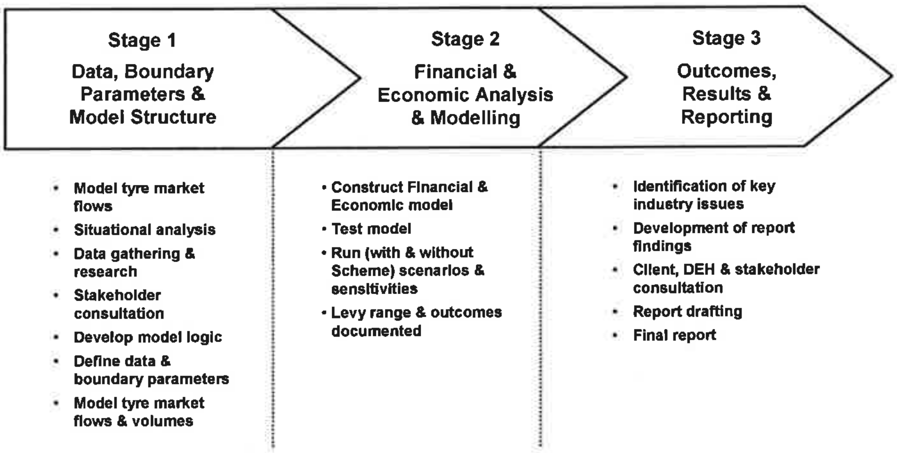
In 2005 ATMA and ATIG contracted URS to conduct this consultancy project *Financial and Economic Analysis of a National Used Tyre Product Stewardship Scheme* in order to investigate the economics of waste tyre recycling, looking in particular at the option to implement a national industry-led scheme involving an ARF to address the waste tyre issues in Australia.

[5] This is not to suggest that in some instances products derived from larger tyre particle sizes do not have values equal to or greater that those of smaller particle sizes.

1.5 Approach and Methodology

This study has been undertaken in three stages as outlined in Figure 1.1 below, flowing through from situation analysis and data gathering in Stage 1, to model development and running in Stage 2, then collation of findings and final reporting in Stage 3.

Figure 1.1 – Project Methodology Overview



1.5.1 Data Collection and Limitations

A range of data has been collected from a number of sources over the timeframe of the Project, and has been analysed and augmented by URS for use in financial and economic modelling. Initial data compilation and information reviewing was from earlier reference reports and studies, beginning with those reports mentioned in Section 1.4 and including both Australian and international studies on used tyres, product stewardship, and recycling, listed in detail in Section 13 – References. Interviews and communications with industry stakeholders and participants as detailed in Appendix B – Stakeholder Communications, provided an important aspect of data collection particularly for industry and tyre-specific information not previously reported or published. This consultation process is discussed in Section 1.5.2.

Data collection covered a range of information including involved volume, financial, demand, growth, and international data relating to tyres. Research was structured to encompass four key areas relevant to the Project:

- Supply side information;
- Demand side information;
- Processing and logistics; and
- Scheme costs.

There are limitations associated with the availability of data which have been encountered in the study as a result of commercial confidentiality over some information, as well as a result of a lack of nationally collated data specific to used tyres, such as by the Australian Bureau of Statistics (ABS). In addition, the use of Australian Harmonised Export Commodity Classifications (ABS 2003) and Asia-Pacific Economic Cooperation (APEC) Tariff Codes (APEC 2005) are broad classifications that were found to make the accurate review of this data difficult, and which will be an issue to be faced by any data monitoring scheme going forward. These APEC classifications are listed in Appendix G.

1.5.2 Consultation Process

Throughout the three stages of the Project, stakeholder communications have played an important role in the data gathering and industry consultation processes. Discussions were carried out with a comprehensive range of industry representatives to gather data and to ensure all stakeholders were informed of Project progress. At the onset of the Project, the Client provided a list of industry contacts, and throughout the Project new contacts have been added and included as URS became aware of the wider range of market players.

Consultation was undertaken through written surveys, telephone interviews, meetings and site visits where possible. A complete list of representatives and stakeholders that were consulted with is provided in Appendix B – Stakeholder Communications. The stakeholders involved in consultation were from all stages of the tyre life cycle, including new tyre manufacturers and importers, as well as used tyre collectors and transporters, TC transformers, end market producers and retreaders. In many instances non disclosure agreements were entered into with specific participants to ensure confidentiality of data provided. A number of the stakeholders contacted for data and input were members of the Tyres Roundtable, and URS attended a Tyres Roundtable meeting in July 2005 in order to receive information and to become aware of the industry position on the proposed Scheme. As DEH attended all Client/URS meetings following onset of the project, they acted as a body to both pass on information and request to commentary from the Roundtable on a range of Project issues.

The consultation and associated data gathering process for this report was challenging for a number of reasons. New participants wishing to enter the industry were willing to share information on processes and potential markets. Many, but not all existing participants in the industry were unwilling to provide detailed market information due to a number of factors, with commercial confidentiality the most commonly sighted reason.

1.5.3 Economic and Financial Modelling

Data collected throughout Stage 1 was analysed and used as key inputs into a basic financial and economic flow model that provided the design basis for the development of the detailed financial and economic model. The purpose of the economic and financial model is to analyse and assess how the Scheme can operate to provide efficient and effective incentives to develop industries that beneficially use end-of-life tyres to recover the HNRV of the tyre resources so that disposal no longer reflects a major loss of resource value. The analysis aims to assess both the current situation, as well as future projections of tyre use and recycling, analysing outcomes both 'with' and 'without' implementation of the proposed Scheme.

The fundamental approach to this modelling is based on principles of benefit cost analysis (BCA), and using a discounted cashflow model that is linked with the model to describe biophysical flows. These modelling approaches are outlined below:

- **Financial analysis** – is used to determine the financial viability and feasibility of the Scheme, utilising cashflow modelling to assist in assessing the viability and undertake sensitivity analysis of key variables and risk areas.
- **Economic (benefit cost) analysis** – is a systematic means of analysing all of the financial, economic, environmental and social costs and benefits associated with the Scheme. In this way, BCA provides a decision-making framework that considers the net impacts on all stakeholders, both positive and negative.

The combined financial and economic model has been used to determine Net Present Value (NPV) of the proposed Scheme, and sensitivity and scenario analyses have been undertaken to examine demand-side issues such as current and potential size of different end use markets and to assess supply-side factors such as growth potential, cost of logistics and processing, and industry leakages (to landfill and illegal dumping).

1.6 Structure of this Report

The report is structured according to the following sectional divisions:

- Section 2 – Background;
- Section 3 – Current and Projected Tyre Flows;
- Section 4 – Current Tyre Collection, Disposal and Transformation;
- Section 5 – Current and Potential Uses of End-of-Life Tyres in Australia;
- Section 6 – Economic and Financial Model;
- Section 7 – Economic and Financial Analysis;
- Section 8 – Implications for Design, Operation and Cost of Stewardship Scheme;
- Section 9 – Summary of Key Findings;
- Section 10 – References; and
- Section 11 – Limitations.

2.1 Tyres in Australia

The tyre industry in Australia is made up of two domestic manufacturers (Bridgestone Australia Ltd and South Pacific Tyres (SPT)) and a range of loose and fitted tyre importers, some of whom are the major brands (Hankook Kumho, Michelin, Pirelli, Toyo and Yokohama) and others specialising in importing a range of brands. These companies supply over 70 brands of tyres into the market serving a variety of sectors and uses from traditional road vehicles, to specialised off-road heavy haulage vehicles, aircraft tyres and niche uses such as non-marking white rubber solid tyres and racing slicks. Within each of these broad areas there is considerable complexity and variety as the tyre industry meets the needs of specific vehicle tyres and users. For example there is a significant variation within passenger tyres including size, aspect ratio, rim diameter, tread width and pattern, composition, construction and tyre performance.

Tyres are not uniform in size, shape, wear characteristics, or in terms of their composition, hence "one tyre" is not generally indicative of the volume or type of tyres that are going to landfill or being recycled. Nevertheless there are common categories of tyre sizes and these are used distinguish tyres throughout this report (see Section 2.1.1).

2.1.1 Tyre Categories

Throughout the study and modelling, six tyre categories are referenced, including Off The Road (OTR) tyres, truck and bus tyres, light and medium commercial tyres, specialty tyres, passenger tyres and motor cycle tyres. A summary of these categories and their Equivalent Passenger Unit (EPU) or Used EPU (UEPU) and weight conversion factors are presented below in Table 2.1.

Table 2.1 – Tyre Categories and Conversion Factors

Tyre Category	New tyres		Used tyres	
	EPU	Weight (kg)	Used EPU	Weight (kg)
Motor cycle tyre	0.5	4.75	0.5	4.00
Passenger tyre	1.0	9.50	1.0	8.00
Specialty tyre	5.0	47.50	5.0	40.00
Light & medium commercials	2.0	19.00	2.0	16.00
Truck & bus tyres	5.0	47.50	5.0	40.00
OTR tyre[6]	100.0	950.00	100.0	800.00

Source: QLD EPA EcoAccess 2004a, p.2 and URS Analysis

6 OTR Tyres vary in size from 24 inch rims to over 57 inches, weighing anywhere from 100 kg to 4 tonnes, with an average weight that is around 100 times the size of a passenger tyre that has been used throughout this report

In general a passenger tyre weighs approximately 9.5kg when new. By the time a tyre has reached its end-of-life it has generally lost between 10% to 20% of its total weight or 30 to 40% of its tread weight (UK Environment Agency 1998, p.15 & 43 and Hird, Griffiths and Smith 2002, p.54). In this report we have assumed that the weight of an average end-of-life EPU is 8.0 kg and looses an average of 1.5 kg of tread weight during use. Therefore an end-of-life/used EPU is 8kg (referred throughout remainder of this report as a Used EPU (UEPU)). Earlier reports have not made this distinction between a new EPU and a used EPU, however as this study examines the opportunities for materials extracted from end-of-life tyres this is an important refinement to make particularly as there is less material in used tyres than from new tyres and in particular the rubber content is reduced.

2.1.2 A Potential Resource – Tyre Composition

The composition of each tyre category impacts on the end-use and the process that is most applicable for recycling, hence the breakdown of compositions is a key input into the economic modelling, as based on data presented below.

In general, manufacturers design and construct tyres to maximise their life in relation to their design parameters. Tyres are not designed for easy disassembly as may be the case for other markets where product stewardship is needed. In addition the design and construction of tyres is dynamic with manufacturers changing the mix of rubber, steel, and textiles to respond to market demands relating to safety, economy, performance, unit costs, material availability and the needs of the automobile industry (CIWMB, 2003, p.12)

In general the raw materials that make up the composition of each tyre category are shown in Tables 2.2 and 2.3 below. The proportions of each material vary depending on the type of tyre, and whether it is new or end-of-life. As the table shows, an end-of-life tyre tends to lose a proportion of rubber, and small amounts of other materials as the tyre wears from use. There are four main groups of materials used for the manufacture of tyres:

- Natural or synthetic rubber;
- Carbon black;
- Steel wire and textile; and
- Various chemicals.

Table 2.2 – Composition and Energy Content of New Tyres

New Tyres	Rubber	Carbon Black	Steel	Textile	Zinc Oxide	Sulphur	Addit-ives	Energy (GJ/tyre)
Motor cycle tyres	45%	22%	15%	10%	2%	1%	5%	0.1
Passenger tyres	45%	20%	18%	6%	1%	1%	9%	0.3
Specialty tyres	45%	22%	25%	0%	2%	1%	5%	1.3
Light & medium commercials	45%	21%	21%	5%	1%	1%	6%	0.5
Truck & bus tyres	43%	21%	27%	0%	2%	1%	6%	1.3
OTR tyres	45%	22%	25%	0%	2%	1%	5%	25.7

Source: Hird et al 2002, p.4; Atech Group 2001, Pt.1, p.28; ETRA and URS Analysis

Table 2.3 – Composition and Energy Content of End-of-life Tyres7

New Tyres	Rubber	Carbon Black	Steel	Textile	Zinc Oxide	Sulphur	Addit-ives	Energy (GJ/tyre)
Motor cycle tyres	42%	21%	18%	12%	2%	1%	5%	0.1
Passenger tyres	42%	19%	21%	7%	1%	1%	8%	0.2
Specialty tyres	42%	21%	30%	0%	2%	1%	5%	1.1
Light & medium commercials	42%	20%	25%	6%	1%	1%	6%	0.5
Truck & bus tyres	40%	20%	32%	0%	2%	1%	6%	1.1
OTR tyres	42%	21%	30%	0%	2%	1%	5%	21.6

Source: Hird et al 2002, p.4; Atech Group 2001, Pt.1, p.28; ETRA and URS Analysis

These tables can be summarised to show the three basic material types: rubber, steel and textiles that are most relevant for TC transformation. Carbon black, zinc oxide, sulphur and additives are combined into the rubber during the manufacturing process and are difficult to separate out except through advanced technologies still under development (see Section 4.4 for further detail).

Table 2.4 – Combined Composition of New Tyres

New Tyres	Rubber (% & kg)		Steel (% & kg)		Textile (% & kg)	
Motor cycle tyres	75%	3.6	15%	0.7	10%	0.5
Passenger tyres	76%	7.2	18%	1.7	6%	0.6
Specialty tyres	75%	35.6	25%	11.9	0%	0.0
Light & medium commercials	74%	14.1	21%	4.0	5%	1.0
Truck & bus tyres	73%	34.7	27%	12.8	0%	0.0
OTR tyres	75%	712.5	25%	234.5	0%	0.0

Source: URS Analysis

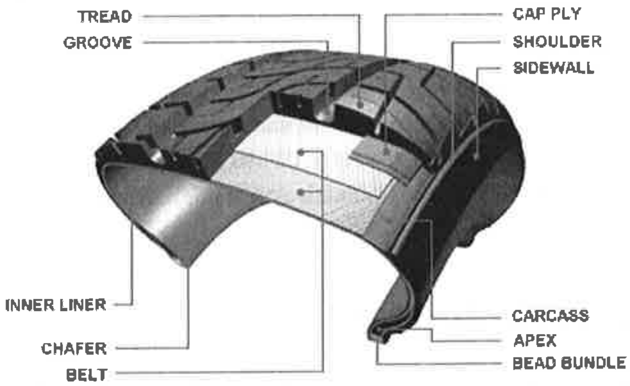
7 As a percentage of the reduced tyre weight (8kg UEPU equivalent)

Table 2.5 – Combined Composition of End-of-life Tyres[8]

New Tyres	Rubber (% & kg)		Steel (% & kg)		Textile (% & kg)	
Motor cycle tyres	70%	2.8	18%	0.7	12%	0.5
Passenger tyres	72%	5.7	21%	1.7	6%	0.6
Specialty tyres	70%	28.1	30%	11.9	0%	0.0
Light & medium commercials	69%	11.1	25%	4.0	5%	1.0
Truck & bus tyres	68%	27.2	32%	12.8	0%	0.0
OTR tyres	70%	562.5	30%	234.5	0%	0.0

Source: URS Analysis

Figure 2.1 – Generic Structure and Composition of a Tyre



Source: Kumho Tyres Website 2005

Rubber used in tyres is either natural or synthetic or a combination of both with a proportion of around 30% natural rubber, with the remainder being synthetic rubber (Atech Group 2001, Pt.1, p.21). Truck, aircraft and OTR tyres uses high proportions of natural rubber. The synthetic rubber used in the production of passenger car tyres is a styrene-butadiene co-polymer (SBR) containing approximately 25% by weight of styrene in combination with SBR. Synthetic rubber generally has its origin in two gases: butadine (a by-product of petroleum refining), and styrene (ACIL Consulting 2000, p.3). Other elastomers such as natural rubber (cis-polyisoprene), synthetic cispolyisoprene, and cispolybutadiene are used in varied amounts. Carbon black is used as a reinforcing agent. Sulphur is used in the vulcanisation process and other additives such as oils, resins, waxes, pigments, various trace metals and halogens are used as age resistors, processing aids, accelerators, vulcanising agents, softeners and fillers (Atech Group 2001, Pt.1, p.21-22).

The following Table 2.6 provides an indication of the distribution of rubber within a tyre. This would also be indicative of a retreaded tyre as retreaded tyres ensure the same standards of use and wear as new tyres.

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8 As note above

Table 2.6 – Rubber Percent by Weight in a New Radial Passenger Tyre (9.5kg)

New Tyre Component	Rubber (% & kg)	
Tread	32.6%	2.35
Base	1.7%	0.12
Sidewall	21.9%	1.58
Bead apex	5.0%	0.36
Bead insulation	1.2%	0.09
Textile insulation	11.8%	0.85
Insulation of steel cord	9.5%	0.69
Innerliner & Undercushion	16.3%	1.18
TOTAL (In whole tyre: Rubber 76%/7.22 kg)	**100.0%**	**7.22**

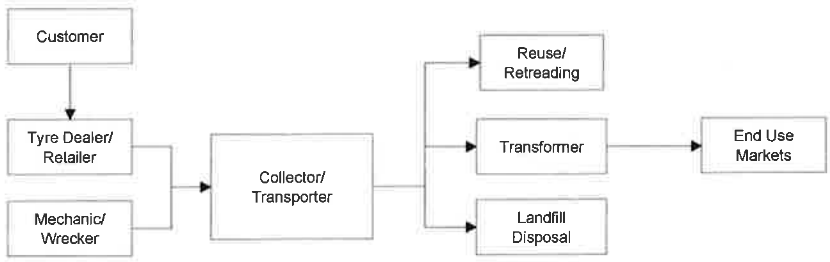
Source: URS Analysis

The metal used in tyres is a high grade steel as bead and belt wire and is coated with bronze (copper and tin) or brass (copper and zinc). Bead wire is generally lower grade carbon steel than belt wire, with a thicker wire gauge. Some tyre manufacturers use the same grade of steel for both as there is a move by manufacturers towards high tensile strength steel (CIWMB 2003, p.73). The textile materials used in tyres vary in their type and include aramid (aromatic polyamide), nylon, rayon and polyester (CIWMB 2003, p.13).

2.2 Tyre Industry in Australia

In terms of end-of-life tyre management, Figure 2.2 below reveals that the industry is currently in a situation (with few exceptions) where the market for end-of-life tyres is being 'pushed' through the waste tyre system from the end of the tyre dealers, wreckers and retreaders. These dealers, wreckers and retreaders are the first players in the waste stream given that they possess waste tyres that they require be removed so pay a fee to transporters who collect and sort used tyres, in a sense 'pushing' their used tyres to collectors and transporters. Transporters in turn pay a fee to transformers to take end-of-life tyres or, in the case of landfilling, pay a disposal fee to a landfill operator. Transformers reprocess the tyres into TDPs that they then supply to end market producers for incorporation into end products for sale to the broader market. The situation of market push presented in the used tyre industry is not untypical of the situation in the waste industry when materials are not valued as having further worth. If end-of-life tyres were at the stage of being considered a valuable resource, then it would be more likely that the market be 'pulled' from the end market producers as they demand inputs into their operations, as such pulling waste tyres through the market for end-use.

Figure 2.2 – Australian Tyre Industry Typical Physical Tyre Flows



Source: URS Analysis

Manufacturers/Importers

As the sectors that originate tyres in the Australian market, manufacturers and importers are the initial producers of tyres so are represented at the start of the industry chain. There are two manufacturers of tyres in Australia: SPT and Bridgestone Australia, operating in Victoria and South Australia respectively. The output of these two domestic new tyre manufacturers is concentrated in passenger tyres and some light truck and bus tyres, with some tyres such as earthmoving tyres not produced at all in Australia. Other types of tyres are imported either loose or fitted to vehicles, by a market dominated by thirteen major importers (Atech Group 2001, Pt.1, p.5).

Dealers/Wreckers

There are over 4,500 tyre dealers and retailers in Australia with some dealers having networks of over 300 stores nationally. The tyre dealers and retailers not only sell new and retreaded tyres into the market, but are also the point in the tyre chain where the majority of passenger vehicle tyres, and many truck tyres, enter the waste stream. It is common for the tyre dealer to arrange for collection of used tyres as they are replaced for new tyres. In the current market setup, the dealers play a key role, as they control arrangements with tyre collectors. Many dealers around Australia charge customers a 'disposal fee' or 'environmental fee' of around $2.50 per UEPU, which in part covers the costs of collection and transportation that they must pay the collector. While the majority of used passenger and truck tyres enter the waste stream through the tyre dealers, mechanics and wreckers also tend to have used tyres that they need to dispose of through collectors.

Collectors/Transporters

The used tyre collection sector has a large influence on the recycling of tyres, as it is connects the transformers with their end-of-life tyre resources. In the tyre collection sector, there currently exist a number of small tyre collectors and transporters, as well as a few large players. Operating in four states, SIMS Tyrecycle is one of the major collectors in Australia. The collection industry has low barriers to entry, with many of the smaller collectors operating on slim margins, indicating that competition is high in this sector. This sector involves not only collection and transportation, but also the sorting of waste tyres to determine which are suitable for (1) export; (2) retreading; (3) recycling; or (4) landfill/disposal. The operation of collectors that are vertically integrated within larger reprocessing and/or landfilling operations has generated some intense competition in the market for end-of-life tyres with downward pressure of prices.

Retreaders

Retreaders receive tyres from collectors, paying a fee per UEPU to the collectors. There exist between 60 and 75 retreading operations in Australia retreading passenger and truck tyres, with some retreading operations located off-shore (Ibis World 2004, p.5 & 10). Retreading activities impact on the waste tyre stream by extending the life of a tyre and reducing the number of new tyres entering the Australian market, and hence the number of tyres entering the waste stream. It has been estimated that a 1% increase in retreading decreases end-of-life tyres for disposal by 1% for passenger tyres and approximately 2% for truck and bus tyres (Atech Group 2001, Pt.1, p.55). This percentage decrease in disposal of truck and bus tyres could be greater as many of these tyres are sold based on their capacity to be regrooved and retreaded two, three or more times (Bandag Website 2005). The market for retreaded passenger tyres is currently declining as a result of competition from cheaper new-tyre imports, tax changes, and the capital cost of setting up moulds in line with vehicle manufacturer specifications. This situation is similar for truck and bus tyre retreading with the impact of cheaper imports. A by-product of the retreading process is buffings, which are commonly purchased by transformers or end market producers as inputs into their operations.

Transformers

Transformers of end-of-life tyres receive a fee from collectors or transporters to take used tyres that in turn meet their reprocessing demands. Transformers process tyres into different end uses such as civil engineering applications, energy recovery, or material recovery when tyres are reprocessing into various grades of TDPs such as chipped, shredded, crumb and granulated tyres. This is a developing industry sector with a few smaller participants and one larger operator. Transformers generally run their own collection operations or have close links with tyre collectors.

In most instances the fees paid by collectors to transformers can be less than the fees the collector would otherwise pay for landfill disposal of tyres. The current structuring of the market makes it necessary for transformers to receive payments for end-of-life tyres to provide an income contribution to support their recycling operations.

Landfillers

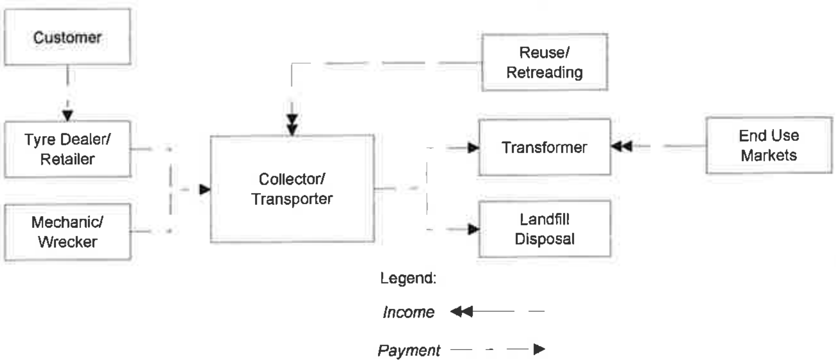
Many landfill operators discourage the general landfilling of tyres for a number of reasons, firstly due to increased licence conditions and secondly due to operational difficulties of landfilling tyres. The most efficient landfill operations are based on the compaction of waste to maximise density, requiring that landfilled tyres are chopped or shredded prior to disposal. Tyres, even in their chopped or shredded form are difficult to compact due to the inherent resilience of the material and their shape. There are many examples of whole tyres 'floating' to the surface of a landfill after repeated compaction. As soon as the tyre is compacted it reforms to its original shape and subsequently expands upwards into areas of less dense waste.

There are a number of specific tyre only landfills, called monofills. In NSW alone, there are 9 licenses issued under the Protection of the Environment Operations Act 1997 (NSW Environmental Protection Agency (EPA)) for used tyre processing or disposal premises. A number of these are for tyre processing and a limited number for landfilling. It is understood that a number of these landfillers are also involved in collection and processing and use the landfill operation as a buffer between collection requirements and market demand from process tyres.

End Market Producers

The end market producers purchase TDPs from transformers as inputs into their final products, which include a range of products such as energy, retaining walls, stemming, road embankments, road surfacing, flooring and mats, moulded products and adhesives. A price is paid by the end market producer based on the tonnes of TDP purchased, and its quality or 'purity'. The markets that these end market producers operate in are discussed in detail in Section 5.

Figure 2.3 – Australian Tyre Industry Typical Income/Payment Flows



Source: URS Analysis

2.3 Legislation that Influences Use and Disposal

Table 2.7 below provides a summary of the existing situation in all states and territories in terms of legislative and regulatory frameworks relating to tyres and their reuse or disposal. There is some variation across jurisdictions in relation to the individual regulatory and policy frameworks, however a general convergence in terms of overall goals (Atech Group 2001, Pt.1, p.12).

Table 2.7 – Summary of Regulatory Frameworks

Item	Jurisdiction	Regulatory Requirement
Landfill disposal	ACT	Allowed
	NSW	Allowed outside SMA/ERA. Whole tyres may not be disposed within the SMA/ERA; license to dispose/process >5,000 tonnes pa; tyres banned from burning at landfills (NSW EPA 1997)
	NT	Allowed; EPA approval required for tyre disposal operating on a commercial or fee for service basis (NT Waste Management and Pollution Control Act 2003)
	QLD	Allowed, whole tyre limit 10,000 EPU pa per new facility (QLD EPA EcoAccess 2004a, p.1)
	SA	Shredded only ≤ 250mm (exception is large earthmoving tyres in remote areas with no shredding facility); Waste Levy applies to all tyres disposed of at landfills (SA EPA Guidelines 2003)
	TAS	Shredded only to approved sites (if fire fighting systems are available)
	VIC	Shredded only
	WA	In Tyre Landfill Exclusion Zone (TLEZ) as defined in the Used Tyre Regulations: shredded only and need approval; other conditions on separation of piles of waste tyres
Recycle / reuse options	ACT	Approval required
	NSW	Allowed on case by case basis in consultation with local council and EPA; license needed if recycle/process >5,000 tonnes pa of rubber product/tyres (NSW EPA 1997)
	NT	Allowed but license required to recycle, treat or dispose tyres on a commercial or fee for service basis (NT Waste Management and Pollution Control Act 2003)
	QLD	Allowed but needs licence if >500 tyres
	SA	Approval required if >5 tonnes/year
	TAS	Allowed at present; approval may be required for large or atypical projects
	VIC	Approved on case by case basis
	WA	Permitted if <100 tyres, else needs approval
Mine sites	ACT	-
	NSW	No disposal on site

Item	Jurisdiction	Regulatory Requirement
	NT	Allowed to be buried on site in an environmentally suitable manner – e.g. within wasterock piles
	QLD	May be buried on site subject to guidelines and becomes notifiable activity
	SA	Subject to general conditions
	TAS	-
	VIC	-
	WA	On site disposal allowed outside TLEZ subject to approval
Transport	National	Transport of waste tyres interstate subject to National Environment Protection (Movement of Controlled Waste between States and Territories) Measure, and requires EPA approval in the state or territory of destination (EPHC 2004b)
	ACT	-
	NSW	Licensed for loads > 2 tonnes
	NT	License required to collect and transport tyres on a commercial or fee for service basis (NT Waste Management and Pollution Control Act 2003)
	QLD	Licensed if >250kg/load (QLD EPA EcoAccess 2004b)
	SA	Licensed
	TAS	Only by approved transporter if tyres are to be disposed
	VIC	-
	WA	Tyres may only be transported to licensed storage site or approved disposal site
Storage	ACT	-
	NSW	Licensed if > 50 tonnes but must comply with NSW Fire Brigades Storage Guidelines and (upcoming) EPA Environmental Guidelines for Used Tyre Storage
	NT	License required to store tyres on a commercial or fee for service basis (NT Waste Management and Pollution Control Act 2003)
	QLD	Considered storage it tyres held ≤ 3 years; licensed if >500 tyres/year (whole or equivalent); must comply with Fire Services requirements (QLD EPA EcoAccess 2004b)
	SA	If more than 500 waste tyres per annum need to be licensed by EPA and comply with Metropolitan Fire Service Guidelines
	TAS	Requires an environmental assessment if >100 tonnes/year. Governed by waste mgt regulations
	VIC	Draft guidelines on stacks: <5,000 tyres each
	WA	Licensed if >100 tyres/year, or >500 for a tyre fitting business
Receival Facility	ACT	-
	NSW	Licensed if processing >5,000 tonnes/year

Item	Jurisdiction	Regulatory Requirement
	NT	Will license in future under the Waste Management and Pollution Control Act
	QLD	Licensed if >500 tyres/year
	SA	Licensed
	TAS	Require an environmental assessment if >100 tonnes/year
	VIC	Covered by general environmental protection regulation
	WA	-
Reporting	ACT	-
	NSW	Reporting under licence conditions; tracking scheme under IWRP
	NT	Will be required under licences issued under the Waste Management and Pollution Control Act
	QLD	Tracking scheme proposed for 2001
	SA	Tracking scheme for whole tyres using docket system
	TAS	Tracking scheme proposed for mid 2001 using docket system
	VIC	-
	WA	-
Tyre Industry Plans	ACT	-
	NSW	Tyre Industry Waste Reduction Plan (IWRP)
	NT	None at present
	QLD	Waste Tyre Strategy
	SA	Extended Producer Responsibility Waste Policy (SA EPA cited in ARRB Transport Research 2004, p.23)
	TAS	Scrap Tyre Management System – voluntary levy by retailer
	VIC	-
	WA	-

Source: Atech Group 2001, Pt.1, p.13-14 (unless otherwise specified within table)

2.4 International Experience

A summary of international tyre recycling schemes from a selection of regions in the world is detailed in Table 2.8 below. The setup of used tyre schemes provides an international context with which to compare the current Australian Proposed Scheme.

Table 2.8 – International Used Tyre Recycling Experience

Location	Levy/Fee Range	Defining Points
USA	AUD 0.34 to AUD 6.90[9]	• Consumers pay fees ranging from AUD 0.34 to 6.90/tyre; • 35 states have tyre recovery schemes in place; • Generally retailers collect fees and arrange for proper management; • States help with funding, education, abatement, market development and research, while manufacturers provide education (Rhodes, cited in Recycling Today 2005); and • In 2003 80.4% of waste tyres were recovered, with TDF the largest single component of this market utilising 44.7% of waste tyres (Rubber Manufacturers Association URS Scrap Tire Markets 2003, p.vi).
Canada	AUD 2.30 to AUD 5.80[10]	• Recycling programs in 10 provinces/territories (and Ontario Province currently developing); • First schemes arose in early 1990s; • Consumers pay AUD 2.30-5.80 for passenger tyres, then sliding scale up based on size of rim; • Some programs operate through provincial government, others focus on industry stewardship operating through an external Board of Directors (CATRA Website 2005); • Differential benefit paid based on the degree of reprocessing and end use; and • Only 13% of used tyres are now used for TDF, with emphasis on 'value-added' operations (ARRB Transport Research 2004, p.26).
European Union	Approx. AUD 5.00	• EU landfill directive bans the landfilling of whole tyres from July 2003 and of shredded tyres from July 2006 (NTDA Website 2005); • 7 EU States have mandated a fee for post-consumer tyres (Shulman 2005, p.10); • EU States diverted ≥73.5% of tyres from landfill in 2003, with 25% going to material recovery, and 24% to TDF[11] (Shulman 2005, p.8); • **UK** - Responsible Recyclers Scheme established in 2000: scheme members are audited on tonnage transported/ processed, with each member paying 25 pence/ tonne of tires collected/processed (Recycling Today 2005); (This is a market based scheme similar to Germany);

9 Based on 1 AUD = 0.727325 USD exchange rate (Universal Currency Converter Website 2005)

10 Based on 1 AUD = 0.868526 CAD exchange rate (Universal Currency Converter Website 2005)

11 EU figures also include 24% of retreaded and exported/reused tyres which are not included in the Australian Data used in the report.

Location	Levy/Fee Range	Defining Points
European Union (Continued...)	AUD 1.75	• **Denmark** - utilises a system of taxation on new tyres, reaching success in recovering approx. 90% of tyres recovered (Shulman 2005, p.6). Take back scheme was established in 1995 with a take-back target of at least 80 %. In 2002, the take-back rate exceeded 100% with used tyres imported from Germany (Danish Environmental Protection Agency 2005);
	AUD 2.20 to AUD 135.00	• **Sweden** - tyre manufacturers' liability directorate established in 1994 and tyre industry sets up the Swedish Tyre Recycling Organisation (SDAB[12]). Levy on new tyres: AUD 2.20 for passenger tyre up to AUD 135 on large earthmoving tyres. Interestingly levies are raised on retreaded passenger tyres at AUD 1.35. Funding is spent on a centralised collection and recovery system as well as R&D with the scheme's success reported at 100% (SDAB 2005, p.6);
	AUD 3.00 to AUD 9.00	• **Finland** – operates a similar centralised scheme to Sweden, establishing a tyre recycling scheme in 1995. Finland generates 30,000 tonnes of used tyres annually with over 90% being collected and recycled, meeting the legislations target (Finnish Tyre Recycling Ltd 2005);
		• **Belgium, Switzerland and Netherlands** - operate highly managed tyre recovery systems supported by set fees, and Switzerland has proposed an approx. AUD5.00 tax for their scheme (MWH New Zealand Ltd 2003, p.25); and
		• **Germany** - operate highly managed tyre recovery systems supported by set fees, and Switzerland has proposed an approx. AUD5.00 tax for their scheme (MWH New Zealand Ltd 2003, p.25).
South Africa	Approx. AUD 4.00 Under review for 2006 start	• Waste tyre collection scheme to be phased in from 2006; • Proposed as co-regulatory industry stewardship scheme; • Levy of about AUD 4.00 a passenger vehicle tyre, and AUD 28.00 a truck tyre has been proposed by the South African Tyre Recycle Process Company; • Levy imposed on importers, manufacturers and retreaders to cover the cost of tyre collection and transportation to defined recycling uses (collectors no longer able to charge collection fee) (SATRP Website 2005 and Cokayne 2005); and • Success of this program to be determined once the scheme has begun in 2006.
India	No scheme	• All waste tyres are recovered with no scheme in place - due to low labour costs, and rubber demand being higher than supply (Atech Group 2001, Pt.1, p.44).

Source: All sources specified within table

[12] Svensk Däckåtervinning AB

Further details on international Tyre Recovery Schemes can be viewed in Appendix E, where Case Study E.1 presents a summary on the experiences of Manitoba Province in Canada, and Table E.1 summarises the recovery rates for end-of-life tyres in a selection of European countries.

International Competition

A potential barrier to the Australian TDF and crumb industry that may become an important consideration for industry players in future years is competition with foreign-produced TDPs. On a number of occasions, industry communications have indicated that imports of rubber crumb and similar products from countries such as Malaysia and South Africa are often lower in price than Australian-produced equivalents. This study has not looked further into international competition, as it is relatively unknown the impacts that will result. The aim is to simply include this as a factor for further consideration as the Scheme continues development. The following Case Study 2.1 indicates that there will be likely increase in foreign imports in the future that may affect Australia:

Case Study 2.1 – Rubber Recovery in Malaysia

A recent report on just one company planning to conduct tyre recycling in a number of locations in Malaysia over the next five years reveals that Malaysian TDP production could be on the increase:

In a report adapted from Malaysian "The Star" from 20 September 2005, it revealed that Octagon Consolidated Bhd has invested in a RM100million waste tyre pyrolysis project in Selangor, with the project expected to come on-stream by early 2006. The plant is slated to process 2.4 tonnes of waste tyres daily into mainly carbon black, recovered oil, as well as steel wire and non-condensable flammable gas.

The company has already secured buyers for the products and except for the steel wires; the remainder of the products would be exported, mainly to Europe, the Middle East and ASEAN.

Octagon also plans to set up five more plants and 12 transfer centres nationwide in the next five years.

Source: Invest in Malaysia Website 2005

2.5 Why a Tyres Extended Producer Responsibility Scheme - Market Failure

Economic efficiency means making the best use of resources to ensure that community well-being is maximized. Resources include natural resources, capital, labour, knowledge and inherited institutions and cultural values (Tasman Institute 1991). An allocation of resources is said to be efficient when a transfer of resources to other uses can not be made to make someone better off without making another individual worse off. This allocation of resources is typically made efficiently within an economy on the basis of price. Market failure occurs when the price mechanism results in an inefficient or grossly unfair allocation of resources (Tasman Institute 1991).

There are four main types of market failure that are experienced within an economy, including:

- Externalities;
- Imperfect information

- Market power; and
- Public good effects (Tasman Institute 1991).

In the case of used tyres, the public good market failure does not have an impact. In various degrees, the other three market failures occur within the tyre market.

Market failure 1 – Externalities

Externalities exist where the consumption or production of a good impacts on people other than the producers or consumers that are participating in the market for that good. They are the side effects borne by third parties, whereby firms or individuals will bear some form of cost known as the external cost. There are a number of forms of externalities:

- Producer on producer externalities;
- Producer on consumer externalities;
- Consumer on consumer externalities; and
- Consumers on producer externalities.

Broadly, an externality means that some effects of an activity are not taken into account in its price. The externality associated with tyres arises because the cost of disposal is not included in the price of the raw material or the finished product, creating a producer on consumer externality. Currently, the majority of used tyres are disposed via landfill, however the social, economic and environmental costs of landfill as a method of disposal are not currently included in the price of a new tyre product. This can result an inefficient allocation of resources when decisions are made on used tyre input allocations and disposal.

Market Failure 2 – Imperfect Information

Information is needed for a market to operate efficiently. Buyers need to know the quality of a good or service to judge the value of the benefit it can provide. Without both sides of the market having access to and full knowledge of market information, a market failure may result (Treasury UK 2003).

Within the used tyre market, the occurrence of imperfect information is at the end user level. Through consultation with end user markets it has been found that there is still a lack of knowledge about the quality, price and availability of recycled tyre materials. The result of this is that alternative product are favoured over TDPs in a number of applications where tyre derived products could provide benefits. An example of this is in the road surfacing end market, where trials have shown the performance benefits if rubber crumb is used in asphalt, however there is still an element of mistrust in the market preventing the use of TDPs in roads in a number of states. There is also a lack of industry players willing to invest in R&D for TDPs, as was highlighted in a number of industry discussions, such as with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) who found difficulty attracting players in the tyre industry to assist funding research of advanced transformation technologies (Personal

Communication[15] 2005).

The current lack of information about product price, information and availability hinders the use of used tyre products, and also impedes industry funded research on the use of TDPs in end market products.

Market Failure 3 – Market Power

Market power can arise as a result of insufficient actual or potential competition to ensure that the market continues to operate efficiently (Treasury UK 2003). Issues such as high start up costs, protectionism and firm size impact on the market power of an organisation. When firms invest in excess capacity or predatory pricing with the aim of barring entry, there exists a market failure.

A large component of the used tyre market is made up of vertically integrated companies who operate in multiple components of the supply chain. Although not currently seen as an issue within the tyre industry because of the relative infancy of the market and because there is still a large supply of used tyres not being captured for transformation, however reduction in competition and market power along the supply chain could result in a market failure if supply of used tyres is further impacted.

Summary of the Market Failure

Markets can fail to allocate natural resources efficiently through the pricing mechanism if they are unable accurately to capture the full social costs of exploiting the natural resource. When there are factors that prevent the market from achieving an efficient allocation of resources, market failure occurs.

The assessment of which type of market failure is the most significant is a determinant on future industry or government interventions, and will affect the Scheme's use of funds. The effects of distortions due to the failure of prices to reflect all costs in markets where waste tyre products compete are almost certainly important. The message at an industry level (and from some Government agencies) is that the major limitation on improved practices for end-of-life tyres is the difficulties associated with secure access to the resource. On the other hand, individual recyclers emphasise the lack of depth in the markets into which they sell their products, including difficulties with consumer acceptance and marketing the benefits of products. It is not possible with any confidence to separate the forms of market failure as to which is the most important; hence it is important for the Scheme to address all forms as far as possible.

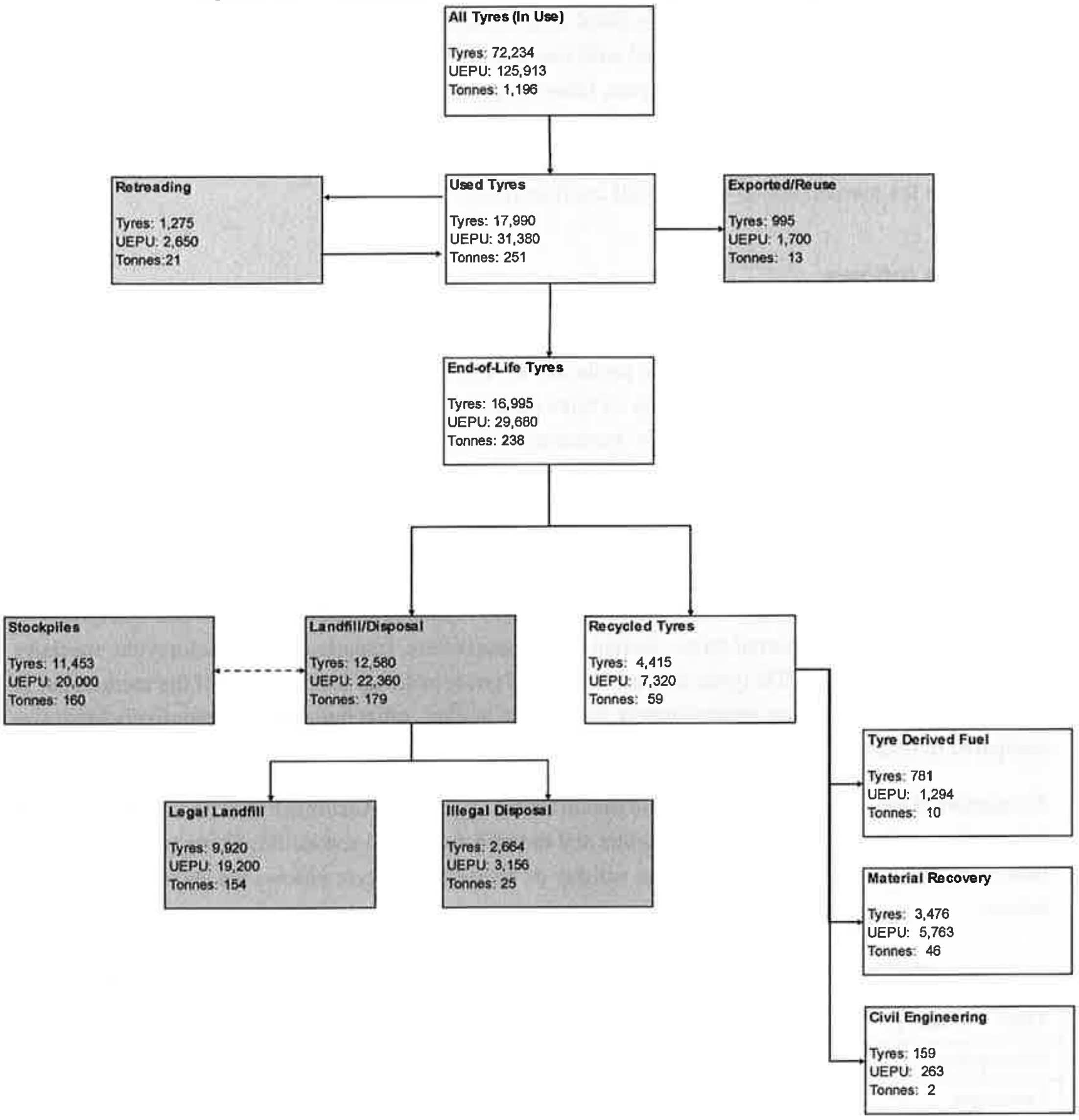
3.1 Current Tyre Flows

The demand for new tyres within Australia and the world market is a derived demand, which originates from the demand for products that use tyres as part of their operations, namely motor vehicles. The inflow of new tyres into the market corresponds to impact directly on the supply of used tyres into the market. In this report, volume flows both in and out of the market are estimated for rubber tyres within Australia. The flow analysis attempts to capture: new tyre volumes (including those that are imported and those that are manufactured within the country); volumes of tyres that are currently in use; and the number of tyres that leave the use-market each year as used tyres (for disposal, reuse or recycling).

3.1.1 Flow Chart of Existing Tyre Markets

Using stakeholder information and previous studies and through consultation with invested parties, the current flow of end-of-life tyres were estimated for use in the modelling process. The flow of tyres in use and becoming end-of-life tyres each year is shown in the flow chart in Figure 3.1 below.

Figure 3.1 – Current End-of-life Tyre Flows (2004-2005) ('000s)



Source: URS Analysis

3.1.2 Tyres Entering the Australian Market and Currently in Use

Motor vehicle tyres are an exhaustible product in that they need to be continually replaced over time. It is estimated that approximately 18 million tyres (31 million EPUs) entered the Australian market in the year 2004 (ABS 2004). These tyres originate from a number of sources and enter the market as both loose tyres and as Original Equipment Manufacturer (OEM) tyres that are fitted to vehicles. Some tyres are imported and then fitted to vehicles manufactured in Australia and are then exported as OEM. It is understood that no imported vehicles are fitted with Australian made tyres. Vehicles imported without tyres (heavy vehicles) are generally fitted with imported tyres, and most domestic manufactured vehicles are fitted with domestic manufactured tyres, however some are fitted with imported tyres. Research indicates that approximately 75% to 80% of annual OEM tyres are imported (Industry Sources and URS Analysis). It should be noted that Figure 3.1 above does not provide a detailed breakdown of all these tyre inflows into the market, due to commercial confidentiality issues.

New Tyre Inflows

The Australian manufacturers produce a range of tyres, with a particular emphasis on passenger vehicle tyres. There are currently two major tyre producers in Australia: SPT and Bridgestone. In terms of tyre production and manufacture, the majority of tyres produced in Australia are for passenger motor vehicles (approximately 85% of tyres produced in Australia). Of the remaining tyres produced in Australia, an estimated 15% are for light and heavy trucks and buses. Tyre manufacturers within Australia do not produce motor cycle tyres or OTR tyres. Producers outside of Australia, including Pirelli, Michelin, Goodyear and other niche operators, provide the market in Australia with product through imported supply. The tyre import market in Australia, on a tyre basis, is again dominated by passenger tyres, with 46% of all imported tyres, light commercial having 39% of the tyre market and truck and bus tyres making up 10% of all imported tyres. Unlike local manufacture, imports also fill motorcycle, specialty and OTR tyre demand. OTR tyres, in total number of tyres, make up less than 1% of the market, but in terms of weight (tonnes) are approximately 22% of the market, reflecting their comparatively large size compared to other tyre categories.

Estimation of the volume of imported and manufactured tyres into Australia has been undertaken using information gathered from the tyre importers and manufacturers and reconciling these volumes to ABS data on rubber product imports to test the validity of the data. New tyre inflows are shown in Table 3.1 below:

Table 3.1 – Current New Tyre Quantities Entering Market Annually ('000s)

Tyre Category	Tyre Numbers	EPUs	Tonnes
Motorcycles	279	139	1
Passenger	13,328	13,328	127
Specialty	41	204	2
Light Commercial	3,439	6,877	65
Truck & Bus	834	4,172	40
OTR	67	6,650	63
TOTAL	**17,807**	**30,807**	**293**

Source: URS Analysis

Tyres in Use

There are an estimated 18 million tyres that enter the Australian market each year either to replace those tyres that are moving out of the 'in use' stage into the post-consumer stage, or as a part of an gradual annual growth in market size. The total estimated tyre quantity in use in Australia is in the order of 72 million tyres, equivalent to 126 million EPUs. The number of tyres currently in use has been derived from the ABS Motor Vehicle Census 2004 (ABS 2004) as well as through the consultative process undertaken in this Project.

In terms of total tyres in use, passenger vehicle tyres account for 74% of all tyres, while light commercial tyres make up 16% of the total market in tyres. The remainder of the tyre market consists of truck and bus, motorcycle, specialty and OTR tyres. On a weight basis these proportions are slightly lower, with passenger tyres contributing 42% of the total tonnage of tyres in use, truck and bus 24%, and OTRs 14% of the total 1.2 million tonnes.

Table 3.2 – Current Tyre Quantities in Use ('000s)

Tyre Category	Tyre Numbers	EPUs	Tonnes
Motorcycles	793	396	4
Passenger	53,347	53,347	507
Specialty	200	1,000	10
Light Commercial	11,715	23,430	223
Truck & Bus	6,003	30,013	285
OTR	177	17,727	168
TOTAL	**72,234**	**125,913**	**1,196**

Source: URS Analysis

Combining the numbers for new tyre entry flows and the existing tyres in use, it can be shown that on average across the product types one in four tyres is replaced each year (approximately 25% of the market).

3.1.3 Used and End-of-Life Tyres

A used tyre is defined as a "used, rejected or unwanted motor vehicle tyre, that can be reused for its originally intended purpose, retreaded, transformed, recycled, or that may be destined for final disposal" (MWH New Zealand Ltd 2004, p.4). Used tyres are either reused, or are defined as end-of-life tyres that cannot be used again as a motor vehicle tyre, so are either disposed of or recycled. Hence used tyres can move in three directions:

- Landfill and disposal;
- Recycling/transformation; and
- Reuse: export and retreading.

End-of-life tyres are those used tyres that cannot or are not reused for its originally intended purpose and are not retreaded. Such tyres may have a further use as a raw material for other processes or be destined for final disposal (MWH New Zealand Ltd 2004, p.4). With this definition in mind, end-of-life tyres move in two directions:

- Landfill and disposal; and
- Recycling/transformation.

Of the total number of used tyres generated per annum (31.4 million UEPU), it is estimated that approximately 29.7 million UEPU became end-of-life tyres in the year 2003/2004. This represents approximately 238,000 tonnes of end-of-life tyres per annum that are unsuitable for reuse so should either be recycled or disposed. The table below summarises the type and quantity of each tyre category that reaches an end-of-life tyre position annually.

Table 3.3 –Current End-of-Life Tyre Quantities Generated Annually ('000s)

Tyre Category	Tyre Numbers	UEPUs	Tonnes
Motorcycles	279	139	1
Passenger	12,704	12,704	102
Specialty	41	204	2
Light Commercial	3,185	6,371	51
Truck & Bus	723	3,614	29
OTR	67	6,650	53
TOTAL	**16,995**	**29,680**	**238**

Source: URS Analysis

The proportion of each tyre category reaching end-of-life annually is estimated to mirror the inbound flow of tyres per annum, with passenger tyres accounting for 43% of the total tonnage of all of end-of-life tyres, light commercial contributing 21%, while OTRs make up 22% of the tonnage of all end-of-life tyres.

To develop the data inputs into this end-of-life tyres stream, URS undertook a review of existing material on the subject, including ARRB Transport Research (2004) and Atech Group (2001) reports, and conducted consultation with industry groups and representatives, a list of which can be found in Appendix B.

Reconciliation of Data

As part of the study process, URS has attempted to reconcile the volume data used in this report to volumes used in reports previously undertaken on the tyre industry. The reports referenced include work undertaken by ARRB Transport Research (2004), Atech Group (2001) and Penry Jane Associates (2003).

The Atech Group report (2001, Pt.1, p.1) estimated that the waste tyre volume in Australia was

18 million UEPU[13] (144,960 tonnes) in that year based on year 2000 data, and the ARRB Transport Research Report (2004, p.13) estimated the volume to be 20.8 million UEPU in 2004 (166,400 tonnes). The Atech Report numbers differ from URS's estimate of 238,000 tonnes due to: not all OTRs were included in Atech's numbers, as well as the time difference of 4 years with Atech and URS's data. As ARRB Transport Research applied an annual growth rate to Atech's numbers, the OTR issue was the same for ARRB and URS data differences, as well as the lessening of accuracy when a straight growth rate is applied over a number of years.

Table 3.4 – Atech Report Summary, End-of-Life Tyres ('000s)

Tyre Category	Tyre Numbers	UEPUs
Passenger	9,769	9,680
Light Commercial	2,194	4,360
Truck & Bus	518	2,740
OTR & Other	12	1,240
TOTAL	**12,493**	**18,120**

Source: Atech Group 2001, Pt.1, p.51

A summary of unpublished data from research undertaken for Renewed Rubber (conducted by Penry Jane Associates 2003) is presented in Table 3.5 below to enable further comparison.

Table 3.5 – Renewed Rubber Report Summary, End-of-Life Tyres (2003)[14] ('000s)

Tyre Category	Tyre Numbers	UEPUs
Motorcycle	413	211
Passenger	12,653	12,653
Light Commercial	3,496	6,992
Truck & Bus	955	4,773
TOTAL	**17,517**	**24,629**

Source: Penry Jane Associates 2003

The Renewed Rubber data estimates that 24.6 million UEPU (197,032 tonnes) end-of-life tyres were generated in 2002. This amount is lower than the URS figure as a result of OTR numbers not being included, as well as the time difference of 3 years between data collection. In addition, different assumptions were considered in this report, e.g. the data from Financial Year 2001/2002 was used in this

[13] Note: Atech Group, ARRB Transport Research and Penry Jane Associates did not factor in tyre loss (1.5 kg per EPU), so URS has converted their tyre number calculations to tonnes based on 8kg UPEUs in order to compare like-with-like

[14] The data for the Renewed Rubber report was taken from the financial year 2001/2002 and included ABS Year Book Australia 2003 (Transport/Transport Equipment); Specific ABS Data Report on: Imported New Pneumatic Tyres (1997 to 2002); Exported New Pneumatic Tyres (1997 to 2002); Imported Retread or Used Pneumatic Tyres (1997 to 2002); Exported Retread or Used Pneumatic Tyres (1997 to 2002); Imported Vehicles (1997 to 2002); Exported Vehicles (1997 to 2002); VFacts (Vehicle Manufacturing and Exports) (1997 to 2002); Correspondence and data ATMA and ATIG and individual tyre importers; Correspondence with EPA NSW; and other sources from web based searches.

unpublished Renewed Rubber report with the following assumptions: (1) 50% of registered motorcycles change their tyres annually; (2) Includes motorcycles exiting the market; (3) 20% of registered cars change their tyres annually (i.e. a set of tyres lasts 5 years on average); (4) Includes cars exiting the market; (5) 30% of registered light trucks change their tyres annually (i.e. a set of tyres lasts 3 years on average); (6) Includes light trucks exiting the market; (7) 15% of registered trucks/buses change their tyres annually (i.e. a set of tyres lasts 6 to 7 years on average including retreading; and (8) Includes trucks/buses exiting the market.

Motorcycle tyres were added to the Renewed Rubber report, although OTR tyres were excluded due to the unreliability of data at the time of the research. The Renewed Rubber report included tyre exports of new (loose or OEM) and second hand tyres. These exported tyres have been removed so that the table below represents end-of-life tyres for year 2001/2002.

3.1.4 End-of-Life Tyre Location

Determining where end-of-life tyres are located around Australia when they enter the waste stream is important to the financial and economic analysis being undertaken because their distance from a transportation or disposal site can greatly impact their flow to the next stage of the tyre life cycle. For the purpose of this analysis, URS has not separated end-of-life tyres on the basis of state, but in terms of the transport distance to disposal or market. End-of-life tyre location has been separated into three streams:

- Metropolitan – tyres that are located within the capital cities and larger cities within Australia;
- Regional – tyres that are located within defined as those larger regional centres; and
- Rural – tyres that are located within low population centres significant distances away from large population centres;

Table 3.6 shows the distribution of end-of-life tyres on the basis of these three location definitions.

Table 3.6 – End-of-life Tyres by Location ('000 UEPUs)

Tyre Category	Metropolitan	Regional	Rural	Total
Motorcycle	118	14	7	139
Passenger	10,798	1,270	635	12,704
Specialty	112	72	20	204
Light Commercial	5,415	637	319	6,371
Truck & Bus	3,072	361	181	3,614
OTR	333	2,328	3,990	6,650
TOTAL	**19,849**	**4,682**	**5,152**	**29,680**

Source: URS Analysis and ABS 2004

Table 3.7 – Regional Distribution of Tyres (% Proportion)

Tyre Category	Metropolitan	Regional	Rural	Total
Motorcycle	85.0%	10.0%	5.0%	100.0%
Passenger	85.0%	10.0%	5.0%	100.0%
Specialty	55.0%	35.0%	10.0%	100.0%
Light Commercial	85.0%	10.0%	5.0%	100.0%
Truck & Bus	85.0%	10.0%	5.0%	100.0%
OTR	5.0%	35.0%	60.0%	100.0%

Source: URS Analysis and ABS 2004

For the analysis, metropolitan tyres are estimated to be transported 25 km, regional tyres are transported 150 km, while rural tyres travel 400 km for disposal/reprocessing (See Table 4.4).

Overall, end-of-life tyres (on a UEPU basis) that are located in metropolitan areas consist of 67% of all end-of-life tyres, regional are 16% and rural contribute 17%. Not surprisingly the figures mainly mirror population distribution throughout the country, except for the rural numbers, which are relatively high on a UEPU basis because of the use of a significant number of OTR tyres within this classification.

3.2 Future Tyre Flows

Unless more specific information was gathered, a growth rate of 2% was assumed for the tyre market in Australia, which is discussed in more detail below.

Population and GDP

There is a relationship between Gross Domestic Product, population and the number of tyres demanded. Population change is determined by changes in the births to deaths ratio and the net migration rate. GDP is a measure of the wealth of a countries, a growth in GDP represents a growth in the nation's wealth and its ability to consume. GDP and population growth are also linked often with one driving the other eg population increase, increases a nations productive capacity and may drive GDP growth; and GDP growth typically increase demand for, and attractiveness to, migration towards a country driving population growth.

Population growth and GDP impact on the number of tyres entering and hence leaving the market each year. The effect of population and GDP on the tyre market is derived from the demand for all types of motor vehicles:

- Increased population typically results in an increase in the demand for motor vehicles and hence the number of tyres required; and
- GDP, or changes in a nation's wealth, impact on the ability to purchase additional motor vehicles and the ability to undertake regular maintenance on motor vehicles (regular tyre changes).

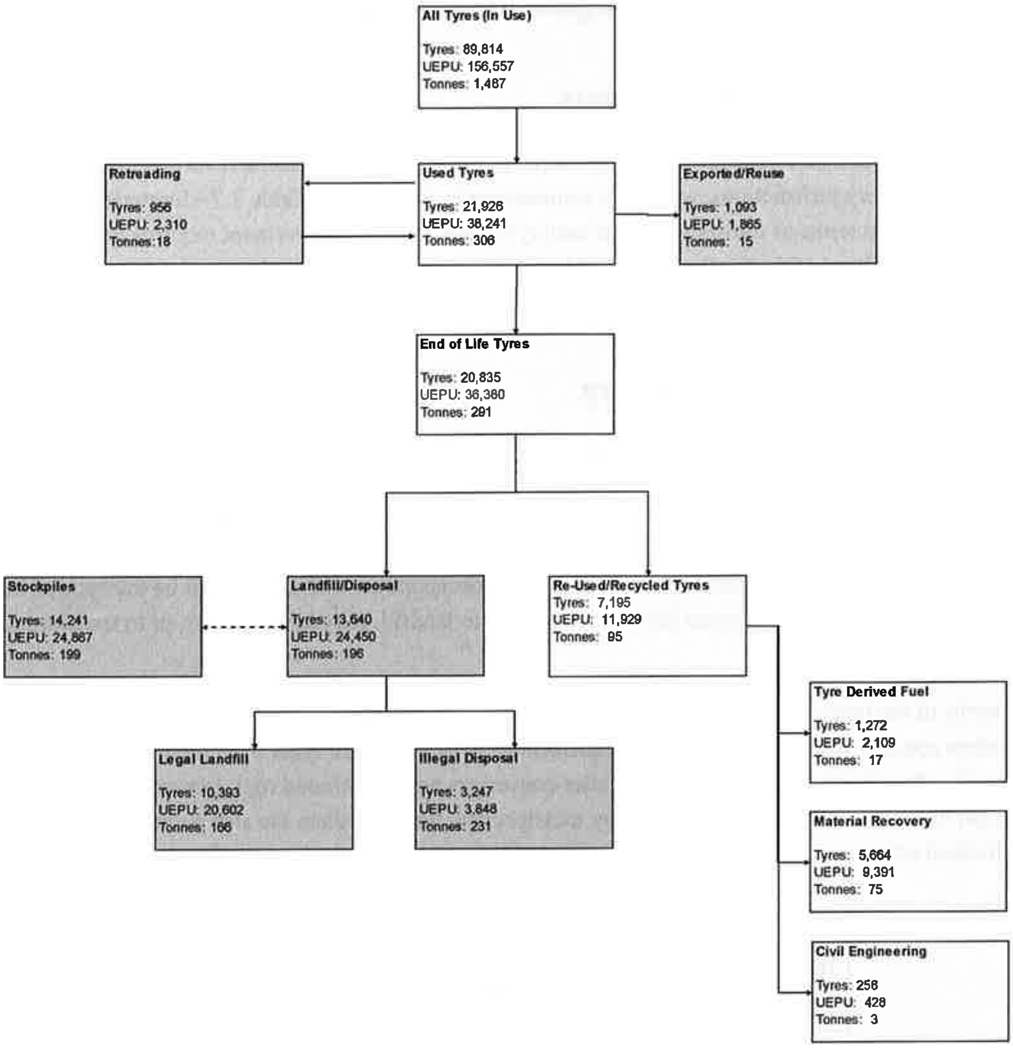
For the purposes of undertaking financial and economic modelling, a growth rate of 2% per annum has been used to account for forecast changes in population in Australia over the ten year period of the evaluation. ABS data on population change and GDP forecast has been used to estimate tyre growth in the Australian market.

3.2.1 Flow Chart of Future Tyre Market

The flow chart presented in Figure 3.2 shows the flow of end-of-life tyres in 2016 if there is no scheme in place to change behaviour towards the recycling of tyres. Analysis on the forecast future of end-of-life tyres shows that the total number of end-of-life tyres is 23% higher after ten years. The amount moving to legal landfill increases by 7%, while illegal dumping increases by 22%. The recycling market is estimated to grow at an annual growth rate of 5% even without introduction of the Scheme, with the introduction of new technologies and improved processing methods (and perhaps with tighter legislative controls on landfilling) growing over the 10 years by an estimated 63%, however it is notable that without a Scheme the amount of tyres going to landfill or disposal is not reduced, impeding further growth of tyre recycling.

Information on movements in the re-use market was gained from discussions with current processors and users of recycled tyre product and through consultation with those developing new technologies.

Figure 3.2 – Future End-of-life Tyre Flows (2015 without Scheme) ('000s)



Source: URS Analysis

4.1 Tyre Collection Arrangement and Costs

4.1.1 Regulatory Requirements

Storage, collection and transport regulatory requirements for tyres in Australia vary between different state and territory jurisdictions, which are summarised in Section 2.3, Table 2.7 - Summary of Regulatory Frameworks. In terms of transportation of used tyres, any interstate movement requires EPA approval in the state or territory of destination (EPHC 2004b). Most states and territories require transporters to be licensed in order to store and transport waste tyres.

4.1.2 Tyre Collection Industry

Current Status and Size of the Industry in Australia

A key link in the end-of-life tyres supply chain is collection, transportation and storage. In the current industry setup, collection and transport operators can determine the destination of used tyres as a function of their own business operations whereby they make decisions on where tyres will be transported based on their expected profit outcomes from moving tyres to landfill, retreading, export, or to transformation industries.

In terms of the post-consumer fate of tyres, the tyre collection industry operates whereby larger tyre retailers contract with tyre collectors or transformers to pick up used tyres from their site, such as those tyres that have been left with the retailer after consumers have purchased replacement tyres[15]. In turn, it is typical that collectors are subcontracted by transformers, however there are also a number of smaller, individual operators (ARRB Transport Research 2004, p.33).

Table 4.1 – Tyre Collection and Transportation Industry Overview

Industry Variable	Quantity
Estimated Industry Size	70 operators nationally
Volume of Used Tyres Collected and Transported – Current	29.7 million UEPU
Average Collection Fee Charged	$1.00-2.50 / tonne

Source: Industry Sources and URS Analysis

Industry Players

The tyre collection and transport industry is made up of a few large firms and a large number of small individual operators. This makes the collection industry a highly competitive industry. The major players are:

15 About 95 percent of used tyres are left with the retailer when a replacement tyre is purchased (ACIL Consulting 2000, p.19).

- SIMS Tyrecycle;
- Geocycle (administers the collection and delivery of tyres to Cement Australia's Gladstone cement kilns, subcontracting the physical collection to local operators (Atech Group 2001, Pt.1, p.6)); and
- Individual Operators.

The larger players in the market are typically vertically integrated tyre supply chain participants. This tends to involve having a collection and transport, landfilling and also tyre reprocessing operations.

Industry Process

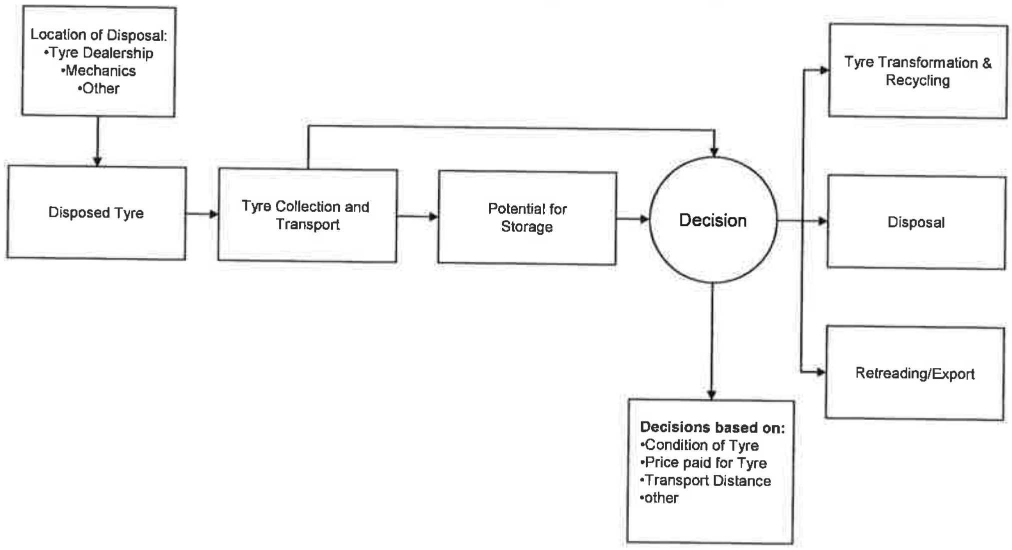
The tyre collection and transport industry is responsible for the movement of used tyres from the point of post-consumption when they are removed from a motor vehicle, to their end use position. There are four main uses or destinations for used tyres:

- Reuse as second hand tyres (export or the domestic second hand tyre market);
- Retreading (retreaded tyres may also be exported);
- Transformation – crumbing, fuel, powder and other uses; or
- Disposal.

The tyre collector and transporter tends to be a decision-maker for the end use of a collected tyre, based on a trade off between the cost of transport and the price received from the point where they collect tyres. In the current situation the tyre collector is paid a fee to remove the tyre, for example for passenger tyres it is generally the tyre retailer/dealer who passes used tyres on to collectors, and subsequently pays this collection fee. As a minimum the collector/transporter will need revenue to cover the cost of collection and transportation and the cost of landfilling for sustainability in the business. A different decision may be made by a collector/transporter as to where they pass tyres on in the industry chain if they can:

- Receive a greater price from another market player (i.e. retreaders generally pay a fee to receive appropriate retreadable casings); or
- Lower their total costs to below landfill costs (i.e. the fee collectors pay to pass a used tyre to a TDP transformer can sometimes be lower than landfill fees).

Figure 4.1 – Tyre Collection, Transport and Storage Flow Chart



Source: Industry Sources and URS Analysis

Figure 4.1 above shows the decision process undertaken by a tyre collector and transporter. After receiving the used tyre, transportation to a landfill, retreader, or direct to transformation will be undertaken. The decision on end use will be made on the basis of the quality of the tyre, distance to end use and price paid by end user.

Potential Industry Size

The tyre collection and transport industry is constrained by the size of the waste tyres market. The number of operators will grow with the size of the overall market. This growth may come from existing participants in the market or new entries.

Barriers to Industry Development

There are comparatively low barriers of entry for firms becoming involved in tyre collection and transportation, with basic requirements a vehicle and a license to carry tyres. Because of the ease of entry and the large number of market players, it is has been estimated that there are low margins in the tyre collection and transportation industry. The value for the larger players within the market is often derived from what can be done with the waste tyres further down the supply chain. For example, a large vertically integrated operator may decide not make sustainable returns on its collection and transportation, but makes a commercial return on its transformation interests. On the other hand it may decide to lower its landfill costs to support the viability and market position of its collections that also support its transformation interests.

4.1.3 Collection Costs

Table 4.2 below describes the current estimated volume flows to the different end users. Currently, the majority of disposed tyres are moved to landfill. The possible reasons for the high volume of landfill is a lack of demand by transformers and retreaders, a lack of quality tyres for retreading and low prices paid by transformers and retreaders.

Table 4.2 – Current Collection and Transport Volumes ('000s)

End location	UEPUs	Tonnes
Transformation	7,323	59
Landfill/disposal	22,361	179
Retreading	2,650	21
Export	1,700	13
Total	**34,034**	**272**

Source: URS Analysis

The cost of collection and transport is influenced by the volume and distance transported. For the purpose of the financial and economic analysis, an estimate of the cost of collection and transport of tyres has been made for three broad regions:

- Metropolitan;
- Regional Centre; and
- Rural Area.

The difference in tyre collection, transport and storage cost varies based on the location of the post-consumer tyre, and the distance the tyres need to be transported to reach a processing point. The distances assumed and the costs are shown in Table 4.3 below, shown as weighted averages over the three regions. These figures have been determined by splitting each tyre category across the three regions dependent on where they are most likely to arise post-consumer, and then the relevant distances and transport costs are applied to show the average cost per trip, per tyre category.

Table 4.3 – Average Collection, Transportation and Storage Costs (per trip)

Tyre category	Collection ($/tyre)	Transport ($/tyre)	Storage ($/tyre)
Motor cycles	0.28	0.27	0.25
Passenger	0.28	0.53	0.25
Specialty tyres	0.64	4.50	0.50
Light trucks	0.55	1.06	0.50
Truck and bus	1.65	2.65	1.50
OTR	17.75	156.57	10.00

Source: URS Analysis

Presenting the average costs per region shows the relative difference if a used tyre must be transported 400 km or 25 km. As Table 4.4 shows, the cost to transport a tonne of tyres to a regional point is approximately 24% higher than the metropolitan fee.

Table 4.4 – Summary of Collection, Transport and Storage Costs (per region)

Region	Assumed kms for Transport	Cost $/EPU	Cost $/tonne
Metropolitan	25	0.81	102
Regional Centre	150	1.96	245
Rural	400	3.35	418

Source: URS Analysis

As mentioned previously, tyre collectors receive a fee from retailers or wreckers to collect waste tyres. The fee varies depending on location and tyre category, in order to cover the costs in Table 4.4. The fees shown in Table 4.5 have been estimated based on consultation with the transport industry and URS analysis. Discussion with industry sources suggests that collection fees vary between $2 to $3 per tyre collected, supported by ARRB Transport Research findings (2004, p.33). There is no standard collection and transportation fee across Australia or within the states themselves as essentially a collector's costs are related to distance travelled and cost of disposal and/or end location for transported tyres; consequently hence a level of aggregation has been required.

Table 4.5 – Approximate Fee Received to Collect Tyres

	Passenger $/EPU	$/tonne
Metropolitan	1.10	125
Regional	2.40	275
Rural	4.00	438

Source: URS Analysis and ARRB Transport Research 2004, p.33

Value of Products

Revenue received by tyre collectors and transporters comes from the tyre retailers/wreckers where post-consumer tyres arise. The value of tyre collection and transport is determined by its end use. Each of the end locations for used tyres demand a volume of tyres to satisfy their production levels, and if there is no demand then tyres are landfilled or disposed. The revenue profile for tyre collectors is shown in Table 4.6 below, and is based on the approximate fees paid to or received from three end locations. Landfill of whole tyres costs the collector approximately $150 per tonne; a collector is estimated to pay up to $1.00 per UEPU to the transformer; and retreaders pay approximately $10 per passenger tyre received, giving the following outcome:

Table 4.6 – Current End Location Fee Paid or Received to Collector

End Location	$/tonne	Tonnes
Landfilling	-150	154,000
Transformation	-125	59,000
Retreading	1,250	21,000

Source: Industry Sources

Based on the revenue received by a collector based on Table 4.6 above, average revenue gained when a collector passes tyres on to landfill, retread or transformation (factoring in the proportion of tyres going to each end location) is a loss of $18 per tonne. Analysing the revenue received by a collector based on Table 4.6 above, and combining it with all other costs and revenues applicable to collectors in their operations (collection, transportation and storage costs and any payments to receive tyres), determines the gross margin that a collector receives. Table 4.7 below shows a summary of all of these costs per tonne of tyres collected and transported. The average return to the transport, collection and storage industry is approximately 15%.

Table 4.7 – Collection and Transportation Gross Margin

End Use	Fee from Retailer $/tonne	Fee at End Location $/tonne	Coll., Trans. & Storage Cost $/tonne	Margin $/tonne
Metropolitan	137.50	-18.10	-102.00	18
Regional	303.00	-18.10	-245.00	40
Rural	503.00	-18.10	-418.00	68

Source: Industry Sources and URS Analysis

4.2 Disposal – Arrangements and Costs

4.2.1 Regulatory Arrangements

There are regulatory requirements for disposal of tyres in Australia. These tend to vary between different state and territory jurisdictions as is summarised in Section 2.3, Table 2.7 - Summary of Regulatory Frameworks. All jurisdictions allow the landfill of tyres; however there are restrictions on the disposal of whole tyres, with four states banning whole tyre landfill and requiring that tyres are shredded. The phasing out of whole tyre landfilling is partly due to the void space, their ability to harbour vectors, as well as the potential of tyres to gradually rise to the surface of a landfill. Approval to operate a disposal operation is also necessary in the majority of states and territories. Any variation to state and territory regulations, such as illegal disposal, illegal burning, or illegal storage/stockpiling of tyres will generally be met with significant penalties (fines and other penalties).

4.2.2 Landfill

In 2005 an estimated 65% of all end-of-life tyres were legally disposed of in an Australian landfill, which is equivalent to more than 19 million UEPU. The reduction of tyres going to landfill is a key aim of this proposed Scheme.

In relation to end-of-life tyres, landfills operate whereby a disposal fee is charged per tyre, per tonne of whole tyres, or per whole tonne of shredded tyres to be disposed. For collectors, transporters or transformers who may dispose of tyres to landfill, bulk prices per tonne are the most common due to the larger volumes dealt with. There is currently a movement within Australian legislation towards no longer allowing whole tyres to be landfilled, hence shredding and its related costs are becoming an important consideration (South Australia, Tasmania, Victoria, Western Australia and the Sydney metropolitan area have already banned this practice). Due to these regulatory requirements, and the national trend toward shredding the majority of waste tyres, the generator of tyre wastes must either pre-shred prior to disposal (paying a shredded tyre landfill fee); alternatively they can dispose of whole tyres but must pay a higher landfill charge to cover handling, coarse shredding, and landfilling. As a result the whole tyre disposal charge per tonne is higher than for shredded tyres.

The level at which landfill gate charges are set can play a critical role in providing appropriate incentives for different options in the management of used tyres (Atech Group 2001, Pt.1, p.10). The market result is that tyre collectors must be required to pay less than the landfill fee to transformers taking their tyres, in order for tyres to be supplied for tyre recycling as opposed to being landfilled. On the other hand, higher landfill disposal charges can encourage inappropriate practices such as illegal dumping so a balance in fees charged is key to the used tyre industry (Atech Group 2001, Pt.1, p.10).

Stakeholder discussions have revealed that within the tyre industry, landfill disposal fees are as low as $0.50-0.60 per UEPU, which translates to $65 per tonne of chopped tyres, and $150 per tonne of whole tyres that still require shredding. These prices per tonne are the landfill costs that have been considered in URS modelling to reflect industry costs in the model. Based on this, it can be estimated that the total cost of disposal of all tyres landfilled in 2005 cost disposers approximately $23 million[16]. The cost of landfill is an important input into the modelling due to the impact landfill prices play in affecting decisions for tyre flows. Table 4.8 below gives a high and low range for landfill fees charged for end-of-life tyre disposal across all Australian states and territories. This data has been gathered from a range of public landfills and councils around Australia, and is the charge for bulk disposal so is generally reflective of the costs revealed in industry discussions.

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16 Calculated based on 154,000 tonnes of UEPUs being landfilled in 2005 at the cost of $150 per tonne

Table 4.8 – Summary of Bulk Landfill Costs in Public Landfills

	Whole Tyres $/tonne		Shredded Tyres $/tonne	
	Low	High	Low	High
ACT	107.53	145.48	54.85	74.21
NSW	104.40	141.24	79.27	107.25
NT	170.00	230.00	35.70	42.00
QLD	130.91	177.11	54.85	74.21
SA	111.75	151.20	46.82	63.35
TAS	95.79	129.69	40.13	54.30
VIC	107.28	145.15	44.95	60.82
WA	177.85	240.62	74.52	100.82
Average	**$125.69**	**$170.05**	**$52.66**	**$71.25**

Source: Communications with 29 landfills around Australia

Note: Some data in this table has been derived from per tyre data collected, and from national averages
Note: High and low values have been presented in order to encompass commercial fees (lower), and general public fees (higher)
Note: In South Australia, Tasmania, Victoria, Western Australia and the Sydney metropolitan area, landfill of whole tyres is banned

4.2.3 Illegal Disposal

Illegal disposal generally refers to the dumping of tyres at sites that have failed to obtain the required approvals or licenses that illegally burn tyres, which cause environmental harm or threat, or that do not comply with fire brigade guidelines (SA EPA Guidelines 2003). In 2005 an estimated 3.2 million UEPU were illegally disposed in Australia, which consists of 11% of all end-of-life tyres entering the waste stream per annum.

Tyres disposed of illegally carry zero immediate cost to the transporter, collector or disposer, however do carry the risk of substantial fines or other penalties. This zero disposal charge in comparison to legal landfill is a chief motivator for the occurrence of illegal disposal. In contradiction, if landfill disposal charges are too low, then landfillers/waste receivers are more likely to conduct illegal disposal if their operating margins are too slim.

Tyres are typically disposed illegally in remote locations, which means that these tyres can be expensive to remove as a result of the high transport costs involved. In addition, if tyres are covered with dirt or are underground, then extraction costs are also high. In addition to the cost of cleanup, other impacts of illegal disposal are the same as for legal landfill of tyres: risk of fire, potential for mosquito breeding, provides habitat for weeds, possible breeding ground for vermin such as rate, and presenting a negative visual impact.

Figure 4.2 – Illegal Tyres Dumped in Rural Gully, NSW

Source: NetWaste[17] 2005 (Email Communication)

4.2.4 Stockpiles

Stockpiles can include illegally dumped tyres, industry stockpiles, or dedicated landfill cells for tyres that can potentially be extracted in the future for recycling (as in Victoria) (ARRB Transport Research 2004, p.45). The number of used tyres currently in stockpiles around Australia is estimated at 20 million UEPU (ARRB Transport Research 2004, p.9). Discussions with industry stakeholders revealed that due to the lack of record keeping, particularly in remote and regional areas, it is difficult to know this figure in more precise terms. It should be noted that the number of stockpiled tyres differs from the per annum amount of tyres illegally disposed (as discussed in Section 4.2.3) in that the tyre stockpile number is an aggregation of tyres dumped over a number of years, as opposed to the annual increase of illegally disposed tyres.

Stockpiles arise for a number of reasons, the main reasons being economic incentives for illegal stockpiling, combined with limited disincentives. Industry discussions have indicated that some stockpiles are set up in expectation that end-of-life tyres will increase in value as the tyre transformation market continues to mature in Australia, with these stockpilers waiting until used tyres will be in such high demand that they will receive a fee to sell them.

The number of tyres contributing to Australian stockpiles will be an important consideration into the model, as it is anticipated that these tyres will be drawn out into the market when the value of end-of-life tyres as a resource rises in line with increased demand for TDPs and the demand exceed the annual tyre

[17] NetWaste is a collaborative waste management project sponsored by the NSW Department of Environment and Conservation and the Central West (CENTROC) and Orana Regional Organisation of Councils (OROC), located in the central and western regions of New South Wales.

disposal quantities.

4.3 Tyre Transformation

Transforming a used tyre into a Tyre Derived Product (TDP) can on a basic level, be described as reducing an end-of-life tyre into gradually smaller and smaller particles, that tend to also become more and more purified. The different TDP categories have been divided into seven Transformation Categories (TCs) based on industry definitions by the Tyres Roundtable and by industry stakeholders.

Differentiating the various levels of transformation into categories of TCs enables closer analysis of each TDP based on the size of the final product's particles, the cost of production, and the value received for its sale in the market.

For this study, the following TCs have been adopted (for further detail see Appendix E – Classifications for Tyre Derived Products):

Table 4.9 – Transformation Categories for TDPs

TC	Type	Size (mm)	Transformation Cost[18] ($/tonne)	Deemed Market Value ($/tonne)
TC1	Whole Tyres		$0	$45 - 65
TC2	Cut Tyres	(300 mm+)	$35 - 50	$55 - 70
TC3	Tyre Chip	(30 mm – 299 mm)	$75 - 140	$120 - 135
TC4	Granulate and Buffing	(1 mm – 29 mm)	$160 - 250	$340 - 630
TC5	Crumb (Powder)	(0 micron[19] – 0.9 mm)	$250 - 350	$500 – 1,000
Steel	Steel	N/A	Included in above costs	$50 - 70
Textile	Textile	N/A	Included in above costs	$150 - 200

Source: Industry Discussions and URS Analysis 2005

The number of UEPU recycled into the various TDP categories in 2005, as well as the tonnes of TDPs that was produced from these end-of-life tyres in 2005 are detailed below:

18 Transformation costs include labour, power, maintenance, overheads, capital depreciation, property rental cost; but do not include collection, transportation or storage costs.

19 Note: 1mm is equal to 1,000 micron

Table 4.10 – Tonnes of TDP Produced in 2005

TDP	Type	TDPs Produced (tonnes)
TC1	Whole Tyres	21,280
TC2	Cut Tyres	210
TC3	Tyre Chip	110
TC4	Granulate & Buffing	9,760
TC5	Crumb (Powder)	17,775
Steel	Steel	9,121
Textile	Textile	1,496

Source: Industry Discussions and URS Analysis 2005

There are a number of transformers who conduct the processing to recycle end-of-life tyres into the various TCs. Transformation is dominated by a certain few companies what include:

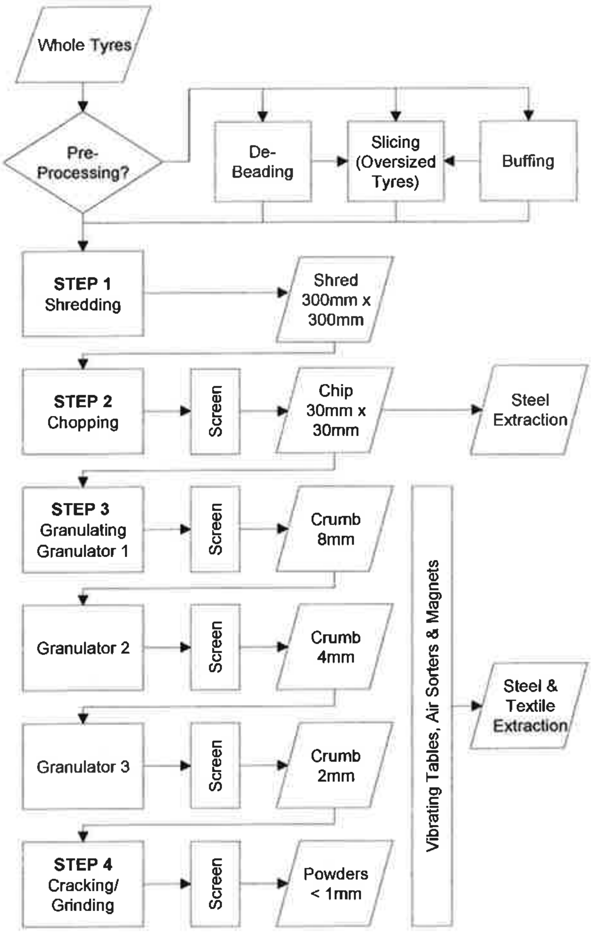
- SIMS Tyrecycle (VIC, NSW, QLD, SA);
- AEM Regenerative Rubber (NSW);
- Chip Tyre (QLD); and
- Affordable Rubber (QLD).

SIMS Tyrecycle is a major player in the used tyre industry as they conduct collection, transportation and transformation. They collect and dispose of approximately 66,500 tonnes of tyres per year, which consists of 28 percent of the entire 238,000 tonne end-of-life stream of tyres entering the market (SIMS Tyrecycle Website 2005 and URS Analysis). In terms of transformation, SIMS Tyrecycle produces about 10,000 tonnes of rubber crumb (TC5) annually, which equates to 56% of all rubber crumb produced in Australia in 2005 (see Table 4.10 above). Industry discussions revealed that three or four new processing plants for tyres are in the planning stages in Australia, revealing that competition for TDP production may be on the increase.

4.3.1 A Description of Generic Used Tyre Transformation

A generic overview of tyre transformation is provided in the following paragraphs, to demonstrate the general procedure working down through the Transformation Categories. The process is illustrated in Figure 4.3 below.

Figure 4.3 – Generic Used Tyre Transformation Process



Source: Personal Communication[6] 2005 and URS Analysis

As depicted in Figure 4.3, initial processing steps may take place including chopping, de-beading and/or buffing depending on the tyre size. In terms of de-beading, bead wire in tyres is demanding on the processing equipment so some processes prefer to conduct this step, however from a health and safety perspective de-beading can be dangerous.

Following this initial processing, there are a number of steps that are undertaken to transform used tyre inputs into the range of TCs, textile and steel. There are two types of tyre processing that are common to produce the smallest TDP particles (TC4 or TC5 size particles) – ambient grinding and cryogenic processing (Personal Communication[6] 2005). While Steps 1 and 2 must occur to begin transformation into any level of TC, Steps 3 and 4 alter depending on whether the ambient or cryogenic processing is to be carried out in the final stages of transformation. Tyre transformers are tending to move away from cryogenic technology to ambient grinding in recent years as it maintains more elasticity and is usually more cost efficient (ARRB Transport Research 2004, p.36).

Ambient Grinding

The ambient grinding process is based on continual size reduction at ambient temperature. Step down size reduction is undertaken so to balance efficient size reduction steps and the heat generated at each step. Moving along the size reduction process, TDP can be produced at any point in the process depending on size requirements and plant configuration, meaning that a range of TCs can be produced in one overall process. The TC5 produced from ambient processing has a rough surface. Industry research suggests that the ambient process generally involves high maintenance costs and down time for equipment maintenance as well as producing a coarser crumb with metal and textile contamination. The steps involved if ambient grinding will occur in the final stages are as follows:

- **Step 1 - Shredding** – Tyres are shredded to produce a coarse shred (TC2) size of 300mm x 300mm or larger. In some cases shredding is undertaken against a screen to sieve out different particle sizes.
- **Step 2 - Chopping** – The coarse shred chopped to produce a chip (TC3) between the sizes of 30mm x 30mm up to 299mm x 299mm. It is possible to chop to produce particles of size 15mm x 15mm (a TC4 granulate) if required for specific end uses. Up to 95% of the steel can be removed at this step.
- **Step 3 - Granulating** – The chips are granulated using two or three granulators depending on the size reduction required for the TC4 produced. Granulators use cutting teeth (or knives) rotating at medium high speed. Each step reduces that type particles by a 4:1 size reduction. Granulators have a normal size reduction limit of 3mm although a smaller size possible under special conditions. Buffing machinery is an alternative to produce TC4, with buffing a tyre removing the need to conduct the previous two steps.
- **Step 4 - Cracking or grinding** – Rubber granules are processed through a cracker (or grinding) mill to produce TC5 or some TC4.

Screens are normally integrated along each step and oversized rubber is returned through each step to be processed until sufficiently size reduced to pass through the screen and vibrating tables /air sorters /magnets can be used between stages of granulation and cracking/griding to remove textile, fine metal particles and provide specific size graded TDP.

Cryogenic Processing

If cryogenic processing will be carried out, the steps can vary slightly from the above steps for ambient grinding. Cryogenic processing is based on the use of liquid nitrogen or super chilled air to shatter the rubber. As with ambient grinding and depending on the tyre sizes some initial processing (de-beading, chopping, etc.) may take place.

- **Step 1 - Shredding** – Same as Step 1 for ambient grinding above.

- **Step 2 - Chopping** – This step may not be required depending on the cryogenic equipment but if done would produce a chip (TC3) between the sizes of 30mm x 30mm up to 299mm x 299mm.
- **Step 3 - Cryogenic process** – Tyre shred (TC2) or chip (TC3) is passed through a freezing chamber where either liquid nitrogen (-90 to -150°C) or super chilled air (-140°C) is used to freeze the tyre pieces to below its 'glass point', a temperature that allows tyre pieces to be shattered in a similar manner to glass. Liquid nitrogen consumption tends to be approximately equal to the quantity of crumb (TC5) produced (i.e. 1kg to 1kg).
- **Step 4 - Fracturing** – Frozen tyre pieces are size reduced using high impact crusher in a fracturing mill to shatter the shred/chip into a TC4 or TC5 particle size. Rubber crumb from cryogenic processing has a smooth surface and steel and textile is removed during fracturing.

Particle Distribution in TDP Transformation

In both ambient and cryogenic processing a plant will be configured from time to time to produce various grades of crumb or powders. In producing a particular crumb size (TC5) the plant will also produce material of a courser and larger grade (TC1-TC4).

Based on this estimate that all levels of TC are produced when creating a finer particle such as a TC5, the following number of UEPU are calculated to produce each TC, factoring that a percentage of each tyre is generally split amongst a number of TCs produced. The number of used tyre casings required to produce each differential level of TC is presented below in Table 4.11. This is based on the composition of a tyre, incorporating the losses as a result of transformation as well as loss based on the type of TDP produced. For example, TC1s do not experience any transformation losses hence the entire 8kg of a UEPU makes up the TDP. For a TC5 however, steel and textile are separated from the rubber so only 5.72 kg per UEPU (the rubber, and additives) is used to produce this TDP.

Table 4.11 – Number of Used Tyres to Produce each TDP

TDP	Type	Casings to Produce 1 Tonne of TDP (UEPU)
TC1	Whole Tyres	125
TC2	Cut Tyres	125
TC3	Tyre Chip	125
TC4	Granulate Buffing	170 700
TC5	Crumb (Powder)	175
Steel	Steel	Product of other TCs

TDP	Type	Casings to Produce 1 Tonne of TDP (UEPU)
Textile	Textile	Product of other TCs

Source: Industry Discussions and URS Analysis 2005

4.3.2 TC 1 (Whole Tyres)

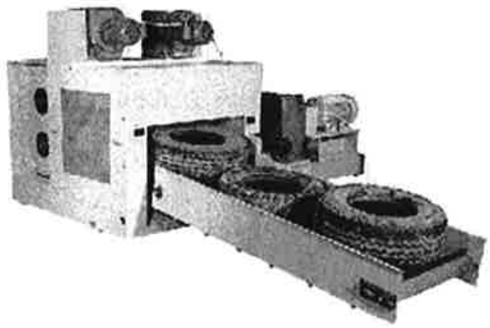
TC1 products are the largest in terms of size of the six TDP categories used in this study. They are whole tyres that are no longer suitable for repair, retreading, or reuse as a vehicle tyre. This TC is characterised by little or no processing occurring, as the tyres can be recycled in their whole form. The principal costs associated with the recycling of whole tyres relates to collection, transport and storage costs, which fall on transporters or end users, but not transformers (with transformers currently receiving a fee to take whole tyres in today's market). This means that the transformation costs for a TC1 product is zero or close to zero.

The market value that end use markets pay for whole tyres is between $45 – 65 per tonne of the TDP. Cement kilns are one of the largest users of TC1 products per year, with over 10,000 tonnes of TC1 used in kilns in 2005 alone for use as Tyre Derived Fuel. End use markets that a TC1 product is used in Australia include:

- Tyre Derived Fuel;
    - Cement kiln energy;
- Civil and marine applications;
    - Retaining walls (with sidewalls removed);
    - Soil embankments (can require sidewalls removed);
    - Void filler;
    - Mine wall stabilisation;
    - Anti-erosion measures; and
    - Artificial reefs and flood defences.

4.3.3 TC 2 (Cut/Shredded Tyres)

Figure 4.5 – Tyre Shredder



Source: Recycling of Scrap Tires Website 2005

The second transformation category (TC2) relates to shredded/cut tyres that are processed and sold into the end use market in sizes ranging from 300 mm and larger. This early stage of processing may include de-beading, sidewall removal, cutting, or basic shredding. Shredding of tyres involves cutting and tearing the waste tyre mechanically with shredders using a series of various sized rotating knives, and water sprayers can be used to lubricate, clean and keep dust to a minimum in the shredder (Monitor Tire Disposal Transformation 2005, p.1). Transformation costs for TC2 (not including collection, transport or storage costs) ranges between $35 – 50 per tonne of end-of-life tyres processed. For some end use markets such as retaining walls and soil embankments, the sidewalls of a tyre are removed, which gives a transformation cost of approximately $25 - $50 per tonne. This type of TC is included in the TC2 category as transformation has occurred over and above a TC1, and market prices are generally higher than for a TC1.

End use markets currently pay between $55 – 70 per tonne of Cut Tyre. The end use markets that a TC2 is used in Australia include:

- Tyre Derived Fuel;
    - Cement kiln energy; and
- Civil applications.

4.3.4 TC 3 (Chip)

Transformation of end-of-life tyres into the TC3 category involves size reduction that generally requires an additional process stage than a TC2 requires. This transformation involves initial grinding whereby TC2 particles are crushed between toothed rotor and stator tools, with the wire in TC2 aiding to accelerate the grinding process (Van Aarsen Rubber Technology 2005). This grinding process converts shreds into a wide range of fine powders and granules (Client Brief, p.6). The TC3 particle sizes produced range from 30 – 299 mm, with the market value and transformation costs varying depending on the amount of size reduction. The cost to transform an end-of-life tyre into Tyre Chip is between $75 – 140 per tonne of product produced.

The most common sizes of TC3 sold in the market are in 30mm, 40mm and 50mm particles (Personal Communication[5] 2005). The applications for TC3 are similar to TC2, but are generally where further size reduction is necessary. The end market value for Tyre Chip is between $120 – 135 per tonne of the TDP, with uses including:

- Tyre Derived Fuel;
  - Cement kiln energy;
  - Blasting;
- Civil applications;
  - Stemming; and
  - Drainage.

4.3.5 TC 4 (Granulate & Buffing)

The fourth transformation category, TC4, encompasses TDPs ranging from 1mm – 29mm in size. This TDP includes granulates that are further processed to a TC4 in a granulator with knives and screens to size reduce the particles another level, and to remove approximately 95% of the steel wire in the shreds (Van Aarsen Rubber Technology 2005). The TC4 category also includes buffings, which are produced either as a by-product of the retreading industry, or as part of a specifically designed process that buffs away the outer layers of rubber by spinning tyres at high speeds to remove their outer layers.

As mentioned, TC4 particles are produced between the sizes of 1 mm – 29 mm, with 4 U.S Mesh[20] (5mm), 12 U.S. Mesh (2.5mm) and 16 U.S. Mesh (1.2mm) being the most commonly traded sizes in the Australian market (Personal Communication[5] 2005). The transformation costs for these TDPs is between $160 - 250 per tonne of TDP produced, and the end market value paid for a TC4 to transformers is between $340 - 630 per tonne of TDP purchased. TC4 buffing from both specialised buffing processes and from retreading, are generally cheaper to produce, as they are generally a by-product of the retreading industry, and receive higher prices in the end market in comparison to the less pure TC4 granulate, hence there is a variation in the cost structure of these final products, although the particle sizes are similar.

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20 Mesh quoted here is based on a U.S. Mesh size, for breakdown into European Mesh size, inches and millimetres, please see Appendix E.

Communications with the industry revealed that there have been significant changes for the retread buffings market over recent years, as 15 years ago retreaders had to pay disposers and collectors to remove buffings, whereas in the current situation retread buffings receive a positive value (Personal Communication[4] 2005). This is perhaps an indicator of the increasingly positive value that TDPs are receiving in Australia.

The end use markets that a TC4 is used in Australia include:

- Energy uses;
    - Blasting material;
- Soft surfacing and matting;
    - Equestrian matting;
    - Sub floors;
- Mulches; and
- Moulded products.

4.3.6 TC 5 (Crumb/Powders)

Figure 4.6 – Production of Tyre Crumb, Cryopolymers Plant, Louisiana, U.S.

Source: NASA Spinoff Website 2005

With an estimated 18,000 tonnes of rubber crumb produced in 2005 in Australia, the TC5 market is the second largest of the TC markets following the TC1 whole tyre market (see Table 4.10). This is a capital intensive activity hence there are only a small number of processing plants, which tend to be located in the more populous States were large numbers of waste tyres are generated (Atech Group 2001, Pt.1, p.6).

As previously discussed and shown diagrammatically in Figure 4.3, there are two basic processes for producing rubber crumb:

- Ambient grinding – this involves mechanical shredding by equipment utilising robust high tensile blades that allow tyres to be shredded and ground (ARRB Transport Research 2004, p.34); and
- Cryogenic crushing (involving liquid nitrogen) – involves waste tyres being cut into chunks before moving into a freezing tunnel for shattering (ARRB Transport Research 2004, p.34).

A transformer reducing used tyres down to the smallest TC5 category tends to create other TCs throughout processing, as rubber particles of all sizes are created as a tyre is processed through. The transformation costs for producing a TC5 TDP is between $250 – 350 per tonne of product created, dependent on the particle size produced.

The most common size of TC5 sold in the Australian market is 30 U.S. Mesh (630 microns[21]), which is used in road surfacing, moulded products and adhesives. 40 Mesh and 60 Mesh particles are also used in a number of applications. 100 micron and smaller (≥140 U.S. Mesh) is not yet produced in Australia, however is commonly used in European markets, particularly for use in elastomers (Personal Communication[9] 2005).

[21] 1 mm is equal to 1,000 micron

The end market value for rubber crumb/powders is between $500 – 1,000 per tonne of the TDP sold, with end uses including:

- Road surfacing;
    - Asphalt;
    - Spray seal;
- Adhesives;
- General rubber mixing; and
- Elastomers.

4.3.7 Steel

The total end-of-life tyre flows for 2005 contains over 60,000 tonnes of steel, indicating that steel recovery is an important transformation to consider in the Scheme. Steel has an established recycling market in Australia and current scrap steel pricing is high due to a world-wide demand. Prices paid by metal recyclers are dependent on a number of factors such as the percentage of contamination (rubber), density (per cubic metre) and any impurities (alloys or non ferrous metal coatings).

Transforming tyres to TC3, TC4 and TC5 will liberate steel as a by-product of the transformation process and as such steel is often viewed a contaminant in TDPs, particularly rubber crumb and powder products. This contamination and its percentage is reflected in market prices in that premium prices are obtained for TDPs that are guaranteed metal free and magnetically separated materials are not acceptable [22] (Recyclers World Website 2005).

The situation for tyre steel recovery has changed little since 2001 when the Atech Group (2001, Pt.1, p.23) stated that "steel from tyres is not generally recycled because it is difficult to handle and is contaminated by rubber and other coating agents, and this reduces its value". Research undertaken for this study revealed that some recyclers are recovering steel and obtaining prices between $50 and $70 per tonne depending on the level of rubber contamination, with the higher price reflecting 'clean' steel. Research did not reveal that any standards exist specifying specify rubber contamination levels, which makes it difficult for tyre transformers to understand the expectations of metal recyclers. It is understood that U.S. steel mills limit rubber on steel to 5% by weight (Charles Lawrence Recycling Website 2005 and Personal Communication[6] 2005).

In the cement making process, steel in tyres does have a value when used as a fuel and contributes to the

[22] Example of specifications for a high-grade TC4 product: "No.1 Tire Granule (minus 40 mesh) shall consist of granulated tire crumb, Black Only Guaranteed Metal Free, sized to minus 40 Mesh. **Magnetically separated materials are not acceptable**. Fluff from tire cord removed. Minus 40 mesh refers to material that has been sized by passing through a screen with 40 holes per inch" Recyclers World Website 2005, Website http://www.recycle.net/Rubber/index.html

requirements for iron (Atech Group, 2001, Pt.1, p.23).

End use markets that steel is used for in Australia include traditional metal recycling markets. Some research in the U.K. has examined the use of steel fibre from tyres in reinforcing concrete structures (University of Sheffield Website 2005).

4.3.8 Textile

The total end-of-life tyre flows for 2005 contains over 10,000 tonnes of textile. Unlike steel, textile does not have an established recycling market in Australia. Research indicates that limited reuse of tyre recovered textile exists, however most transformers stockpile or landfill this material. Prices paid by recyclers are dependent on a number of factors including the percentage of contamination (rubber or other impurities), and its density (per cubic metre). Dependent on these factors, textile is reported to receive $150 to $200 per tonne based on world market prices.

Rubber with textile 'fluff' is a world traded commodity with prices ranging from US$40 to US$200[23] per U.S. ton dependent on steel removal, crumb size and rubber quality. The percentage of fluff is not specified (Recyclers World Website 2005). However, fluff by itself (or tyre derived textile) is not commonly traded. This recovered textile is a fluff-like material with the appearance of cotton or dirty cotton, and it is removed from the tyre process using screening systems, air classification systems, or both (CIWMB 2003, p.45).

A U.S. study concluded that tyre derived textiles have only a few isolated end uses with no well-established niche, regional, or global markets. This study attributed the situation to a lack of documentation of the characteristics of textiles, lack of types of uses and user-defined feedstock specifications, and lack of user knowledge of and experience with the textiles in specific applications (CIWMB 2003, p.113).

End use markets that textile can be used include carpet backing fuel, concrete additive and insulation (CIWMB 2003, p.113).

4.4 Enhancement of Tyre Derived Products

The TCs detailed in Table 4.9 and Appendix E that form the basis for analysis of TDPs throughout this study have been established based on the different particle sizes that end-of-life tyres are reduced to during transformation. In addition to the proposed TCs 1-5, the Roundtable has identified that differentiation by size alone will fail to recognise some other value adding activities that are entirely compatible with the objectives of the Scheme (Client Brief 2005, p.7). TDPs can be further value added by steel, fibre and miscellaneous contaminant removal, devulcanisation, advanced thermal treatments, solvent deconstruction and surface activation techniques, etc., to improve their marketability and net

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[23] Premium pricing relates to metal free and magnetic separation not acceptable

value to defined end uses and applications.

These incremental enhancements to the various size-based transformational categories can be recognised as possible Enhancement Benefits (EBs) additional to the basic size based categories (TCs), as they tend to produce the same sized particles but that are of a higher quality or are more applicable to particular end uses than the basic TCs. As EB technologies are only in initial developing stages and are comparatively experimental in Australia, there is little or no transformation cost or end-market value data available to determine in precise dollar terms the increased costs or values for EBs over TCs at this stage so it has not been possible to model them in this study. The Producer Responsibility Organisation (PRO) should be able to include these technologies into the Scheme to receive benefits as the industry advances and data becomes available.

Categories of enhancement might include:

- Further beneficiation (steel, fibre, contaminant removal);
- Devulcanisation;
- Advanced thermal treatments;
- Solvent deconstruction;
- Surface activation;
- Pyrolysis;
- Strategic inventory management; and
- Other sustainable activities to be promoted.

Details of the more significant EBs are below:

Devulcanisation

Devulcanisation refers to the technology that works to break the carbon-sulphur bonds of rubber so that the material can be recombined with polymers in a greater percentage than vulcanised rubber. This recycled rubber can be used as, or is compounded back into virgin rubber to give lower cost rubber products with good physical properties (Hickman and Sunthonpagasit 2003, p.9).

Devulcanisation technology remains under development around the world, with some patents developed in the U.S. Problems such as breaks in polymer chains that cause degradation of quality, as well as economic and environmental concerns have arisen through research of the process (Ohio Department of Natural Resources Website 2005). In addition, devulcanisation is reported to be both energy intensive and utilises a range of chemicals that could harm the environment (Atech Group 2001, Pt.1, p.72).

Through URS industry discussions it was found that a pilot plant will be opening in NSW in December

2005 for trialling of a patented devulcanisation process (Personal Communication[11] 2005). It was reported that this plant will demand buffings (TC4) as opposed to other TCs due to price and supply reliability (Personal Communication[11] 2005). This and other trials are anticipated to arise in Australia over the next few years, and this technology could transform the industry if progress is made in production of devulcanised rubber.

Surface modification

Surface activation/modifications involves treating crumb rubber particles so they bond together better, and is a compromise between using recycled rubber strictly as a filler and wholesale devulcanisation (Ohio Department of Natural Resources Website 2005). It is a technology whereby size-reduced rubber is exposed to either fluoride or bromide gas, and the gas causes a permanent chemical change to the outer layer molecules of rubber particles and allows it to blend with urethane (Hickman and Sunthonpagasit 2003, p.9). The technique is under research in a number of countries; however there still exist barriers to its full development and implementation on a large scale, in particular relating to the economic viability of the process (Ohio Department of Natural Resources Website 2005).

Atech Group (2001, Pt.1, p.72) reported on the commercial failure of an Australian operation using a U.S. proprietary process for surface treatment, following which there were no further commercial examples of this technology use in Australia. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed a technique that allows the surface of rubber crumb to be modified so as to make it compatible with virtually any other substance, and they were aiming to work with companies to complete a demonstration trial and commercialise the process (Atech Group 2001, Pt.1, p.72). Recent discussions with the CSIRO revealed that it has been a challenge to raise industry support for the continued trial of this technique: in part due to the technology being ahead of market demand 5-6 years ago when it was initially developed, and also because the funding for research has not been made available through support from industry players (Personal Communication[15] 2005).

Pyrolysis

Pyrolysis involves the heating of an end-of-life tyre (usually shredded) in the absence of oxygen in order to decompose the tyre into a number of products: carbon black, oil, gas, steel and a small quantity of inorganic slay or ash (Atech Group 2001, Pt.1, p.72). While markets exist in Australia for all of these products, they are generally of a low quality when separated from tyres hence their commercial value is limited. One of the major concerns with tyre pyrolysis has proved to be the difficulty in securing long term contracts for the produced carbon black and pyrolysis oil at attractive prices. In addition, end market users of the separated outcomes still regard new processes such as this as relatively unproven - and therefore risky (Juniper Consultancy cited in Scrap Tire News Website 2005)

Players involved in pyrolysis technology development in Australia include:

- EcoMat in NSW converting waste to fuel (process called Thermolysis) (ARRB Transport Research 2004, p.20); and

- Molectra Industries in QLD recovering jet fuel, diesel, carbon black and activated carbon (ARRB Transport Research 2004, p.20).

Current and Potential Uses of End-of-Life Tyres in Australia

The various TDPs that can be transformed from end-of-life-tyres have been discussed in Section 4 in terms of the Transformation Categories that are produced. Each of the TDP categories are applicable for use in a number of final end markets, dependent on particle size, TDP purity, and other requirements specific to each application.

There are generally three broad classifications of end use markets that currently or potentially utilise TDPs in Australia:

- Civil engineering;
- Energy; and
- Material recovery (rubber and other materials).

5.1 Civil Engineering Uses

Considerable research has been undertaken in Europe and the U.S the use of tyres for civil engineering applications and on the number of existing uses (European Tyre Recycling Association (ETRA) 2005). Civil engineering applications that utilise TDPs are characterised by the use of end-of-life tyres to utilise inherent structural properties and resilience that requires relatively little processing. Although relatively little processing may occur, the applications can be relatively sophisticated. Examples are retaining walls, roads, building foundations and stemming. ETRA has identified a range of civil engineering applications for whole tyres, and has estimated the quantity of tyres that would be utilised for each application, as listed below in Table 5.1:

Table 5.1 – Used Tyres in Civil Engineering Applications

Application	No. of Used Tyre Casings	Product
Sea embankment	3,000 UEPU	500m x 1.5m high
Temporary roads	3,000 truck tyres	1km of road
Heavy load road	200,000 UEPU	350m long x 10m wide
Artificial reef	30,000 UEPU	1km x 1m high
Breakwater	4,000 UEPU	1km x 0.7m high
Retaining wall	5,000 UEPU	500m x 2m high
Slope stabilisation	750 UEPU	500m x 1m high
Sound barriers	20,000 UEPU	1km x 3 m high
Heavy load road	200,000 UEPU	350m x 10m wide
Drainage culvert bed	50,000 UEPU	1km long
Riverbank stabilisation	5,000 bales	1500m riverbank
Coastal stabilisation	2,000 bales	1.3m high x 1km

Source: ETRA Website 2005 and URS Analysis

One difficulty related to the usage of whole or partially-whole tyres is determining whether or not they have reached a valid end use and ensuring they do not re-enter the waste tyre flows to present a disposal issue in the future. Under the structure of the proposed Scheme, structural or civil applications qualify as approved end uses if they are deemed as a permanent structure approved by a relevant planning authority and/or are subject to an approved environmental impact assessment (Tyres Roundtable Discussions and Client Brief 2004, p.16).

The following end use markets for rubber recovery will be discussed in this section:

- Retaining walls;
- Building foundations;
- Paving;
- Erosion control;
- Stemming; and
- Landfill engineering.

5.1.1 Retaining Walls, Building Foundations, Paving/Roads and Erosion Control

Retailing Walls

Retaining walls are made using whole tyres (TC1) with one side wall removed, that are then filled with crushed aggregate to form a 'structural' unit that can be used in various configurations and can be surfaced with a range of surface finishes such as coloured spray concrete (spraycrete or shotcrete), timber or coloured metal cladding. The walls can be either a gravity type, relying on its own weight to retain the supported material, or a reinforced type if the supported material is greater than a specified height. These principals are common to retaining wall design regardless of their construction material. In storm water retaining wall applications tyres can be used in conjunction with geofabrics.

Proponents of retaining wall systems utilising end-of-life tyres list their advantages in terms of high strength, high drainage capacity, flexibility in design and appearance, reduced construction time, ease of installation and low maintenance. A recovered rubber retaining wall system can be produced to comply with AS 4678 (Earth Retaining Structures). These are key attributes of any new construction system targeting market acceptance.

Building Foundations

An increasingly popular practice in concrete floor design for domestic and commercial ground floor concrete slabs is the use of permanent internal subfloor formwork to reduce the volume of concrete and steel used. A 'pod' system using tyres as effective filler provides an alternative to traditionally used polystyrene blocks. This type of system has the ability to utilise site generated fill material that is otherwise likely to be disposed off-site.

Paving/Roads

End-of-life tyres can be used in permeable road and hardstand construction systems for use in areas with poor soil conditions. For this application, truck or passenger tyres are used as containment devices enabling a structural sub base to be constructed from a single or double layer arrangement depending on ground conditions and load requirements. These roads can be left with permeable surface or sealed. This application is based on similar principals to retaining wall systems by making use of inherent structural characteristics of tyres.

The advantages of using used tyres in these road construction systems include their ability to withstand high structural loads, stability, draining characteristics and ease of laying and construction. The system utilises the minimum quantity of materials to achieve a given load-bearing standard with a reduction in excavation and construction materials and has been used in areas of wet, soft sub-grades and poor soil conditions.

Erosion Control

An additional application of end-of-life tyres is in the control of water erosion. The principal underpinning this use is that the inherent structural properties of tyres are used to retain free-draining aggregates similar to other devices such as rock mattresses. The properties of used tyre erosion control systems relate to energy dissipation, improving flow characteristics, reducing the velocity of the water, and providing a resilient surface that is not washed away. Proponents of these systems list the advantages in terms of construction speed, durability and reusability and a claim that the prices are 20% below competing technologies

Current Status and Size of the Industry in Australia

Table 5.2 – Industry Overview

Industry Variable	**Quantity[24]**
TDP Inputs	TC1
Price paid for TDP inputs	$45 – 65 per tonne
Industry size	3 major end market producers
Volume of TDP inputs pa – Current	174,000 UEPU 1,400 tonnes
Volume of TDP inputs pa – Potential	5 million UEPU 40,000 tonnes

Source: Industry Sources 2005 and URS Analysis

It is understood that three organisations operate in this sector in Australia who conform to the Roundtable and Client Brief requirements for a structural or civil application to qualify as an approved end use. These include:

- Ecoflex: civil engineering systems including retaining walls, foundations, erosion control, roads and paving;
- Biofloat: evaporation pontoons (e.g. cotton growers); and
- Industrial Recyclers: underground retention/distribution of on-farm water (ARRB Transport Research 2004, p.20).

Ecoflex has stated that over 1.2 million UEPUs of used tyres have been recycled to date in over 450 projects that they have carried utilising tyre derived civil engineering systems as described above. All Ecoflex construction using these used tyre systems has been engineer designed, certified and DA approved (Personal Communication[7] 2005). An example of this is the 16 km access road that they have built over soft ground conditions to access high voltage transmission lines for an energy utility company, which used 75,000 truck tyres (Personal Communication[7] 2005). The experience of Ecoflex suggests that this markets use of TDP inputs has potential in Australia.

Regarding the overall market size in Australia for retaining walls, building foundations, paving/roads and erosion control combined, there is uncertainty in regard to the entire market as there many sub-sectors within each end use market. Some sources have suggested that the retaining wall market is valued at between $220 - $270 million and the concrete slab market at between $120 - $170 million (Personal Communication[7] 2005).

[24] Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

5.1.2 Stemming

When blasting and charging is conducted in mines in Australia, this commonly occurs whereby holes are charged with explosives, with a detonator and primer lowered into the hole then Ammonium Nitrate and diesel (ANFO) pumped down the hole. The hole is then filled with stemming – certain-sized gravel that acts as a plug and forces the explosive energy to go into the surrounding rock, rather than back out the hole (Superpit Website 2005).

Stemming aids to maximise the amount of the energy utilised in the fragmentation process and to prevent dust explosions. Recently, tyre derived stemming has been successfully trialled at a number of Hunter Valley open cut coal mines, whereby gravel is replaced by used tyre products to act as the stemming agent. Data has been collected regarding the affects of tyre derived stemming on placement, environmental performance and distribution of waste post blasting. Details are as follows:

- Actual field trials conducted in 2000 and 2001 demonstrated that the tyre material performs as well as conventional stemming materials in highwall blasting applications;
- Studies showed that this material contributes no additional gasses other than those normally emitted from conventionally stemmed blast holes;
- Comparisons of CO^2 emissions with standard quarried stemming indicating a 50% reduction of CO^2 per tonne of product per annum for tyre derived stemming; and

Current Status and Size of the Industry in Australia

Table 5.3 – Industry Overview

Industry Variable	**Quantity[25]**
TDP Inputs	TC4 Granulate
Price paid for TDP inputs	$5 - 10 per tonne (price of gravel substitute)
Industry size	1 potential producer trialling
Volume of TDP inputs pa – Current	0 tonnes (trials only)
Volume of TDP inputs pa – Potential	9.4 million UEPU 55,000 tonnes

Source: Industry Sources 2005 and URS Analysis

The total stemming market in Australia is difficult to determine as stemming material varies in its characteristics and for some mining operations the material is quarried onsite. For those operations that require stemming to be imported to their sites, costs depend on the way in which the product supply is

[25] Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

contracted into the mine operation. One example is on a cost basis for material placed, whereby the cost of stemming encompasses the cost of the material quarried, transported to site, stockpiled and placed by a dedicated vehicle or fleet of vehicles.

Approximately one tonne of stemming is consumed for every 35 tonnes of saleable coal (URS Analysis). It is estimated that a total of 273 million tonnes of saleable coal was produced in NSW and Queensland in 2002 (Australian Mine Atlas, 2005) which would have made the total stemming usage in excess of 700,000 tonnes per annum[26]. These market sizes indicate the potential in the industry should tyre derived stemming build market share.

5.1.3 Landfill Engineering

Chipped tyres (TC3) can be used as material in landfill leachate draining layers. Leachate collection and removal systems are key components of modern-day engineered landfill sites and are designed to remove contaminated water from the base of a landfill cell to minimise the hydraulic head on the liner system (Warith, Evgin and Benson 2004, p. 967-979). Currently leachate collection layers are constructed at the base of each landfill cell using a 300mm think layer of river gravel. River gravel is a diminishing resource, and priced at $35 to $40 per tonne is one of the more expensive construction cost items in landfill development. The opportunity exists to use shredded tyres independently or in combination with gravel, the latter is a practice already used in North America (Warith et al 2004, p.967-979).

Current Status and Size of the Industry in Australia

Table 5.4 – Industry Overview

Industry Variable	Quantity
TDP Inputs	TC3, TC4 Granulate
Price paid for TDP inputs	$35 - 40 per tonne (price of river gravel substitute)
Industry size	1 potential producer trialling
Volume of TDP inputs pa – Current	0 tonnes (trials only)
Volume of TDP inputs pa – Potential	Unknown

Source: Industry Sources 2005 and URS Analysis

It is understood that end-of-life tyres are not used in this application in Australia, but that opportunity may exist in the future. The potential industry size has been difficult to estimate due to the fact that the market is not yet operating in Australia.

26 This figure is indicative as stemming is not used for underground mining and conditions of use vary with each mine and the mine geology and overburden characteristics and profile

5.2 Energy Uses

As end-of-life tyres have a chemical make and calorific/heating value consistent with energy recovery, tyres can be used to generate energy for various applications. The energy value of each tyre category is listed in Section 2 in Table 2.3 – Composition and Energy Content of End-of-life Tyres. Energy recovery is used in the following end uses in Australia:

- Tyre derived fuel; and
- Blasting material.

5.2.1 Tyre Derived Fuel

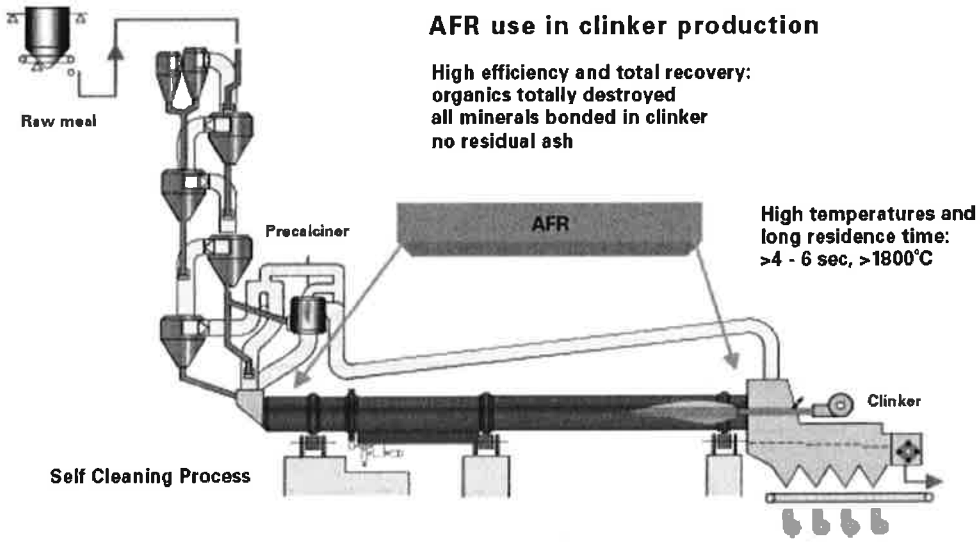
Tyre Derived Fuel (TDF) refers to the use of tyres as a fuel substitute for fossil fuels within furnaces for cement kilns, power stations, smelters or paper mills (ARRB Transport Research 2004, p.40). In Australia cement kilns are currently the only TDF facilities in operation.

In cement kilns, TDF utilises whole tyres (TC1), shredded tyres (TC2) or tyre chip (TC3) that are fed directly into the kiln that produces cement clinker. Tyres are burnt at very high temperatures (1450 degrees Celsius), and the steel in the tyres actually contributes to the kilns chemical requirements, so there are very little remains and close to the entire tyre is used. Any residue can be incorporated into the clinker material that is ground to gypsum to produce cement (Cement Industry Federation (CIF) Submission to Energy Efficiency Inquiry 2004, p.5 and ARRB Transport Research 2004, p.40-41).

There is an acknowledgement in the industry that TDF is not the HNRV for end-of-life tyres, and that it is not the most favourable sustainable solution to the waste tyre problem from a waste management hierarchy perspective. However it is a viable alternative that has benefits over alternative options including landfill and waste incineration (ARRB Transport Research 2004, p.40).

A process diagram for the use of Alternative Fuels and Raw Materials (AFR) in cement kilns is shown in Figure 5.1 below:

Figure 5.1 – AFR – Destruction of Industrial By-products in Cement Kilns



Source: Geocycle – Environmental Solutions for Industry 2001, p.3

Current Status and Size of the Industry in Australia

Table 5.5 – Industry Overview

Industry Variable	Quantity[27]
TDP Inputs	TC1, TC2, TC3
Price received by kilns for TDP inputs	≤ $2.50 per UEPU
Value of TDP inputs	$74 – 88 per tonne[28] (price of energy equivalent)
Industry size	2 cement kilns
Volume of TDP inputs pa – Current	1.2 million UEPU 9,740 tonnes
Volume of TDP inputs pa – Potential	8.8 million UEPU 70,000 tonnes

Source: Industry Sources 2005 and URS Analysis

There are three producers of cement in Australia: Adelaide Brighton Ltd, Blue Circle Southern Cement Ltd and Cement Australia Pty Ltd, all of which are represented by CIF, the national representative body (CIF 2005, p.1). At present there are two cement facilities that are using tyres for fuel: the Blue Circle Southern Cement plant at Waurn Ponds in Victoria, and the Cement Australia plant at Gladstone in Queensland. Commencing the use of waste tyres as fuel first in 1993, the Waurn Ponds plant is considered the Australian industry leader with respect to alternative fuels, with 50% of its energy needs supplied by used tyres, waste oil, carbon anode dust and tallow bottoms (CIF 2004, p.9). This plant uses around 9,500 tonnes of tyres per annum (ARRB Transport Research 2004, p.40). There are industry expectations that within two years alternative fuels will supply 75-80% of the kiln's energy needs (CIF 2004, p.9). In terms of the technical process, currently whole tyres are fed into the back end of the kiln where combustion occurs at 900 degrees Celsius (ARRB Transport Research 2004, p.40).

The Gladstone plant is the only kiln of the four Cement Australia kilns that recovers energy from used tyres. This plant uses approximately 240 tonnes per annum, despite expectations of Cement Australia that without certain barriers to industry development, the plant could consume 2,000 tonnes of tyres per year (Personal Communication[10] 2005). Pre-calciner kilns such as Gladstone cannot take whole tyres, so tyre

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27 Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

28 Calculations for Price of Whole Used Tyre Energy Equivalent:
Given that October 2005 thermal coal price USD 54/tonne = AUD 74/tonne (CNN International Website 2005 and Universal Currency Converter Website 2005)
And given that Energy from used tyres = 27 GJ/tonne, and Energy from thermal coal = 27 GJ/tonne (Atech Group 2001, p.28)
Hence, price of used tyre energy equivalent = (27 GJ/tonne / 27 GJ/tonne)*AUD 74/tonne = AUD 74/tonne

Calculations for Price of Shredded Used Tyre Energy Equivalent:
Given that October 2005 thermal coal price USD 54/tonne = AUD 74/tonne (CNN International Website 2005 and Universal Currency Converter Website 2005)
And given that Energy from used tyres = 32 GJ/tonne, and Energy from thermal coal = 27 GJ/tonne (Atech Group 2001, p.28)
Hence, price of used tyre energy equivalent = (32 GJ/tonne / 27 GJ/tonne)*AUD 74/tonne = AUD 88/tonne

chip is demanded at this plant and the plant must chip on-site or purchase pre-chipped TDP (ARRB Transport Research 2004, p.41). The issues with chipping is that unless the tyres are cleanly cut the metal can cause 'bear claws' and foul the smooth flow of TDF into the kiln (Personal Communication[10] 2005).

In terms of the industry process for tyres used in kilns, this varies between the two operating tyre-kilns. Blue Circle Southern Cement contracts a collector to transport and deliver their tyre resources, with Atech Group reporting in 2001 (Pt.1, p.7) that they had contracted with SIMS Tyrecycle to deliver a minimum number of tyres each year. As a result Blue Circle Southern Cement uses a significant proportion of waste tyres generated in Victoria in their kiln, with estimates of over 50% of all Victoria-generated waste tyres going to TDF applications in cement kilns (Atech Group 2001, Pt.1, p.7).

For Cement Australia, Geocycle is a wholly owned subsidiary of the group operating as a vertically integrated tyre collector that directly controls the supply of tyres for fuel in Queensland (Atech Group 2001, Pt.1, p.7). Geocycle charges collection fees to take post-consumer tyres in the order of $2.50 per tyre, with this price being supported by the local councils agreeing to increase their landfill fees to this level or above (Atech Group 2001, Pt.1, p.11). Atech Group (2001, Pt.1, p.11) reported this to be a higher price for collection than States where there is significant competition for the collection of waste tyres.

It is understood that the cement industry in other States (in particular NSW and SA) are keen to investigate further the use of waste tyres for fuel (ARRB Transport Research 2005, Pt.1, p.7). In terms of other cement kilns:

- Berrima Plant in South West Sydney has initiated trials including tyre burning and are reviewing options however they do not currently have facilities to receive or burn whole tyres or chips (ARRB Transport Research 2004, p.41); and
- Adelaide Brighton's plants in Port Adelaide, Birkenhead, Cockburn, Dongara, and Northern Territory are utilising AFR however are "progressing cautiously to ensure environmental and quality issues are resolved" so are still not using tyres in their fuel mix (ARRB Transport Research 2004, p.41).

5.2.2 Blasting Material (Fuel)

Ammonium nitrate is used in the mining industry as a blasting medium in a mixture with diesel. This blasting material is placed in pre-drilled holes which are plugged with stemming. Blasting is used as an efficient method of over burden removal in open cut mining operations and it use is essential with respect to productivity, environmental performance and safety (Personal Communication[13] 2005).

The blasting industry is structured to provide specialist contracting services to mining operators based on material supply and placement over a specified contract terms. Blasting materials are delivered to the mine placed in the blast holes using specially designed vehicles that mix the ammonium nitrate, diesel and emulsifiers into an emulsion. The mixture is commonly a proportion of 94% ammonium nitrate and 6% diesel.

An alternative mixture has been developed and patented that is based on replacing the diesel in the blasting mix with granulate (TC4) in a proportion that reduces the ammonium nitrate percentage to 93%. It is understood that successful trials of this mixture have been undertaken.

Current Status and Size of the Industry in Australia

The blasting material market is dominated by two suppliers, Orica and Dyno Nobel. It is understood that this market has changed recently with Orica purchasing the business of Dyno Nobel. These suppliers are also manufacturers of ammonium nitrate. It is understood that that in 2002 approximately 1 million tonnes of ammonium nitrate and approximately 64,000 tonnes of diesel was supplied to the Australian mining industry for blasting (URS Analysis).

Table 5.7 – Industry Overview

Industry Variable	Quantity[29]
TDP Inputs	TC4 Buffing
Price paid for TDP inputs	$500 – 600 per tonne
Price of substitute	$1,025 per tonne
Industry size	Developing
Volume of TDP inputs pa – Current	0 tonnes (trials only)
Volume of TDP inputs pa – Potential	12.6 million UEPU 74,000 tonnes

Source: Industry Sources 2005 and URS Analysis

5.3 Rubber Recovery Uses

As anywhere between 40 to 42 percent of a used tyre consists of rubber, the recovery of rubber is an important industry in terms of recovering value of tyres (See Table 2.2 – Composition and Energy Content of New Tyres for reference to percentages). Rubber recovery from end-of-life tyres is a growing market in Australian and many other countries in the world, and a number of TDPs are becoming inputs into of a variety of end market products.

The following end use markets for rubber recovery will be discussed in this section:

- New tyres;
- Road surfacing;
- Flooring and mats;
- Moulded products; and

[29] Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

- Adhesives.

5.3.1 New Tyres

It is important to address, at least briefly in this study, why recovered rubber is not commonly transformed for use in the production of new tyres. Because of speed, safety and other performance requirements of new tyres, they need to be made mostly using virgin rubber compound, however some stakeholders in the U.S. have found that mixing 5 - 15 percent recycled rubber into the virgin rubber provides a few advantages in the production process, including better mixing properties and an increase in plant efficiency due to reduced curing times (Ohio Department of Natural Resources Website 2005). SPT use 5% recovered rubber in the raw material input mix for some of their tyres, however there are constraints associated with the properties of vulcanised rubber derived from recycled waste tyres, with Bridgestone not using any recycled rubber in their manufacturing process (ARRB Transport 2004, p.30). Devulcanised rubber is more suitable for use in new tyres; however this technology is only in development stages in Australia, which in combination with a low new tyre manufacturing levels in Australia compared with other countries, means that this end use is not likely to increase significantly in Australia (ARRB Transport Research 2004, p.34). However if changes in devulcanisation cost and technology occur, this situation could move towards increased new tyre production from recycled tyres. (Devulcanisation will be discussed further in Section 4.4 below.)

5.3.2 Road Surfacing

The use of TDPs in road surfacing has been discussed with a range of stakeholders including New South Wales Roads and Traffic Authority (NSW RTA), VicRoads, Queensland Department of Main Roads, South Australia Transport SA, Tasmanian Department of Infrastructure Energy and Resources, Northern Territory Department of Infrastructure Planning and Environment, Australian Asphalt Pavement Association, Sprayline, SAMI, Boral Asphalt and Bituminous Products.

In Australia, there are two road surfacing applications where rubber crumb can be used as inputs:

- Spray Seal – rubber modified binder can be used in this process (CSR Website 2005); and
- Asphalt – bitumen can be modified by the incorporation of rubber top create asphalt (CSR Website 2005).

Recovered Rubber in Spray Seal

Spray seal is a "pavement surface treatment consisting of a sprayed film of bituminous binder covered with aggregates" (ARRB Transport Research 2004, p.35). Successful trials have been conducted on the use of recovered rubber in spray seals by the AAPA, VicRoads and NSW RTA, and the use of rubber crumb in spray seals is now a standard practice in NSW and Victoria, and is included in the specifications of use for most other Australian states/territories. Of the total 915 tonnes of rubber crumb used in roads annually nearly all contributes to spray sealing.

A rubber modified binder used in a Spray Seal is commonly referred to as Crumb Rubber Modified binder (CRM). The use of CRM tends to be limited to sealing applications targeting pavements under distress that are cracked or near end-of-life, in order to give added surface life. The use of spray is reported to deliver reliable performance in terms of addressing the characteristics of pavement fatigue such as the loss of stone and the onset of cracking (ARRB Transport Research 2004, p.35).

There are two ways that CRM can be combined in spray seals:

- Mixed at plant – CRM is manufactured then transported to the site where paving is to occur
→ *total spray seal mix usually contains at least 20% recovered rubber by mass*; or
- Mixed in the field (generally preferred approach) – bitumen is delivered to the site where a machine incorporates the recovered rubber into the binder; then there is an ingestion process of 30-60 minutes before the spray seal can be applied
→ *total spray seal mix usually contains at least 20% recovered rubber by mass* (ARRB Transport Research 2004, p.35).

Of the two basic processes for producing rubber crumb: ambient grinding or cryogenic processing, the ambient grinding method produces a better product for CRM modified binder applications. The cryogenic processes tend to result in a crystalline structure in the rubber that reduces the elastic properties of the binder, even though the cryogenic process is better in term of being more pure (ARRB Transport Research 2004, p.35). Tyre transformers have moved away from cryogenic technology to ambient grinding. An input specification requires a minimum metal content as this can be detrimental to the spraying operation, as well as defining a specific particle size (ARRB Transport Research 2004, p.36).

Recovered Rubber in Asphalt

Crumb rubber asphalts are relatively uncommon in Australia although they have been used overseas. In the U.S., various types of rubber asphalts are used and performance has been varied, in part due to the mixing process used (ARRB Transport Research 1999). The few trials carried out in Australia where crumb rubber asphalt has been placed over badly cracked concrete and flexible pavements have performed very well. Boral Asphalt, NSW RTA and Pioneer Road Services are currently involved in trials for the use of crumbed rubber in asphalt (Sustainable Strategic Solutions 2005, p.30).

In asphalt, TC5 can be used as a part of the asphalt binder that is modified, or as an aggregate substitute. There are two processes used to incorporate TC5 into asphalt:

- Wet process – crumb rubber and bitumen are combined together at high temperature to produce a crumb rubber binder. The crumb rubber binder is then added to aggregate in a mixing plant in the same way as any other binder
→ *binder usually contains at least 20% recovered rubber by mass*; or

- Dry process – dry rubber particles are added to aggregate and bitumen in a pugmill at the asphalt mixing plant, with rubber usually mixed with the aggregate prior to bitumen addition
→ *total asphalt mix usually includes 2.5% recovered rubber by mass* (ARRB Transport Research 1999).

Table 5.9 – Amount of Recovered Rubber Used in Asphalt

Category	Amount
Amount of rubber used	4-6% of total mix (weight-based)
Density of asphalt mix	2,200 kg per m^3
Amount of asphalt mix used	59 tonnes per lane-km
Amount of rubber for each km of mix per lane (at 5% of mix)	3 tonnes per lane-km

Source: ARRB Transport Research 2004, p.36

Generally, the amount of TC5 that can be used in asphalt roads is 5% of the mix (in comparison with 20% of the mix in spray sealed applications) (ARRB Transport Research 2004, p.37). Asphalt mix is usually about twice the density of a spray seal mix, so as shown in Table 5.9 above, 3 tonnes of recovered rubber is required for each lane-km constructed using asphalt (in comparison to 1.6 tonnes of TC5 for each lane-km of spray seal) (ARRB Transport Research 2004, p.37).

Current Status and Size of the Industry in Australia

Table 5.10 – Industry Overview

Industry Variable	Quantity[30]
TDP Inputs	TC5 (30 U.S. Mesh)
Price paid for TDP inputs	$400 - 600 per tonne
Price of substitute input	$3,000 per tonne (price of polymer)
Industry size	3 states use TDPs in roads 5 main road contractors supply
Volume of TDP inputs pa – Current	160,125 UEPU 915 tonnes
Volume of TDP inputs pa – Potential	15.8 million UEPU 90,000 tonnes

Source: Industry Sources 2005 and URS Analysis

In terms of the end market producers using TDPs, there are five main road contracting companies that produce and supply rubber modified products for road construction and maintenance in Australia:

30 Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

Sprayline, SAMI, Boral Asphalt, Bituminous Products and Pioneer Road Services. The supply-side of modified road construction/maintenance products operates similarly in most Australian states, whereby long-term (10-year) maintenance contracts are used, meaning that private contractors hold control and responsibility for roadway system maintenance, rehabilitation, and capital improvements (US Department of Transportation 2002, p.17). These contracts are performance based and require contractors to meet a set of standards, hence the use of TDPs or not in road products is a decision of the road contractors as long as they adhere to local/state/national specifications (US Department of Transportation 2002, p.17).

In relation to the demand for TDPs of the road end market producers, the annual use of rubber crumb in Australia's roads is estimated below:

Table 5.11 – Use of TDPs in Roads 2005 (per state/territory)

State/Territory	Tonnes pa
VIC	400
NSW	500
WA	15
SA	0
QLD	0
TAS	0
NT	0
ACT	0
Total	**915 tonnes pa**

Source: Industry Sources July/August 2005

Table 5.12 – Use of TDPs in Roads 2005 (per use)

Use	Tonnes of TDP Used pa	No. of Casings Used pa (UEPU)	Km of Laneway surfaced pa (lane-km)
Asphalt Use	50	8,750	17
Spray Seal Use	865	151,375	541
Total	**915 tonnes**	**160,125 UEPU**	**558 km of laneway**

Source: Industry Sources July/August 2005

Table 5.12 above shows that assuming a 20% mix of CRM in the spray seal mix indicated above, the current Australian usage of 865 tonnes of TC5 in spray seal is equivalent to 541 lane-km of spray sealed road for one year[31]. This is equivalent to 151,375 used tyre casings per annum that are removed from the waste stream.

The 50 tonnes per annum for asphalt use that is reflected in Table 5.12 above relates to the use of rubber

[31] Based on 1.6 tonnes of TC5 per each km of lane, at 20% of mix as determined above (865 tonnes / 1.6 tonnes = 541 lane-km)

crumb for NSW RTA/Boral Asphalt trials. Assuming a 5% mix of crumb rubber in the asphalt mix, the current Australian national usage of 50 tonnes of rubber crumb in asphalt is equivalent to 17 lane-km of rubberised asphalt road over one year[32]. In UEPU this would work out as 8,750 used casings per annum used for this asphalt trialling.

5.3.3 Flooring and Mats

The use of recovered rubber in flooring and mats is a growing industry in Australia. Examples of the use for TDPs in flooring and matting applications are as follows:

- Soft fall rubber surfacing for use in playgrounds, work areas, industrial applications, etc.;
- Carpet underlay;
- Safety matting;
- Marine decking;
- Horse float and utility linings;
- Sport flooring, athletic tracks, tennis courts, gymnasium flooring and matting, and equestrian surfaces and workout areas;
- Livestock mats (used in dairies, processing plants, etc.) (Sustainable Strategic Solutions 2005, p.30); and
- Rubber mulch.

For this end use market, TDPs provide the benefits of being low cost fillers that can add elasticity and performance to products. In the manufacture a wide range of flooring and mats, TDPs can prevent injury and stop slipping, or assist with anti-fatigue for high traffic areas (Sustainable Strategic Solutions 2005, p.30). Recovered rubber can be used as 'filler' in industrial products, such as in the manufacture of carpet underlay, where the rubber is used as cheap filler that provides bulk and weight (Sustainable Strategic Solutions 2005, p.30). TDPs are also used in leisure applications that require a coarser granule product, e.g. athletic tracks, hockey fields, sports and playground surfaces (ARRB Transport Research 2004, p.34).

32 Based 3 tonnes of rubber crumb per each km of lane, at 5% of mix as determined above (50 tonnes / 3 tonnes = 17 lane-km)

Current Status and Size of the Industry in Australia

Table 5.15 – Industry Overview

Industry Variable	Quantity[33]
TDP Inputs	TC4, TC5
Price paid for TDP inputs	$350 - 600 per tonne
Industry size	35 surfacing companies
Volume of TDP inputs pa – Current	2.12 million UEPU 10,850 tonnes
Volume of TDP inputs pa – Potential	3.21 million UEPU 15,850 tonnes

Source: Industry Sources 2005 and URS Analysis

Flooring, mats and other surfacing is a major business stream for recovered rubber, using approximately 10,850 tonnes of TC4 and TC5 in end market products. An estimated 35 surfacing companies operate Australia-wide producing playgrounds, footpaths, flooring for stables, etc., though it is unclear how many of these utilise recovered rubber in their products (ARRB Transport Research 2004, p.44).

Sports Technology International (STI) is a Sydney and Hong Kong-based company (linked with Balsam Pacific) that serves the Asia Pacific market as a manufacturer and installer of synthetic turf, and they have a product that utilises recovered rubber: Poligras MT, which is an artificial turf utilising a layer of recycled rubber granules for force reduction and improved maintenance (see Figure 5.6 below). This recovered rubber turf has been used in Hong Kong, Dubai, Korea, U.S. and Japan, with Telstra Dome in Melbourne recently laying recycled-rubber Poligras MT on its boundaries and boundary surrounds, as shown in Figure 5.5 below (STI Website 2005).

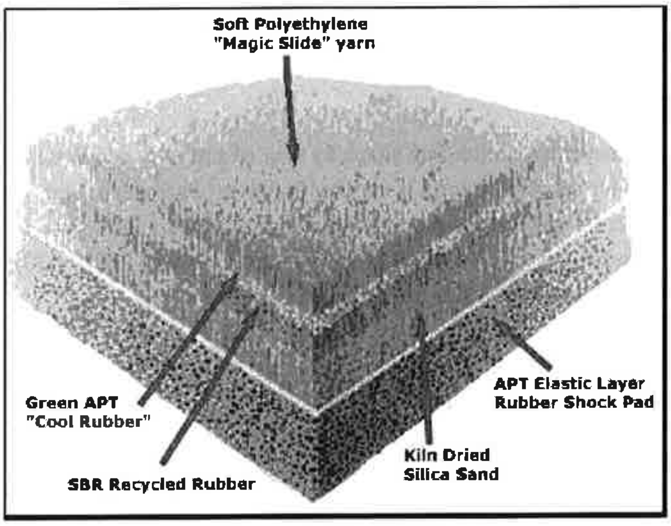
33 Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

Figure 5.5 – Laying Artificial Turf Containing Recovered Rubber at Melbourne's Telstra Dome (April 2005)

Source: STI Website 2005

The composition of this artificial turf showing the layer of Green "Cool Rubber" is shown below in Figure 5.6:

Figure 5.6 – POLIGRAS NF Composition



Source: STI Website 2005

Table 5.16 below shows the number of used casings (UPEU) that are required to produce surfacing/flooring products:

Table 5.16 – Tyre Usage for Surfacing/Flooring Products

Treatment	No. of Casings Used (UEPU[34])	Product
Playground surface (25 mil)	1,400	per playground (av. 500m^2)
Play area safety surface	300	per play area (av. 50m^2)
Sports field (15 mil)	6,000	per 6000m^2
Tennis courts	700	per 680m^2
Indoor tracks & surfaces	1,300	per 1000m^2 gymnasium
Tram rail beds	2,000	per kilometre
Metro rail	2,000	per kilometre

Source: Annex 5, Basel Convention Technical guidelines on the identification and management of used tyres, URL: www.basel.int, cited in SATRP 2005

Another flooring product that is achieving success from the use of TDP inputs is rubber mulch. Rubber mulch is a flooring product that is currently being produced in Australia by a company called Rubberilliant. This company buff solid rubber tyres (mainly solid forklift truck tyres) into coarse mulch for use in landscaping and sporting/equestrian surfaces. Rubberilliant processes approximately 500 tonnes of types per annum for this use, with all of their mulch produced currently all exported to the U.S. There could be growth in this market if Australian demand for this product is tapped in the future (Personal Communication[15] 2005).

5.3.4 Moulded Products

Moulded products are those that are set into shape by way of a mould, and these products utilise both new and recycled rubber as inputs. This market is another important business stream that makes use of recovered rubber TDPs. These products can be made from more than 90% recovered rubber, with added binder and colour pigment if required (Sustainable Strategic Solutions 2005, p.30). The products that typically are included in this end use market are:

- Speed humps and cushions;
- Crash barriers;
- Guideposts;
- Bollard bases; and
- Regulatory signage (Sustainable Strategic Solutions 2005, p.30).

[34] Note: source quoted tyre usage in number of 'tyres', so was assumed that reference was to 1 tyre = 1 UEPU

Current Status and Size of the Industry in Australia

Table 5.17 – Industry Overview

Industry Variable	**Quantity[35]**
TDP Inputs	TC4 Buffing, TC5
Price paid for TDP inputs	$350 - 600 per tonne
Industry size	Unknown
Volume of TDP inputs pa – Current	2.2 million UEPU 10,000 tonnes
Volume of TDP inputs pa – Potential	4.3 million UEPU 13,000 tonnes

Source: Industry Sources 2005 and URS Analysis

Table 5.18 below shows the number of used tyre casings (UEPU) that are used to produce moulded products, indicating the possibility to utilise a number of used tyres in this market:

Table 5.18 – Tyre Usage for Moulded Products

Product	**No. of Casings Used (UEPU)[36]**
1 traffic cone base	3
1 speed cushion	120
1m kerbing or speed hump (approx 15cm wide)	6

Source: Sustainable Strategic Solutions 2005, p.30

Elastomers are polymers that resist and recover from deformation produced by force, producing similar in behaviour to natural rubber. There are currently a number of moulded products that utilise elastomers containing polyvinyl chloride (PVC), and industry discussions have revealed that recovered rubber can be used in elastomers to replace PVC. This could be seen as an advantage considering that many countries are already banning PVC due to the high environmental and human health costs of its use, such as emitting toxic compounds (Greenpeace International Website 2005). There is market interest in taking advantage of the potential market in Australia for PVC-free elastomers, particularly for use in the car injection modelling industry e.g. dashboards and sound deadening devices under bonnets. The elastomer market would require the finest grades of TC5, from 40 to 60 microns, which are estimated at an end market value of $1,200 – 2,000 per tonne. These fine-grade TC5s are currently not produced in Australia, however Europe and particularly Germany have a strong market for these TDPs, indicating that there are a number of potential uses. It is understood that there is strong potential in the Australian elastomer market, and these figures have been incorporated into the model to allow for this growth. This potential

35 Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

36 Note: source quoted tyre usage in number of 'tyres', so was assumed that reference was to 1 tyre = 1 UEPU

growth has not been included in Table 5.17 as the potential market becomes significantly higher with the inclusion of elastomer moulded products.

5.3.5 Adhesives

Recovered rubber can also be used to produce industrial adhesives, particularly as a tile adhesive (Sustainable Strategic Solutions 2005, p.30). Rubber crumb (TC5) is used in the manufacture of tile adhesives providing a range of product benefits such as weight reduction (bag weight), improved coverage, longer workability, flexibility and sound attenuation. The addition of rubber crumb in adhesives is a uniquely Australian product with the lower adhesive densities allowing double the surface coverage of products sold in Europe or the U.S. Interest in TDP use in adhesives is now spreading to Europe as manufacturers develop global formulations of products in keeping with international standards (Personal Communication[14] 2005).

Rubber crumb does have disadvantages in this end use market however, primarily related to poor bonding into the adhesive matrix. Research indicates that this because SBR binders present in motor vehicle tyres generally do not bond as well as polymer additives, which are used specifically to improve adhesion and are substitute products to TDPs in adhesives. Rubber with higher proportions of natural and not synthetic rubber (as is the case for most motor vehicle tyres) generally has higher proportions of SBR. The use of surface modification to solve this difficulty and bond particles together better has proven to be too expensive in this end market use.

Current Status and Size of the Industry in Australia

Table 5.19 – Industry Overview

Industry Variable	Quantity[37]
TDP Inputs	TC5
Price paid for TDP inputs	$550 - 900 per tonne
Volume of TDP inputs pa – Current	1.1 million UEPU 6,000 tonnes
Volume of TDP inputs pa – Potential	1.8 million UEPU 10,000 tonnes

Source: Industry Sources 2005 and URS Analysis

It is estimated that approximately 6,000 tonnes of TC5 is used in the adhesive current market with the majority of crumb being supplied in the 30 U.S. Mesh range. The majority of the crumb is cryogenically processed, however for adhesive production, ambient griding crumb is preferred as it provides a rougher surface that is better for adhesion in the adhesive mix. Limited markets exist for 50 U.S Mesh crumb although it is estimated that this market will grow in the future. It is uncertain as to the percentage of

[37] Refer to Table 4.11 for basis of UPEU – tonne conversion per TC

adhesives that have rubber crumb additives in proportion to the total tile adhesive market (Personal Communication[14] 2005.

5.4 Recovery of Other Materials

5.4.1 Steel

As discussed in Section 4.3.7, if steel is recovered from end-of-life tyres in a clean and pure enough form, then tyre derived steel can be sold into the scrap steel market in Australia. Attaining steel that is relatively free of impurities and tyre residue is difficult in the tyre transformation process, and this is the major barrier to tyre derived steel's increased use. Steel is one of the world's most recycled products, and currently in Australia about 70 percent of available steel scrap is recycled, indicating that if tyre steel is clean enough, that there is a large market opportunity (Bluescope Steel Website 2005).

Current scrap steel pricing is high due to a world-wide demand, prices in Australia ranging from $50 – 100 per tonne. Any contamination and its percentage resulting from transformation of steel from used tyres is reflected in market prices (Recyclers World Website 2005).

In the cement making process, steel in tyres does have a value when used as a fuel and contributes to the requirements for iron (Atech Group, 2001, Pt.1, p.23).

5.4.2 Textiles

The total end-of-life tyre flows for 2005 contains over 10,000 tonnes of textiles. Unlike steel, textile from tyres does not have an established recycling market in Australia. As tyre derived textile recycling is still a very immature market, data has been difficult to obtain on textile recovery. Research has revealed that most textiles arising from the TDP transformation process is either stock piled or landfilled.

End uses identified include fuel, concrete additive, carpet backing and insulation.

5.5 Summary of Market Potential for Approved End Uses

Table 5.20 – Current and Potential Size of TDP End Use Markets

End Use	TDP Input	Current Used Tyre Inputs	Potential Used Tyre Inputs[38]
Civil Engineering			
Retaining Walls, Foundations, Pavings & Erosion Control	TC1	1,400 tonnes 174,000 UEPU	40,000 tonnes 5 million UEPU
Stemming	TC4 Granulate	0 tonnes (trials only)	55,000 tonnes 9.4 million UEPU
Landfill Engineering	TC3, TC4 Granulate	0 tonnes (trials only)	Unknown
Energy			
Tyre Derived Fuel	TC1, TC2, TC3	9,740 tonnes 1.2 million UEPU	70,000 tonnes 8.8 million UEPU
Blasting Material	TC4 Buffing	0 tonnes (trials only)	74,000 tonnes 12.6 million UEPU
Rubber & Material Recovery			
Road Surfacing	TC5	915 tonnes 160,125 UEPU	90,000 tonnes 15.8 million UEPU
Flooring & Mats	TC4, TC5	10,850 tonnes 2.12 million UEPU	15,850 tonnes 3.21 million UEPU
Moulded Products	TC4 Buffing, TC5	10,000 tonnes 2.2 million UEPU	13,000 tonnes 4.3 million UEPU
Adhesives	TC5	6,000 tonnes 1.1 million UEPU	10,000 tonnes 1.8 million UEPU
Steel		Unknown	Unknown
Textile		0 tonnes	Unknown

Source: Industry Sources and URS Analysis

38 Note: Potential inputs of used tyres is based on stakeholder feedback and estimates for growth

This section aims to describe the structure and function of the model that has used to undertake the economic and financial analysis of the proposed stewardship Scheme.

6.1 Economic and Financial Model

The economic BCA and the financial feasibility analysis for the operation of the Scheme were undertaken within the same spreadsheet model. This analysis is underpinned by current estimates of new and used tyre stocks and flows, and on estimates of current and potential uses based on consultations with key industry stakeholders. The economic and financial analysis is modelled over a ten year period, with 2006 set as the base year for establishing base volumes for tyre stocks and flows, and with 2007 assumed as the start year of the Scheme and correspondingly the start year for 'without the Scheme' and 'with the Scheme' comparisons within the model. Tyre flows are estimated for six tyre categories: OTR tyres, truck and bus tyres, light truck tyres, specialty tyres, passenger tyres and motorcycle tyres. These flows are calculated in total EPUs/UEPUs and tyre numbers for each of the six tyre categories. The model is based upon an interlinked set of modules, which comprise the following.

6.1.1 Module 1 – Tyre Flows

The base parameters in the model define the net number of new and used tyres entering and leaving the market for the base year, then annual rates of change and flows over the next ten years. These tyre flows are presented on the basis of volume used, reused, disposed or transformed, and are assumed to be in line with Gross National Product (GNP) growth (2% annually). The data accounts for EPU/UEPU, tyre numbers and tonnes of tyres for the six tyre categories. This module also tracks the volume of buffings from retreaded tyres that are available for use in TDPs. Model parameters for this module include:

- Domestically produced new tyres;
- Imported new and used tyres;
- Total tyre input flows;
- Total tyres in use;
- Exported new and used tyres;
- Total end-of-life tyres available for transformation;
- Legally landfilled tyres;
- Illegally disposed tyres; and
- Transformation categories and size of end-use markets.

These numbers are estimated for both 'with' and 'without' Stewardship Scheme scenarios. More detail on tyre flows is presented in Section 3 above.

6.1.2 Module 2 – Tyre Location

Tyre flows have been estimated in terms of their location at post-consumer stage, into: metropolitan, regional or rural tyres (refer to Table 3.7). This is to differentiate between collection, storage and transport costs across the six tyre categories, as the tyre location can affect the economics of collecting and transporting tyres to sites for processing and transformation. The model has been set up to enable either including or removing tyres from any of these regions, which allows assessment of the comparative merits of their inclusion in the Scheme, particularly important for rural tyres with higher collection and transportation costs. Data also enables differentiation between States and Territories, however state specific modelling has not been carried out, rather a national model has been formulated.

6.1.3 Module 3 – Collection, Transport, Storage, Transformation and Disposal Costs

For each of the six tyre categories, collection, transportation, storage and transformation costs have been estimated, incorporating differences between metropolitan, regional and rural sourced tyres. Transport and collection costs vary depending on location, however storage costs are estimated with the assumption that any major storage will be located in the metro area as this is where tyres are stored prior to transformation. Transformation costs have been estimated across the range of five TC definitions and based on stakeholder data and URS analysis. Costs are developed on the basis of cost per tyre and cost per tonne of tyres transformed. Estimated collection, transportation and storage costs are shown in Table 4.3 and 4.4, and TDP transformation costs are detailed in Table 4.9.

The model estimates disposal costs for any tyres considered to be disposed of legally to landfill. Those that are suggested to be disposed of illegally are costed at three times the base collection cost to account for cost of retrieval and then charged landfill costs as per the rate for legally disposed tyres. The cost of landfill disposal as either shredded or bulk tyres is also incorporated, with the model including the option for these landfill costs to be deducted from net collection, transportation, storage and transformation costs in order to assess the avoided costs and to calculate gross margins if landfill does not occur.

6.1.4 Module 4 – Composition of Tyres and TDPs

The composition of new tyres for each of the six tyre categories was defined, this was then adjusted to reflect the proportional losses during wear and the changes during each of the transformation processes. This allows the mass and volume of each tyre component to be tracked to measure volumes used and disposed. This also allows any wastage during transformation to be tracked. This means of accounting for the mass of tyre components, tyre numbers and EPUs/UEPUs was applied to each TDP and associated sub-groups. Tables 6.1 and 6.2 below show the composition of new tyres, composition after wear, and the loss rates during each transformation process.

Table 6.1 – Composition of New Tyres

	Rubber	Carbon Black	Steel	Textile	Zinc Oxide	Sulphur	Additive	EPU
New Tyres (proportion)								
OTR	45%	22%	25%	-	2%	1%	5%	100.0
Truck and bus	43%	21%	27%	-	2%	1%	6%	5.0
Light trucks	45%	21%	21%	5%	1%	1%	6%	2.0
Specialty tyres	45%	22%	25%	-	2%	1%	5%	5.0
Passenger	45%	20%	18%	6%	1%	1%	9%	1.0
Motor cycles	45%	22%	15%	10%	2%	1%	5%	0.5
Kg per EPU	**9.5**							
Wear Loss per EPU	**1.5**							
New Tyres (kg)								
OTR	427.50	209.00	237.50	0.00	19.00	9.50	47.50	950.00
Truck and bus	20.43	9.98	12.83	0.00	0.95	0.48	2.85	47.50
Light trucks	8.55	3.99	3.99	0.95	0.19	0.19	1.14	19.00
Specialty tyres	21.38	10.45	11.88	0.00	0.95	0.48	2.38	47.50
Passenger	4.28	1.90	1.71	0.57	0.10	0.10	0.86	9.50
Motor cycles	2.14	1.05	0.71	0.48	0.10	0.05	0.24	4.75

Source: URS Analysis

Table 6.2 – Composition of Used Tyres and TDPs

	Rubber	Carbon Black	Steel	Textile	Zinc Oxide	Sulphur	Additive	UEPU
Used Tyres TC1 (proportion)								
OTR	42%	21%	30%	-	2%	1%	5%	100.0
Truck and bus	40%	20%	32%	-	2%	1%	6%	5.0
Light trucks	42%	20%	25%	6%	1%	1%	6%	2.0
Specialty tyres	42%	21%	30%	-	2%	1%	5%	5.0
Passenger	42%	19%	21%	7%	1%	1%	8%	1.0
Motor cycles	42%	21%	18%	12%	2%	1%	5%	0.5
Kg per UEPU	**8**							
Used Tyres TC1 (kg)								
OTR	337.50	165.00	237.50	0.00	15.00	7.50	37.50	800.00
Truck and bus	16.01	7.82	12.83	0.00	0.74	0.37	2.23	40.00
Light trucks	6.73	3.14	3.99	0.95	0.15	0.15	0.90	16.00
Specialty tyres	16.88	8.25	11.88	0.00	0.75	0.38	1.88	40.00
Passenger	3.39	1.51	1.71	0.57	0.08	0.08	0.68	8.00
Motor cycles	1.69	0.83	0.71	0.48	0.08	0.04	0.19	4.00
TC2 – Cut (proportion)								
Losses TC1-TC2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
TC3 – Chip (proportion)								
Losses TC2-TC3	0.0%	0.0%			0.0%	0.0%	0.0%	
Losses TC1-TC3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
TC4 – Granulate (proportion)								
Losses TC3-TC4	0.0%	0.0%	95.0%	95.0%	0.0%	0.0%	0.0%	
Losses TC1-TC4	0.0%	0.0%	95.0%	95.0%	0.0%	0.0%	0.0%	
TC4 – Buffing (proportion)								
Losses TC1-TC4	75.0%	75.0%	100.0%	100.0%	75.0%	75.0%	75.0%	
Specialty Tyre Losses	25.0%	25.0%	100.0%	100.0%	25.0%	25.0%	25.0%	
TC5 – Crumb (proportion)								
Losses TC4-TC5	0.0%	0.0%	4.9%	4.9%	0.0%	0.0%	0.0%	
Losses TC1-TC5	0.0%	0.0%	99.9%	99.9%	0.0%	0.0%	0.0%	

Source: URS Analysis

6.1.5 Module 5 – Value of Transformation Categories

Budgets were developed for a range of TDP transformation categories. Value was based on the prices paid by the end use markets, or as the value of a TDP as a substitute for another input. It was necessary to have this double definition because currently some products have zero or negative market value as a result of the benefits of avoiding landfill costs, i.e. a collector businesses will pay to have tyres recycled or reused rather than pay landfill costs. These products still have a real value as they substitute other inputs, for example in cement kilns for energy sourced as substitute for thermal coal. The highest value is the value used for the transformed products.

Gross margins indicate the returns from each TC according to tyre category, they also include the value of any steel or textile recovered, and the collection, transformation, storage and transportation costs developed in Module 3. The model includes estimated gross margin returns for each of the assumed TCs for tyres sourced from metro, regional and rural areas. The cost of landfill can be deducted from transformation costs to highlight the end use market where the influence of landfill costs is currently making some activities viable, whereas they might not otherwise be.

6.1.6 Module 6 – Tyre Derived Product Demand

The module uses estimates of current and potential use volumes for the range of TDPs, in a range of end markets: civil engineering, energy, rubber and material recovery, enhancement and export. There is capacity to estimate rates of use with and without the Scheme. Targets may be set as set tonnages for each year, or as percentage rates of annual change. The category of tyre used in each end use market was also specified to allow for an alignment of usage targets with supply of each tyre category, e.g. some engineering uses may require truck tyres rather than motorcycle tyres. The flows for each TC are calculated as tonnes of TDP used and as total UEPU casings transformed (shown in tonnes below in Table 6.3). The tonnes of buffings from retreading are also accounted for in the model. Annual growth rates in usage of TDPs were assumed to be 5% without the Scheme, and 7% with the Scheme if specific tonnage targets were not specified through industry consultations. The availability of buffings from retreading was assumed to be declining at an annual growth rate of 2% due to the decline in the overall retread market size. The ARF was set to achieve target numbers that recover 90% of end-of-life tyres ten years into the Scheme.

In Section 5 the current and potential volumes of end use markets that were presented were based on consultation with industry stakeholders. Based on these consultations, URS estimated ten year volume targets as the end use markets increase towards their potential sizes, with these targets included in the financial and economic model. Table 6.3 below summarises the estimates of current and potential usage levels that achieve 90% recovery rate of end-of-life tyres ten years into Scheme operation.

Table 6.3 – Current and Potential TDP End Use Markets – Total Tonnes or EPUs

End Use Markets	TC	Base Year Inputs	Target Inputs	Start Year[39]	Years to Target
Civil Engineering					
Ret Wall & Rd Embanks	TC1	1,200 tonnes	Growth rate[40]		7
Ret Wall & Rd Embanks	TC2I[41]	0 tonnes	658 tonnes		7
Pod Slabs	TC1	80 tonnes	Growth rate		7
Drainage	TC3	110 tonnes	Growth rate		7
Energy					
Tyre Derived Fuel	TC 1	10,000 tonnes	Growth rate		5
Tyre Derived Fuel	TC2	0 tonnes	4,800 tonnes		7
Tyre Derived Fuel	TC2	110 tonnes	Growth rate		7
Blasting Material	TC4	0 tonnes	15,000 tonnes	2	7
Rubber & Material Recovery					
Road Surface - asphalt	TC6	50 tonnes	10,000 tonnes		7
Road Surface - spray seal	TC6	865 tonnes	15,000 tonnes		7
Flooring and Mats	TC4	5,000 tonnes	6,500 tonnes		7
Flooring and Mats	TC5	480 tonnes	2,000 tonnes		7
Flooring and Mats	TC6	5,000 tonnes	6,500 tonnes		7
Rubber Mulch	TC5	350 tonnes	850 tonnes		7
Moulded Products	TC4	3,000 tonnes	2,930 tonnes		7
Moulded Products	TC5	1,000 tonnes	4,000 tonnes		7
Moulded Products	TC6	5,860 tonnes	5,850 tonnes		7
Moulded Prods - elastomers	TC6	0 tonnes	13,500 tonnes	2	7
Moulded Prods - elastomers	TC6	0 tonnes	15,000 tonnes	2	7
Adhesives	TC6	6,000 tonnes	10,000 tonnes		7
Other					
Export - Whole used tyres	TC 1	10,000 tonnes	440 tonnes		0
Export - Shredded used tyres	TC2	100 tonnes	Growth rate		7

[39] Begins in base year if not specified

[40] Where 'growth rate' is specified, indicates that annual growth rates of increase are assumed (at 5% without the scheme and 7% with the scheme)

[41] Based on 152 UEPU casings required to produce 1 tonne of TC with only sidewall remaining

Source: URS Analysis

6.1.7 Social and Environmental Values

A number of social and environmental impacts are commonly raised in literature that result from the disposal of end-of-life tyres that the proposed Scheme can attempt to address as used tyres are pulled into transformation over landfill or illegal disposal. Some impacts from disposal in landfill, illegal dumps or mines that are commonly discussed and that are important considerations in deciding to implement a stewardship scheme such as this include:

- Resource loss – A major driver to attempt to reduce the volume of tyres being disposed or burned is to reduce the loss of resources contained in these products. In addition tyre disposal takes up landfill space (approximately 75% of the volume of a tyre is void), which is also a resource as it is limited in many areas (Atech Group 2001, Pt.1, p.23).
- Risk of fire and associated pollution – Fires in tyre dumps "are very damaging to the environment, emitting large amounts of thick ugly smoke and noxious gases including carcinogens. Attempts to extinguish these fires are difficult due to the geometry of tyres, are dangerous to fire fighters and the resultant runoff can carry hazardous pollutants into groundwater, waterways and wetlands" (Atech Group 2001, Pt.1, p.2).;
- Breeding grounds for pests which may cause increased rates of disease – Tyres offer attractive breeding grounds for pests such as mosquitos which, in the more tropical parts of Australia, can be the vectors for the transmission of life-threatening diseases to humans" (Atech Group 2001, Pt.1, p.2);
- Habitat for weeds – Outdoor tyre stockpiles can provide a habitat for weeks to grow, which can be a problem especially if weeds are noxious (Atech Group 2001, Pt.1, p.30); and
- Aesthetic and environmental effects especially when disposed of in streams and creeks where they may divert flows, increase erosion, and create negative visual impact.

It is the consideration of these issues which has led to the Roundtable and tyre industry to focus on development of a product stewardship scheme. The deferral of used tyres from disposal and landfill will improve the impacts on society and the environment, and will increase the positive economic NPVs of the Scheme.

6.2 Economic Criteria – Indicators of Scheme Performance

The model enables analysis of Scheme performance based on a number of economic indicators. These indicators include the net value of TDPs that are produced both with and without the Scheme. The value of lost resources and the cost of disposal with and without the Scheme are also estimated, which includes cleanup costs from illegal dumping, landfill costs of legal dumping and any landfill costs from waste resulting from transformation. The option exists to include any other social and environmental impacts into the model, such as public health impacts (mosquitos) and pollution (burning) – this was subject to availability of existing value data on these impacts that have not been obtained. The BCA provides the following indicators of Scheme performance:

- Benefit cost ratio;
- Payback time;
- Internal rate of return;
- Resource recovery value (product / energy);
- Resource loss and cost of disposal;
- Social and environmental costs;
- Stewardship Scheme operation costs; and
- Net present value.

6.3 Financial Criteria – Scheme Financial Performance

The financial analysis encompasses the revenue sourced from the ARF, the amount of benefit payments based on a set payment per tonne of TDP produced and sold on to an approved end use, as well as indicating funds available for other market development strategies. The cost of implementing and operating the Scheme is estimated on the basis of the following expense categories:

- Administration;
- Compliance and monitoring;
- Industry coordination;
- Research and market development;
- Legislative support;
- Public education programme;
- Benefit payment – TDP transformation;
- Benefit payment – steel recovery;
- Benefit payment – textile recovery;
- Rebate payment – rural / regional collection and transport;
- Capital grants; and

- Contingency amount.

6.4 Options for Undertaking the Analysis

The model functions to allow a number of potential stewardship Scheme design options to be compared. These design options include:

- Option exists to vary the number of years over which the ARF is collected;
- Capacity to compare the cost of paying benefits on the deemed market value of TDPs or on the cost of the transformation process for each TDP;
- Ability to raise an ARF as a flat rate per EPU over each of the six tyre categories or to vary or exclude ARF payments for any selected categories;
- Capacity to calculate benefit amounts if they are paid on the difference between current levels of TDP demand (or the levels estimated without the Scheme in the future) and change in the level of demand with the Scheme at the time of benefit payment, or to pay benefits on the total level of demand occurring from onset of the Scheme;
- Option exists to compare the relative costs and impacts for inclusion of metro, regional and rural sourced tyres by excluding tyres sourced from any of these locations;
- Option to calculate regional and/or rural rebates for collection and transport costs so as to subsidise cost for transformers to source these tyres by equalling costs to metropolitan-located tyre collection costs. The option is also included for transport rebates to be paid from onset of Scheme, or to begin after two years and end after year seven; and
- Ability to calculate benefits to be paid on the value of steel and textile recovered.

6.5 Evaluation Criteria for Comparing TDPs

A key objective of the Scheme is to encourage recovery of the HNRV of end-of-life tyres, where HNRV is defined as the net present value of a TDP, involving the calculation of all costs, expenditures, and the net benefits of a resource to determine the value of resource value recovered. Analysis of the HNRV of different TDPs is an important evaluation tool encompassed in the model.

It is worth noting that achieving HNRV of end-of-life tyres may or may not contradict the achievement of a number of other potential criteria for assessing the merits of a product stewardship scheme. Other objectives that may not necessarily be encompassed by HNRV may include:

- Reduced social and environmental impacts;
- Greatest reduction in waste to landfill;

- Highest financial value;
- Highest employment generation; and
- Greatest potential to be sustainable.

This analysis has monitored reductions in waste to landfill and illegal disposal, and includes estimates for financial returns, and potential for enterprises to be sustainable. These criteria have been used in conjunction with the HNRV to assess the Scheme.

This section aims to detail some of the major outcomes from the base case financial and economic analysis, and incorporates a discussion of a number of scenarios to the base Scheme. The outcomes to this analysis reflect the assumption that for a given level of incentive provided by Scheme benefits, a particular level of industry expansion will be achieved. Incentive encourages additional investment in capacity and industry development.

7.1 The Base Case

The base case in the model assumes the parameters and modules as described in Section 6 above, and includes the following settings in terms of Stewardship Scheme operation:

- ARF of $0.85 per new tyre EPU, to be charged across all tyre categories;
- Free rider rate of 5% is assumed i.e. the ARF is not collected from 5% of EPUs;
- ARF to be collected for a length of eight years over the ten year Scheme;
- ARF to be charged for three months prior to Scheme funding and benefit payments to enable near to $6 million to be raised to back the Scheme; and
- TDP benefit paid based on 20% of the deemed market value of a TDP (based on value that end market users of TDPs pay in the market, or the value of a TDP as a substitute for an equivalent input – value to be determined by PRO);
- Metal recovery benefit paid based on 15% of the market value of each tonne metal recovered (i.e. 15% of $60, with value to be determined by the PRO);
- Textile recovery benefit based on 15% of the market value of each tonne of textile recovered (i.e. 15% of $180, with value to be determined by the PRO);
- Benefit payments are made on total value of TDP sold on to end use market following onset of Scheme, not based on the difference between current levels and potential future levels (this option chosen due to ease of management and monitoring);
- Rural and regional collection and transport cost rebate to start in the second year of the Scheme and to run for five years;
- Rural collection and transport cost rebate is paid to bring costs down to a metro equivalent;
- Regional collection and transport cost rebate is paid to bring costs down to a metro equivalent; and
- A discount rate of 6 percent has been used to calculate Net Present Values (NPVs).

7.1.1 Economic Results from the Base Case

BCA Indicators

A summary of the BCA indicators are shown in Table 7.1 below, and relate to the base case as described above. The results indicate a positive social benefit of $7 million. Given a 20% benefit paid on the value of TDPs, the Scheme is budgeted to cost approximately $146 million over ten years of operation. The additional value of recovered resources is estimated at $71 million and the reduction in disposal costs is $83 million. A detailed cash-flow budget over ten years for the same data is presented in Table 7.2.

Table 7.1 – Summary Indicators for the Base Case

BCA Summary Indicators	
Benefit Cost Ratio	1.05
Payback Time	9 years
Internal Rate of Return	10%
Resource Recovery Value (Product/ Energy)	$70.8m
Resource Loss and Cost of Disposal	$82.6m
Environmental Costs	0
Stewardship Scheme Operation Costs	-$146.1m
Net Present Value	**$7.3m**

Source: URS Analysis

A financial cashflow for the Scheme's revenues and expenditures is summarised in Table 7.3. This table details the base case scenario with the rural and regional collection and transport rebate operating for five years beginning at the second year of Scheme operation, the TDP benefits paid over ten years of the Scheme, and the ARF being applied for eight years beginning from year one. Any surplus generated through the ARF is allowed to run down by year ten of the Scheme. Table 7.3 also show the ARF being charged for three months in the year prior to the benefits and other funding being offered, to raise sufficient starting funds to operate the Scheme. This data shows that with an AFR of $0.85 per EPU, the Scheme should have sufficient revenues to fund budgeted expenses, only requiring funds from the ARF for the first eight years of the Scheme. Accumulated funds are used to fund the last 2 years of activities.

The base case suggests that an ARF of $0.85 per EPU applied across all tyre categories can enable the funding of some major incentives: a benefit covering a 20% reduction in the market price TDPs, as well as a rebate reducing rural and regional transport costs to a metro equivalent cost. The breakdown of the allocation of Scheme funding not only to benefits, but also to public education, research, market development, etc., reflects an acknowledgement of the Client, the Roundtable and other stakeholders that financial barriers are not the only factor inhibiting expansion of the use of TDPs. Research, market development and other incentives to improve product quality and surety of supply could be major contributors to growth in the industry.

Table 7.2 – Cashflow Budget for Economic Benefit Cost Analysis – Base Case ($ '000s)

Net Effects: With - Without ($'000s)	NPV	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Civil Engineering Uses	-273	-8	-16	-24	-31	-38	-44	-49	-56	-64	-72
Energy Uses	8,582	81	159	523	883	1,242	1,597	1,950	2,063	2,182	2,309
Rubber Recovery Uses	53,201	-18	-38	2,511	5,058	7,605	10,150	12,694	13,594	14,560	15,597
Steel & Textile Recovery Uses	10,177	127	249	646	1,043	1,438	1,833	2,228	2,407	2,599	2,808
Exported Used Tyres	-863	-17	-35	-56	-79	-105	-134	-165	-200	-239	-281
Resource Recovery Value	**70,824**	**165**	**319**	**3,600**	**6,874**	**10,142**	**13,402**	**16,658**	**17,808**	**19,038**	**20,361**
Landfill & Cleanup costs - legal & illegal disposal	95,757	1,738	3,394	6,775	10,132	13,469	16,791	20,102	21,857	23,722	25,711
Landfill costs - TC waste	-13,088	-365	-728	-1,092	-1,454	-1,816	-2,177	-2,538	-2,795	-3,069	-3,361
Cost of Disposal	**82,669**	**1,374**	**2,666**	**5,684**	**8,678**	**11,653**	**14,614**	**17,564**	**19,061**	**20,653**	**22,350**
Social and Environmental Costs	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Scheme Administration, Compliance & Monitoring	-12,773	-2,000	-2,000	-2,000	-2,000	-1,500	-1,500	-1,500	-1,500	-1,500	-1,500
Industry Coordination	-5,518	-1,000	-1,000	-1,000	-1,000	-1,000	-750	-500	-250	-250	-250
Research and Market Development	-10,370	-3,500	-3,500	-1,000	-1,000	-1,000	-500	-500	-500	-500	-500
Public Education Programme	-2,711	-1,000	-500	0	0	-1,000	0	0	0	-500	-500
Legislative Support	-3,680	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500
Benefit – TDPs produced	-73,358	-3,660	-4,286	-6,245	-8,209	-10,180	-12,159	-14,145	-15,136	-16,195	-17,329
Benefit – Recovery of Steel & Textile	-2,692	-148	-173	-240	-305	-373	-440	-507	-542	-580	-621
Rebate – Rural / Regional Collect & Trans	-35,944	0	0	-6,458	-8,110	-9,772	-11,443	-13,125	0	0	0
Contingency	-6,319	-1,500	-1,500	-1,500	-1,500	-1,500	0	0	0	0	0
Stewardship Scheme Operation Costs	**-146,130**	**-11,308**	**-11,459**	**-17,441**	**-21,125**	**-25,325**	**-27,292**	**-30,777**	**-18,428**	**-20,026**	**-21,200**
Net Effect: With - Without	**7,364**	**-9,770**	**-8,474**	**-8,158**	**-5,573**	**-3,530**	**725**	**3,444**	**18,441**	**19,668**	**21,511**
Cumulative Net Effect		**-9,770**	**-18,244**	**-26,402**	**-31,976**	**-35,505**	**-34,780**	**-31,336**	**-12,895**	**6,772**	**28,283**

Source: URS Analysis

Table 7.3 – Cashflow Budget for Scheme Financial Analysis ($ '000s)

Scheme Financial Analysis	Base	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Revenue											
Advanced Recycling Fee	5,992	24,462	24,965	25,478	26,001	26,536	27,081	27,637	28,204	0	0
Sub-Total	5,992	24,462	24,965	25,478	26,001	26,536	27,081	27,637	28,204	0	0
Expenditure											
Scheme Administration		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Compliance and Monitoring		1,000	1,000	1,000	1,000	500	500	500	500	500	500
Industry Coordination		1,000	1,000	1,000	1,000	1,000	750	500	250	250	250
Research and Market Development		3,500	3,500	1,000	1,000	1,000	500	500	500	500	500
Legislative Support		500	500	500	500	500	500	500	500	500	500
Public Education Programme		500				1,000				500	500
Benefit – TDPs produced		3,660	4,286	6,245	8,209	10,180	12,159	14,145	15,136	16,195	17,329
Benefit – Recovery of Steel		99	116	161	205	250	295	340	364	389	417
Benefit – Recovery of Textile		49	57	79	100	123	145	167	178	191	204
Rebate – Rural / Regional Collect & Trans		0	0	6,458	8,110	9,772	11,443	13,125	0	0	0
Capital Grants											
Contingency		1,500	1,500	1,500	1,500	1,500					
Sub-Total	0	12,808	12,959	18,941	22,625	26,825	27,292	30,777	18,428	20,026	21,200
Surplus/ Deficit	5,992	11,653	12,005	6,536	3,376	-289	-211	-3,141	9,776	-20,026	-21,200
Cumulative Surplus/ Deficit	5,992	17,645	29,651	36,187	39,564	39,275	39,063	35,923	45,699	25,673	4,473

Source: URS Analysis

Table 7.4 – Consumer Impact of ARF Vs Current Passenger Tyre Collection Fee – Base Case

Impact on Consumers	NPV	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Current Collection Fee (Passenger Tyres)	259,234	32,410	33,074	33,752	34,443	35,148	35,867	36,601	37,350	38,114	38,893
Scheme AFR on Passenger Tyres	129,443	42,879	43,757	10,902	11,125	11,353	11,585	11,822	12,064	0	0
Saving to Australian Consumers	129,791	-10,468	-10,683	22,850	23,318	23,795	24,282	24,779	25,286	38,114	38,893

Source: URS Analysis

Level of Resource Recovery

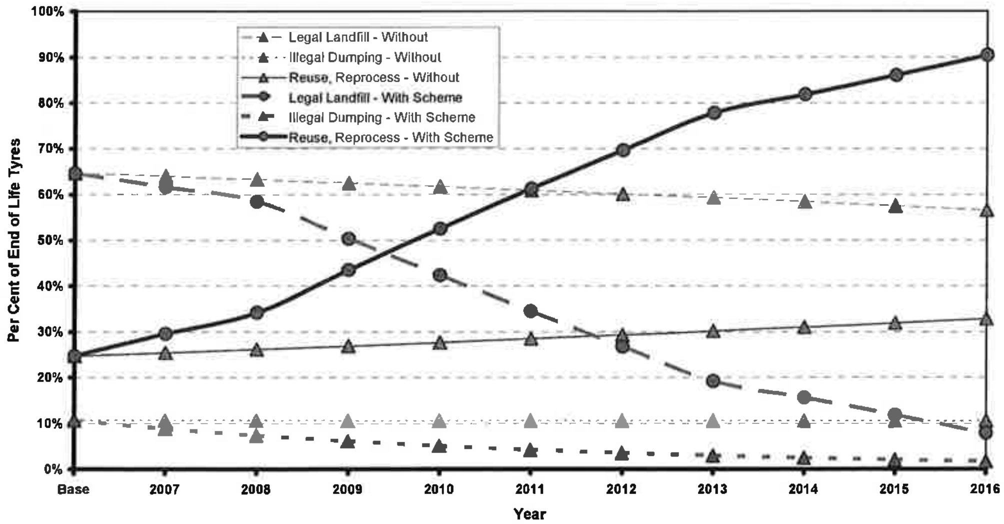
The numbers of used tyres that are projected to be landfilled, illegally dumped or transformed are shown in Table 7.5. This table presents the number of tyres in each of the six tyre categories used in this study, showing with and without the Scheme scenarios for these figures. Projections show that with the Scheme target recovery of 90% of end-of-life tyres in year ten, the number of tyres going to landfill is reduced to 8%. Likewise the level of illegal dumping is projected to decrease from 11% to 2% over the 10 years of the Scheme. The rates of change over the life of the Scheme are shown diagrammatically in Figure 7.1.

Table 7.5 – Estimated Tyres to Disposal and Recovery With and Without Scheme ('000s tyres)

	Total Tyres	OTR	Truck & bus	Light trucks	Specialty tyres	Passenger	Motor cycles	Total U/EPUs	Per Cent
Total Inputs – Yr 1	16,995	67	723	3,185	41	12,701	279	29,680	
Total Inputs – Yr 10	20,835	81	894	3,912	50	15,559	340	36,380	
Landfill – Without (Yr 10)	10,393	61	540	1,997	23	7,624	148	20,602	57%
Dumping – Without (Yr 10)	3,247	-	15	577	-	2,578	77	3,848	11%
Recovery – Without (Yr 10)	7,195	20	338	1,338	27	5,357	115	11,929	33%
Landfill – With (Yr 10)	1,600	6	83	335	0	1,157	19	2,858	8%
Dumping – With (Yr 10)	524	-	2	93	-	416	12	621	2%
Recovery – With (Yr 10)	18,711	75	808	3,484	49	13,986	308	32,901	90%

Source: URS Analysis

Figure 7.1 – End-of-life Tyre Recovery and Disposal With and Without Scheme



Source: URS Analysis
Source: URS Analysis

7.2 Issue Analysis

7.2.1 Freerider Effect of ARF Levels

The base case assumes that five per cent of imported or locally produced tyres may evade payment of the ARF. Given this level of freeriders, an ARF of $0.85 is required to cover suggested levels of benefit and incentive payments, and Scheme operating costs. Table 7.13 shows the outcome of the freerider effect on the level of the ARF estimated to be required to cover Scheme budgeted expenses. If the freerider effect was absent then the ARF could be reduced to $0.80 per EPU, whereas if the freerider effect is as high as 50% then an ARF of $1.60 would be required.

Table 7.13 – Freerider Influence on Size of ARF

Freeriders	Advanced Recycling Fee
50%	$1.60
40%	$1.35
25%	$1.10
20%	$1.00
15%	$0.95
10%	$0.90
5%	$0.85
0%	$0.80

Source: URS Analysis

7.2.2 Consumer Impacts

The potential impact on consumers was assessed by comparing the financial load placed on purchasers of passenger tyres as a result of the ARF versus the current informal cost of tyre disposal that is commonly added to the cost of a new replacement tyre. Generally speaking a cost of $2.50 is charged to consumers by tyre retailers to dispose of their end-of-life tyres. If it is assumed that the ARF and the current arrangements will both exist simultaneously for a period of two years while the industry accustoms to the Scheme, and then after two years the $2.50 disposal cost is replaced by the ARF, then over the ten years of the Scheme, the saving to consumers on passenger tyres alone is approximately $130 million. These results are demonstrated in Table 7.4 above.

7.2.3 Effects on Retreading Sector

In the model, the base case scenario assumed a benefit will be paid on buffings sourced from retreading. This is not necessarily the premise on which the Scheme may operate, so sensitivity has been undertaken to assess the non-inclusion of retread buffings. The marginal cost of generating buffings as a by-product of the retreading process is expected to be much less than undertaking such a process on end-of-life tyres. However, available data does not enable a comparison between the raw transformation cost of buffings from retreading and buffings from end-of-life tyres with a 20% benefit. If the Scheme includes a 20% benefit on the value of buffings on retreads to ensure the retreading sector is not disadvantaged, then the additional cost over 10 years of the Scheme is only $1 million (see Table 7.16). This is a small share of the total Scheme operating costs of $145 million. Provided that buffings from retreads maintain a price advantage then increased supply of transformed products should not lower the demand for the retread buffings, a product with specific quality specifications.

Table 7.16 – BCA Summary Indicators – Inclusion of Retread Buffings in TC4

BCA Summary Indicators	No Buffing Benefit	Base	Change
Benefit Cost Ratio	1.04	1.05	
Payback Time (Years)	9	9	
Internal Rate of Return	9%	10%	
Resource Recovery Value (Product/ Energy)	$70.8	$70.8	$0.0
Resource Loss and Cost of Disposal	$82.7	$82.7	$0.0
Environmental Costs	$0.0	$0.0	$0.0
Stewardship Scheme Operation Costs	-$147.1	-$146.1	-$1.0
Net Present Value	$6.4	$7.4	-$1.0

Source: URS Analysis

7.2.4 Remote and Transport Issues – OTR Tyres

OTR tyres are tyres that used in industries such as mining, construction, civil engineering and forestry. These tyres can weigh up to 7 tonnes, standing up to 5 metres high and costing approximately $25,000 a tyre. Classification of OTR tyres is difficult as there is no industry standard so different new tyre producers have their own classifications (ARRB Transport Research 2004, p.30-31).

The size, construction and invariably remote location make OTR tyres very difficult and expensive to handle. Currently, alternative uses for scrap OTR tyres in Australia are limited. Used tyres on mines are either stockpiled in numbers allowable under the regulations or are monofilled (Corbett 2000, p.1). Transport costs to recover these tyres from mining operations are high. Rubber particle size and the degree of steel and textile in OTR tyres, as well as their large size, makes them difficult to process for further use and shredding equipment requires a large capital investment.

The issue of transport and transformation of remote tyres and OTR especially is an issue that probably requires further more detailed analysis that was able to undertaken as part of this report. However, what the results of this report have been able to show is that OTR tyres and even those in remote locations are likely to be a valuable and sizable resource if targeted to high value uses. The gross margin analysis (See Figure 7.4) suggests OTR tyres to be viable for transformation into TC5 products. This analysis is limited in that it has not taken into account any necessary investment to handle and process the bigger tyres that are included in this OTR category. There remains a need for specific analysis of transport and transformation cost of the extremely large and remotely located tyres that are commonly used in mining.

Background

URS Australia Pty Ltd (URS) was engaged by the Australian Tyre Manufacturers Association (ATMA) and Australian Tyre Importers Group (ATIG) to conduct a financial and economic analysis to determine the feasibility and practicality of the proposed National Used Tyre Product Stewardship Scheme (the Scheme), and to suggest alternatives and options as required to ensure achievement of the Scheme's objectives. The Scheme was initiated by ATMA and ATIG, the original tyre manufacturers (of both local and imported tyres), and supported by the Federal Government through the Department of Environment and Heritage (DEH) and an industry representative roundtable.

The National Used Tyre Product Stewardship Scheme will be Australia wide, industry-led and co-regulatory, and will involve an Advanced Recycling Fee (ARF) to fund a benefit, rebate and market development system that will address the prevailing market failure. New tyre manufacturers and importers of both loose and fitted tyres will be responsible for payment of the ARF, the collection and allocation of which will be managed by a Producer Responsibility Organisation (PRO). The funds collected will be used to fund a range of market development and waste management strategies, including benefits paid to transformers and transport rebates paid for regional and rural tyre collection.

Agreed Scheme Principles identify that the aim of the proposed Scheme is to "develop a scheme that will aim to recover the optimum resource value from end-of-life used tyres in Australia" (Client Brief 2004, p.9). Highest Net Resource Value (HNRV) is one of the underlying concepts for this analysis, as it focuses on the aim to prevent resources being directed to markets or uses with negative values, in particular landfill and illegal disposal. HNRV can be defined as the net present value of a Tyre Derived Product (TDP), involving the calculation of all costs, expenditures, and the net benefits of a resource to determine the resource value recovered. As such, this study analysed the TDPs to determine the HNRV of used tyre resources.

Methodology

A range of data was collected and has been analysed and augmented by URS for use in financial and economic modelling. Initial data compilation and information review was from earlier reference reports and studies. Interviews and communications with industry stakeholders and participants provided an important aspect of data collection particularly for industry and tyre-specific information not previously reported or published. Data collection covered a range of information including volume, financial, demand, growth, and international data relating to tyres. Research was structured to encompass four key areas relevant to the project:

- Supply side information;
- Demand side information (including an assessment of barriers to industry development);
- Processing and logistics; and
- Scheme costs.

The financial and economic modelling was based on principles of BCA, and used a discounted cashflow model that was linked with a model to describe biophysical flows. The financial analysis was used to determine the financial viability and feasibility of the Scheme, and the economic (benefit cost) analysis was used as a systematic means to analyse all financial, economic, environmental and social costs and benefits associated with the Scheme. In this way, BCA provides a decision-making framework that considers the net impacts on all stakeholders, both positive and negative.

The combined financial and economic model has been used to determine Net Present Value (NPV) of the Scheme. Sensitivity and scenario analyses have been undertaken to examine demand-side issues such as current and potential size of different end use markets, and to assess supply-side factors such as growth potential, cost of logistics and processing, and industry leakages (to landfill and illegal dumping).

The economic and financial analysis is modelled over a ten year period, with 2006 set as the base year for establishing base volumes for tyre stocks and flows, and with 2007 assumed as the start year of the Scheme and correspondingly the start year for 'without the Scheme' and 'with the Scheme' comparisons within the model. Tyre flows are estimated for six tyre categories: OTR tyres, truck and bus tyres, light truck tyres, specialty tyres, passenger tyres and motorcycle tyres. These flows are calculated in total EPUs/UEPUs and tyre numbers for each of the six tyre categories. The model is based upon an interlinked set of modules, which comprise the following:

- Tyre flows;
- Tyre location;
- Collection, transport, storage, transformation and disposal costs;
- End-of life tyre and transformed product composition;
- Value of transformation categories;
- Tyre derived product demand estimates; and
- Social and environmental values.

The Assumed Base Case for Stewardship Scheme Design and Operation

The base case in the model assumed the following settings in terms of Stewardship Scheme operation:

- ARF of $0.85 per new tyre EPU, to be charged across all tyre categories;
- Free rider rate of 5% is assumed i.e. the ARF is not collected from 5% of EPUs;
- ARF to be collected for a length of eight years over the ten year Scheme;
- ARF to be charged for three months prior to Scheme funding of programs to enable near to $6 million to be raised to back the Scheme;

- Benefit paid based on 20% of the deemed market value of a TDP (based on value that end market users of TDPs pay in the market, or the value of a TDP as a substitute for an equivalent input). The deemed market value of a TDP product will be determined by the PRO at the beginning of operation of the Scheme, it is not envisage that this deemed market value will change with market movements over the course of the Scheme operation, but is open to review;
- Metal recovery benefit paid based on 15% of the market value of each tonne metal recovered;
- Textile recovery benefit based on 15% of the market value of each tonne of textile recovered;
- Benefit payments are made based on total value of TDPs sold on to end use markets following onset of the Scheme, not based on the difference between current levels and potential future levels;
- Rural and regional collection and transport cost rebate is paid to bring costs down to a metro equivalent; and
- Rural and regional collection and transport cost rebate to start in the second year of the Scheme and to run for five years.

Results from the Base Case Stewardship Scheme Operation

The results indicate a positive NPV social benefit of $7 million for the base case. Given a 20% benefit is paid on the deemed market value of TDPs, the Scheme is budgeted to cost approximately $146 million over ten years of operation. The additional value of recovered resources is estimated at $71 million and the reduction in disposal costs is $83 million. Results show that with an AFR of $0.85 per EPU, the Scheme should have sufficient revenues to fund the budgeted expenses, only requiring funds from the ARF for the first eight years of Scheme operation. Accumulated funds are then used to fund the last two years of activities. The base case suggests that an ARF of $0.85 per EPU applied across all tyre categories can enable the funding of some major incentives: a benefit covering a proportional reduction in the market price TDPs and recovered steel and textile, as well as a rebate reducing of rural and regional transport costs to a metro equivalent cost.

If that level of incentive does not achieve the target recovery rate of 90% of end-of-life tyres, however, then the net present value will decline. At 80% the NPV is a loss of $5 million and at 70% a loss of $16 million. The overall result is sensitive to the recovery rate for the cost of a given benefit incentive.

Projections show that with the Scheme target recovery of 90% of end-of-life tyres in year ten, the number of tyres going to landfill is reduced to 8%. Likewise the level of illegal dumping is projected to decrease from 11% to 2% over the 10 year period of the Scheme.

Free Riders

The base case assumes that five per cent of imported or locally produced tyres evade the ARF. Given that level of free-riders then an ARF of $0.85 is required to cover suggested levels of benefit and Scheme operating costs. Analysis on freerider effects on ARF level showed if the freerider effect was absent then the ARF could be reduced to $0.80 per EPU, whereas if the freerider effect is as high as 50% then an ARF of $1.60 would be required.

Further assessment of the freerider effect and Price Elasticity of Demand (PED), to analyse the impacts of freeriders on new tyre demand, revealed that at 50% freerider level, producers of medium priced passenger tyres participating in the Scheme would see a 1.6% increase in the price of their tyres, resulting in a reduction in total market share of 1.8% or approximately $56.5 million for Scheme participants. Consequently freerider or other legislation would be required to avoid this loss in market share. Industry discussions have indicated that once a certain non-participation level of producers is reached, voluntary participation in the Scheme will fall away rapidly because other participants will experience or fear loss of market share and the Scheme will collapse (with the key point that fear of loss of market share alone will be enough to cause non-participation).

Consumer Impacts

The potential impact on consumers was assessed by comparing the financial load placed on purchasers of passenger tyres as a result of the ARF versus the current informal cost of tyre disposal that is commonly added to the cost of a new replacement tyre. Generally speaking a cost of $2.50 is charged to consumers by tyre retailers to dispose of their end-of-life tyres. If it is assumed that the ARF and the current arrangements will both continue to exist simultaneously for two years while the industry accustoms to the Scheme, and then after two years the $2.50 disposal cost is replaced by the ARF, then over the 10 years of the Scheme the saving to consumers on passenger tyres alone is approximately $130 million.

Effects on New Replacement Tyre Demand and Tyre Manufacturers

The budgeted size of the ARF to provide incentives in the form of benefits and rebates, and to operate and manage the Scheme is suggested at $0.85 per EPU. This is less than the $2.50 that is currently charged to many consumers for the disposal of their end-of-life tyres, a cost that is born by household and commercial consumers at the time of replacement tyre purchase. Consequently it is suggested that an ARF of some $0.85 cents per EPU will have little or no effect on new replacement passenger tyre demand. This will especially be the case if legislative changes result in low or insignificant freerider rates.

Remote and Transport Issues – OTR Tyres

What the results of this report have been able to show is that OTR tyres, and even those in remote locations, are likely to be a valuable and a sizable resource if targeted to high value uses. The gross margin analysis suggests OTR tyres to be viable for transformation into TC5 products. There remains a need for specific analysis of transport and transformation cost of the extremely large and remotely located tyres that are commonly used in mining.

Possible Advanced Recycling Fee-Benefit Structure

The ARF-benefit structure that is suggested and used as part of this analysis, is primarily a 20% benefit based on the deemed market value of TDPs that an end market user would pay the transformer. The categories of TDPs (TCs) are presented in a simplified manner in the report as it is understood that the PRO will finalise categories and values prior to the Scheme beginning. It is paid proportionally on value on the basis that it links incentive directly to achieve HNRV, the values of which will be determined by the PRO. It is not paid on the basis of transformation costs because this will not necessarily serve to encourage efficiency and will not necessarily serve to achieve HNRV. This approach does not need to be tied to validation of transformation processes and their definition, it simply rewards on the basis of product value. Essentially the higher the TDP value, the higher the TDP benefit paid per tonne.

This benefit payment is directed at creating a demand for high value products. By creating demand for end uses of TDPs it should work to pull resources through the supply chain. Flow-on benefits should be created from end users to transformers to collectors. This type of scenario is opposite to the current system whereby fees are paid to collectors to dispose of tyres, which tends to push used tyres towards the cheapest form of disposal.

Alternative mixes in benefit structure were costed because a shift to payment on value may cause short term structural adjustment as the consequence is likely to be a stronger emphasis on production of high value products whereas the current set of forces tends to lead to low value uses or the waste stream. A useful short term strategy to allow an adjustment period in the industry may be to provide a fixed bottom line incentive and then a variable incentive where values exceed this minimum. There may be grounds based on fairness for such an approach, although is should be made transparent how long such a minimum payment will continue.

Using the Stewardship Scheme to Expand Industries

Mechanisms for the Scheme to increase the rate of TDP use or achievement of HNRV should not focus only on using financial benefits or rebates as incentives for expansion to the exclusion of addressing a number of other barriers to expansion of industries based on transformed product. The consultation with industry stakeholders raised a number of issues seen as barriers to industry expansion, and generally these were not financial constraints.

Variability of TDP quality and reliability of supply (resource security) were commonly cited as barriers to industry expansion. These are critical areas the Scheme needs to address via industry coordination and education efforts, and it will be important that industry standards are developed to encourage production of high quality TDPs. Supply and quality problems may be symptoms of an infant industry but they currently appear to be real constraints to industry development. It should be a key area for development of the business case to assess the balance of resources put towards expenditure on incentive benefits and development of industry standards and coordination. Indicative budgets presented by this analysis provide for a high proportion of non-incentive payments to be allocated to research purposes. It might be that the setting of industry standards and enforcement of some code of practice can replace the perceived need for financial incentives and need for research.

Potential Highest Net Resource Value after ARF

It is a specific requirement of the Scheme to encourage the use of tyre derived products (TDP) that have the highest net resource value (HNRV). Generally the highest net resource after the Scheme is anticipated to come from TC4 and TC5 transformations, they also present the highest margins without any benefit payments and probably represent the best long term uses to encourage for sustainable use post the Scheme.

What Might Happen after the Scheme?

The outcome following ten years of the Scheme should be industries operating with security of supply, surety of the quality of the product they purchase and potentially no ongoing requirement for an ARF payment by producers and manufactures of tyres. Networks should be well developed, investment made in new processing equipment, and efficiencies for improved economies of scale achieved. Fundamentally, the expectation might be that the products that currently demonstrate the highest margins might well continue to have the highest margins once these future efficiencies are achieved.

An issue the PRO will need to monitor is whether sufficient demand arises for these products to achieve the long term reprocessing target of 90% of all tyres. In addition, a critical issue is how efficiently and cost effectively regional and rural tyres can be bought into the system, and how sustainable their use will be post ARF incentive benefits. The analysis presented for OTRs, which represent a major share of regional and rural UEPUs, suggest reprocessing is viable for TC5 products even when sourced from rural areas.

An important role of the operation and monitoring of the Scheme by the PRO will be an ongoing assessment of the numbers and value of tyres sourced from all areas. Improved market intelligence will be a necessary basis for any revisions of incentive that may need to be made during the operation of the Scheme to maximise sustainable use from all areas. It may not be reasonable to expect that all tyres can be sourced and transformed economically with or without ARF benefit payments. However, the expectation from stakeholder discussions regarding feasible industry growth is that 90% recovery can be achieved using high value products and the recovery of tyres for transformation into these products should be viable without the need for benefit payments in the future.

Advanced Recycling Fee (ARF)

In line with the conceptual rules of a product stewardship scheme, or extended producer responsibility scheme, the ARF is to be paid by the tyre importers and local tyre manufacturers on loose or fitted tyres. The ARF will be paid to the PRO, with one suggestion for ARF payment involving a Letter of Credit that is triggered after a tyre enters the market (when sold to retailer/dealer). The payment of the ARF will be monitored by the PRO, but will need to be enforced from an import perspective by customs and for local manufacture via the PRO.

The ARF is essentially transferable from producers to consumers, in part or in full, through the pricing of the tyre. At the current suggested ARF level ($0.85) it is thought that there will be limited if any effect on the demand for tyres, with the fee representing a small percentage of an average UEPU.

Benefit Payments

The financial and economic modelling has been undertaken assuming that the benefit will be paid at the TDP point of sale. The model setup means that it does not impact the outcome of the fee if the benefit is paid to the transformers or the end market users.

The collection of the ARF gives the PRO the resources to provide a benefit payment to facilitate the flow of tyres away from the waste stream towards recycling and transformation. The analysis shows that a benefit payment will result in a change in behaviour from the perspective of a reduced price for end users and through the provision of a payment to processors. For benefit provision the fund is directed towards two groups:

- Transformers of TDP, steel and textile; and
- Transport cost neutralisation.

The likely working of this Scheme will be for the transformers of TDPs to register with the PRO as approved transformers and end market producers, using TDPs as inputs registering with the PRO as approved end users. A transformer will need to provide the PRO with a proof of sale to a registered end market user in order to secure a benefit payment. The proof would need to provide details including:

- Quantity of product sold; and
- Proof of purchase by approved end use market producer.

The modelling of the Scheme has not allocated any of the ARF to upfront capital expenditure for capital grants on infrastructure, assuming that the payment of benefits for TDP product will provide the necessary incentive or security for private investment into the tyre recycling industry. It is possible for the PRO to allocate collected funds to capital investment if, after review periods 1 and 2, there has not been the necessary movement in end-of-life tyre flows.

Scheme Operating Costs

There are a number of expenses associated with the running of the Scheme, from collection and distribution of funds to monitoring and marketing the Scheme. In effect a budgeted cost for PRO and any subsidiary administrative requirements has been developed for the course of the evaluation period.

These Scheme operating costs that have been included in the financial and economic modelling are:

- Administration;
- Compliance and monitoring;

- Industry coordination;
- Research;
- Legislative support; and
- Marketing and education.

It is envisaged that the Scheme will be administered by the PRO, an industry established body that will have the task of collecting the ARF and will be required to allocate the benefits on the agreed basis.

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URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Australian Tyre Recyclers Council and the Australian Tyre Importers' Group and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 26 May 2005.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 20 June 2005 and 19 December 2005 and is based on the research undertaken, data provided by stakeholders and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A
Tyres Roundtable Member Organisations
(August 2005)

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Tyres Roundtable Member Organisations (August 2005)

Company/Organisation	Contact Name	Position
Tyre Industry		
South Pacific Tyres	Kevin Halpin	Manager Industry Affairs, Customer & Corporate Relations
Bridgestone Australia LTD	Stanley Toh	Marketing Manager
Bridgestone Earthmover Tyres Pty Ltd	Bruce Connor	Executive Manager – Marketing
Bridgestone Earthmover Tyres Pty Ltd	Michael Ryan	Executive Manager – Diversified Products
Yokohama Tyre Australia Pty Ltd	Steve Clifford	General Marketing Manager
Toyo Tyre & Rubber Australia Limited	Matthew Grovenor	Position not recorded
Tyre recycling industry		
Ecoflex	Tim Edwards	National Manager
SIMS Tyrecycle/Devote Pty Ltd	Allan Kerr	General Manager/ ATRA President
Reclaim Industries	Christopher Forrester	Position not recorded
Renewed Rubber Pty Ltd	Mark Glover	Director
Cleanaway	Paul MacBride	Manager – Resource Recovery
Associations		
Australian Tyre Recycling Association / Kreitals Consulting Group	Peter Kreitals	Managing Director
Australian Tyre Dealers & Retreaders Association / Claremont Tyre Service	Morrie Pinfold	ATDRA President
Australian Tyre Importers Group / de Denaro & associates	Silvio de Denaro	Secretary
Australian Tyre Manufacturers Association	Greg Mackey	Executive Director
Cement Industry Federation	Ros de Garis	Adelaide Brighton Cement
Cement Industry Federation	Stuart Ritchie	Policy Development Manager
Minerals Council of Australia	Melanie Stutsel	Director, Environment & Social Policy
Minerals Council of Australia	Cormac Farrell	Policy Officer, Environment & Social Policy
Motor Trades Association of Australia	Sue Scanlan	General Manager, Policy & Operations
Governments		
New South Wales Department of Environment & Conservation	Alex Young	Manager - Product Stewardship, Sustainability Programs Division
New South Wales Department of Environment & Conservation	Rod Clare	Sustainability Programs Division
Western Australia Department of Environment (Waste Management)	Vic Andrich	Project Coordinator EPHC Waste Initiatives
Western Australian Local Government Association	Maree Jones	Position not recorded
South Australia Environment Protection Authority	Rob Middlin	Senior Project Officer, Department for Environment & Heritage

Appendix A
Tyres Roundtable Member Organisations (August 2005)

Company/Organisation	Contact Name	Position
South Australia Environment Protection Authority	Tom Whitworth	Manager, Industry Sustainability
South Australia Zero Waste	Vaughan Levitzke	Chief Executive, Zero Waste SA
Victoria Environment Protection Authority	Claire Curry	Waste Management
Victoria Environment Protection Authority	Scott Maloney	Position not recorded
Victoria Environment Protection Authority	Jenn Sisson	Waste Management Unit
Ecorecycle Victoria	Diana Gibson	Position not recorded
Queensland Environmental Protection Agency	Peter Collins	Sustainable Industries Division
Queensland Environmental Protection Agency	Tim Powe	Manager, Clean Environment Policy
Queensland Local Government Association	Bryce Hines	Position not recorded
Tasmania Department of Primary Industries, Water & Environment	Mark Cretney	Department of Primary Industries, Water and Environment
Australian Capital Territory Department of Urban Services	Margaret Nicholson	ACT NoWaste
Australian Capital Territory Department of Urban Services	Graham Mannall	Position not recorded
Northern Territory Government	Brett Struck	Position not recorded
Northern Territory Local Government Association	Peter McLinden	Position not recorded
National Environment Protection Council	Dr Bruce Kennedy	Executive Director
National Environment Protection Council	Monina Gilbey	Position not recorded
National Environment Protection Council	Kerry Scott	Position not recorded
Commonwealth Department of Environment & Heritage	Michael Bissell	Assistant Director, Environmental Stewardship Section
Australian Customs	Bob Judd	Position not recorded
Australian Tax Office/Treasury	Trevor King	Position not recorded
Department of Industry	Alan Piira	Assistant Manager, Automotive Policy Section
New Zealand Ministry for the Environment	Alison Handley	Tyres & Oil

Source: Department of Environment & Heritage (August 2005)

Appendix B
Stakeholder Communications

Appendix B
Stakeholder Communications

Company/Organisation	Contact Name	Position
Tyre Industry (Producers, Importers & Retreaders)		
Bearcat Tyres	Mark Bloxham	Position not recorded
Bridgestone Australia Ltd (BSAL)	Stanley Toh Bob Hope	Marketing Manager Product Development Manager
Bridgestone Earthmover Tyres Pty Ltd	Bruce Connor Michael Ryan Peter Comninos	Executive Manager, Marketing Executive Manager, Diversified Products Senior Engineer
Michelin	Darren Scotti	Marketing Manager
Trojan	Nick Dimitriadis	Position not recorded
Yokohama Tyre Australia Pty Ltd	Steve Clifford	General Marketing Manager
Tyre Recycling Industry (Collectors, Transformers, End Market Producers & Technology Providers/Suppliers)		
A1 Rubber	John Randell	Position not recorded
Affordable Rubber	Wayne Houghton	Position not recorded
Allied Rubber	Michael Clayton	Assistant General Manager, QLD
ANRUB	Des Kennedy	Patent holder fro ANRUB
Australian Cement	Shane Borger,	AFR Market Manager
AustralAsian Rubber Pty Ltd	John Rossi	Director
AZPI Tyre Recycling	Phillip Isaccs Africa Zanella	Managing Director, Enervision Australia Pty Limited Representative, Regione Piemonte
Biofloat	Malcolm Hill	Evaporation pontoons
Bituminous Products Pty Ltd	John Bradley	Position not recorded
Blue Circle Southern Cement Berrima Cement Kiln	Grant Williams	Position not recorded
Boral / Blue Circle Southern Cement	Kathryn Turner	Business Development Manager
Boral Asphalt	Graham Hennessy	Pavement Engineer
Brambles Industrial Services	Geoff Keith	Business Development Consultant
Chip Tyre Pty Ltd	Robert MacDonnell	Managing Director
Cleanaway	Paul MacBride	Manager, Resource Recovery
Davco	Lian Devlin	R&D and QC Manager
Ecoflex	Tim Edwards	National Manager
Ecomat	Kevin Torpey	Position not recorded
Flexitec Rubber Surfaces (Tyre Recyclists Pty Ltd)	Bruce Pomery	Managing Director
Hays Group	Steve Hays	General Manager

Appendix B
Stakeholder Communications

Company/Organisation	Contact Name	Position
Levgum	Barry Batagol Greg Woodward	Australian Representative Levgum licensee
Molectra	John Dobozy	Managing Director
Reclaim Industries	Christopher Forrester	Position not recorded
Regenerative Rubber	Richard Banford	Director (AEM Pty Ltd)
Renewed Rubber Pty Ltd	Mark Glover	Director
Rubberilliant Pty Ltd	Andrew Pincott	Director
Sami	Azeem Remtulla	General Manager, Technical & Manufacturing
Sprayline	Joe Clodpher	Logistics Manager
SIMS Tyrecycle/Devote Pty Ltd	Allan Kerr	General Manager/ ATRA President
Tyre-Met Recycling (Sweden)	Dag Karnå	Former vice president of the European Tyre Recycling Association (ETRA) Board (up to 2003)
Associations		
Australian Tyre Dealers & Retreaders Association / Claremont Tyre Service	Morrie Pinfold	ATDRA President
Australian Tyre Dealers and Retreaders Association	Brian Cummins	Chairman, ATDRA Retreaders
Australian Tyre Recycling Association	Peter Kreitals	Secretary (ATRA)
Australian Tyre Importers Group	Silvio de Denaro	Secretary
Australian Tyre Manufacturers Association	Greg Mackey	Executive Director
Cement Industry Federation	Ros DeGaris Stuart Ritchie	Adelaide Brighton Cement Policy Development Manager
Motor Trades Association of Australia	Sue Scanlan	General Manager, Policy & Operations
Minerals Council of Australia	Cormac Farrell	Policy Officer, Environment & Social Policy
Governments		
ACT NoWaste, Department of Urban Services, ACT	Graham Mannell	Policy & Strategy Manager
Bellingen Shire Council	Robert Burgess	Building and Services Manager
Commonwealth Department of Environment & Heritage	Michael Bissell	Assistant Director, Environmental Stewardship Section
Commonwealth Department of Tourism Industry & Resources (Cement Industry Action Agenda)	Chris Lloyd	Manager, Major Projects Section Resources Division
Cooma-Monaro Council	Jeannie Ambrose	Resource & Waste Service Co-ordinator
Gloucester Shire Council	Ben Roberts	Environmental Health Officer
Griffith City Council	Santha Santhaseelan	Waste / Assets Engineer

Appendix B
Stakeholder Communications

Company/Organisation	Contact Name	Position
New South Wales Department of Environment & Conservation	Alex Young	Manager - Product Stewardship Sustainability Programs Division
	Rod Clare	Program Manager EPR Sustainability Programs Division
	Dr Bill Gara	Manager Technical Advisory Unit. Waste Policy Section, Environmental Protection Authority
	Dr John Chapman	Co Director, Environmental Protection Authority
New South Wales Environmental Protection Agency	Jane Mallen-Cooper	Head Waste Reform Unit, Environmental Protection Authority
New South Wales Minister for the Environment	Tony Wright	Chair of EPR Expert Reference Group
New South Wales Road Transport Authority	Greg Hall	Manager, Pavement Surfacing, Asset & Project Technology
	Mal Bilaniwskyj	Regional Asset Manager, RTA Wollongong
NetWaste (NSW)	Chris Foley	Projects Coordinator
North East Waste Forum (NSW)	Bernadette Thomas	Co-ordinator
Northern Territory Roads	Steve Marsh	Road Asset Management
Parkes Shire Council	Steven Campbell	Director Planning and Environment
Queensland Environmental Protection Agency	Peter Collins	Team Leader, Waste Management and Recycling
Queensland Roads	Peter Jamandijeria	Engineer
Riverina Eastern Regional Organisation of Councils	Belinda Maclure	Waste Programme Co-ordinator
Tamworth Regional Council	Jason Stratford	Senior Waste Officer
Transport SA, South Australia Department for Transport, Energy & Infrastructure	Hugo van Loon	Senior Asphalt Engineer, Materials Group, Pavements and Structures Section, Department for Transport, Energy and Infrastructure
Tasmania Department of Infrastructure & Energy	Jonathan Mulcahy	Roads surfacing
Victoria Environmental Protection Agency	Jenny Slatter	Position not recorded
VicRoads	Sandra Simpson	Position not recorded
VicRoads	Ian Cossens	Position not recorded
Western Australia Department of Environment (Waste Management)	Vic Andrich	Project Coordinator - Strategic Policy
Western Australia Environmental Protection Agency	Phillip Hine	Position not recorded
Western Australia Main Roads	Steve Hallagan	Position not recorded

Appendix B
Stakeholder Communications

Company/Organisation	Contact Name	Position
Other Industry Stakeholders		
Sita Environmental Solutions	Andrew Kosciuszko	NSW Post Collection Manager
Closed Loop London	Edward Kosior	Technical Director

Appendix C
Landfill Fee Data Collected Throughout Consultation

Appendix C
Landfill Fee Data Collected Throughout Consultation

Landfill Gate Fees on per Tyre Basis

Number of Sources per state	Motorcycle tyres (each)	Passenger tyres (each)	Small truck tyres (each)	Large truck tyres (each)	Tractor/ heavy machine (each)	Earthmoving tyres (per tonne)
VIC (5)	$2.25	$3.36	$5.54	$11.60	$35.95	$150.00
NSW (11)	$4.17	$4.38	$9.22	$12.57	$49.77	$120.00
NT (1)	$4.00	$4.00	$8.00	$16.00	$30.00	
QLD (3)	$3.43	$4.10	$5.50	$21.50	$42.50	$66.00
ACT (2)	$3.00					
TAS (3)	$2.50	$3.00	$6.00	$12.00		
SA (2)		$3.50	$9.00	$14.00	$27.50	
WA (3)		$5.57				

Note: The number in each bracket designates sites within each state of which figures were obtained.

Source: Industry and Local Government Sources

Appendix D
Particle Size Comparative Table (sieve-mesh-mm-in)

Appendix D
Particle Size Comparative Table (sieve-mesh-mm-in)

U.S. Sieve Size	Tyler Equivalent Europe	Opening	
		mm	in
-	2½ Mesh	8.00	0.312
-	3 Mesh	6.73	0.265
No. 3½	3½ Mesh	5.66	0.233
No. 4	4 Mesh	4.76	0.187
No. 5	5 Mesh	4.00	0.157
No. 6	6 Mesh	3.36	0.132
No. 7	7 Mesh	2.83	0.111
No. 8	8 Mesh	2.38	0.0937
No.10	9 Mesh	2.00	0.0787
No. 12	10 Mesh	1.68	0.0661
No. 14	12 Mesh	1.41	0.0555
No. 16	14 Mesh	1.19	0.0469
No. 18	16 Mesh	1.00	0.0394
No. 20	20 Mesh	0.841	0.0331
No. 25	24 Mesh	0.707	0.0278
No. 30	28 Mesh	0.595	0.0234
No. 35	32 Mesh	0.500	0.0197
No. 40	35 Mesh	0.420	0.0165
No. 45	42 Mesh	0.354	0.0139
No. 50	48 Mesh	0.297	0.0117
No. 60	60 Mesh	0.250	0.0098
No. 70	65 Mesh	0.210	0.0083
No. 80	80 Mesh	0.177	0.0070
No.100	100 Mesh	0.149	0.0059
No. 120	115 Mesh	0.125	0.0049
No. 140	150 Mesh	0.105	0.0041
No. 170	170 Mesh	0.088	0.0035
No. 200	200 Mesh	0.074	0.0029
No. 230	250 Mesh	0.063	0.0025
No. 270	270 Mesh	0.053	0.0021
No. 325	325 Mesh	0.044	0.0017
No. 400	400 Mesh	0.037	0.0015

Appendix E
Classifications for Tyre Derived Products

Appendix E
Classifications for Tyre Derived Products

TC	Type	Sizes (mm)	Common Industry Sizes (mm)	Mesh (USA)	Mesh (Europe)	Typical Use
TC1	Whole Tyres			N/A	N/A	Energy/Civil
TC2	Cut Tyres	(300 mm+)	300 mm +	N/A	N/A	Energy/Civil
TC3	Tyre Chip	(30 mm – 299 mm)	30 mm 40 mm 50 mm	N/A N/A N/A	N/A N/A N/A	Energy/Civil Energy/Civil Energy/Civil
TC4	Granulate	(1 mm – 29 mm)	8-15 mm 5-7 mm 1-4 mm	N/A 3-4 mesh 5-18 mesh	N/A 3-4 mesh 5-16 mesh	Civil/Equestrian Limited Market Soft Surfacing
	Buffing		5 mm 2.5 mm 1.2 mm	4 mesh 12 mesh 16 mesh	4 mesh 10 mesh 14 mesh	Sub Floors Soft Surfacing/Matting Soft Surfacing/Matting
TC5	Crumb (Powder)	(0 micron* – 0.9 mm)	630 micron 425 micron 250 micron 180 micron 100 micron 40 micron	30 mesh 40 mesh 60 mesh 80 mesh 140 mesh 400 mesh	28 mesh 35 mesh 60 mesh 80mesh 150 mesh 400 mesh	Roads/Adhesives General Rubber Mixing General Rubber Mixing General Rubber Mixing Elastomers Elastomers
Steel	Steel					
Textile	Textile					

* 1 mm is equal to 1,000 micron
Source: Industry Discussions 2005

Appendix F
International Experience

Appendix F
International Experience

Experiences of Manitoba Province, Canada

Manitoba Province in Canada has had a Used Tyre Levy in place since 1992.

Levy Operation & Setup:

- 1992 Government instituted a $3 levy on all tyres sold in the Province for use on licensed vehicles or trailers
- Levy imposed on consumers by retailers
- Levy imposed as part of Provincial Sales Tax
- 1995 Tire Stewardship Board (the Board) was established to coordinate with stakeholders, manage revenues and develop tyre solutions
- The *Waste Reduction and Prevention Act* and the *Tire Stewardship Regulation 33/95* provide the authority to make waste tyres a designated material and allow the Board to collect the levy and manage the funds
- 2000 tyre levy reduced to $2.80 for all tyres sold for use on licensed vehicles or trailers
- Levy only imposed on passenger, light truck and medium truck tyres
- Industrial and farm off-road tyres are not levied
- The Board registers tyre collectors and directs the destination of the tyres colleted

Outcomes from 2004/2005:

- 1,391,886 EPU or 13,908 tons did not enter landfills
- 1,390,886 EPU were recycled into the following products:

2004/05 Products from Waste Tyres (EPU)		
Moulded Products	193,945	14%
Shred	543,603	39%
Tyre Derived Fuel	556,894	40%
Mats	72,840	5%
Cut Products	23,604	2%
Total	**1,390,886**	**100%**

- 29 audits of retailers undertaken, which returned $17,360.94 (from Freeriders)
- 841,907 car, light and medium truck (levied) tyres were sold
- 55,654 off-road (non-levied) tyres were sold
- Levies collected and recycling payment made were as follows (with reserve funds needed to cover payments):

2004/05 Levies and Payments (CAN $)	
Total Levies Collected	**$2,324,639**
Product Credits Paid to Processors	($2,578,611)
Transportation Payments	($80,546)
Off-road Tire Clean Up Project	($75,700)
Municipal Incentive Payments	($95,769)
Total Payments Made	**($2,830,626)**

Issues/outcomes arising from scheme:

- Over 8 years of the scheme, the Board's processors have generally recycled more EPU that new EPU sold and levied (result of recycling un-levied off-road tyres from industry and agriculture)

- The Board has used surplus funds to remove and recycle all off-road tyres that were stockpiled on processors' yards, the reserve fund is now depleted
- The Board has been active in promoting the use of used tyres in geotechnical works, and in advertising tyre derived products, with plans to continue and expand this in the future

Source: Manitoba Tire Stewardship Board Annual Report 2004/2005

Comparison of European recovery rates for tyres

	Tyre arisings (tonnes)	Weight of Tyre/person /year (kg)	Overall recovery rate (%)	Reuse (%)	Retreading (%)	Materials recycling (%)	Energy recovery (%)	Export (%)
Belgium	45,000	5	94		22	11	33	28
Finland	30,000	6	80		6	60	2.5	11.5
France	370,000	6	39		20	9	7	3
Germany	596,000	7	92	2	14	15	45*	16
Netherlands (car only)	45,000	3	100	16	29	8	47	
Spain	241,000	6	19		13.5	0.5	3.5	1.5
Sweden	58,000	7	98	19	8.5	6.5	54	10
UK	468,000	8	70	16	18.5	10.5	18	7.5

* (Capacity not actual usage)

Source: U.K. Used Tyre Working Group (2000) (Cited in MWH New Zealand Ltd 2003)

Appendix G
Australian Harmonised Export Commodity Classification, Index of Commodities (July 2003)

Appendix G Australian Harmonised Export Commodity Classification, Index of Commodities (July 2003)

Australian Harmonised Export Commodity Classification, Index of Commodities

Commodity Description	Code
Tyres, pneumatic, new, of rubber or Pneumatic tyres, new	4011
Motor car pneumatic tyres, new	4011.10
Bus or lorry pneumatic tyres, new	4011.20
Aircraft pneumatic tyres, new	4011.30
Motorcycle pneumatic tyres, new	4011.40
Bicycle pneumatic tyres, new (excluded from study)	4011.50
Tyres, pneumatic, used or retreaded, of rubber	4012
Retreaded tyres	4012.1
Pneumatic tyres, used	4012.20
Solid or cushion tyres of rubber, or Tyre flaps of rubber, or Tyre treads, interchangeable, of rubber	4012.90
Tyre cord textile of high tenacity yam of nylon or other polyamides, polyesters or viscose rayon	5902

Source: ABS 2003

The Australian Harmonised Export Commodity Classification is based on the APEC Tariff Codes as presented below:

Tariff Headings for Chapter 40, Chapter Description, Rubber and Articles Thereof

Commodity Description	Code
Tyres, pneumatic, new, of rubber or Pneumatic tyres, new	4011
Motor car pneumatic tyres, new	4011.10.00
Bus or lorry pneumatic tyres, new	4011.20.00
Aircraft pneumatic tyres, new	4011.30.00
Motorcycle pneumatic tyres, new	4011.40.00
Bicycle pneumatic tyres, new (excluded from study)	4011.50.00
Other, having a "herring-bone" or similar tread	4011.6
Agricultural or forestry vehicles and machines	4011.61.00
Construction or industrial handling vehicles and machines and having a rim size not exceeding 61 cm	4011.62.00
Construction or industrial handling vehicles and machines and having a rim size exceeding 61 cm	4011.63.00
Other	4011.69.00
Agricultural or forestry vehicles and machines	4011.92.00

Appendix G
Australian Harmonised Export Commodity Classification, Index of Commodities (July 2003)

Commodity Description	Code
Construction or industrial handling vehicles and machines and having a rim size not exceeding 61 cm	4011.93.00
Construction or industrial handling vehicles and machines and having a rim size exceeding 61 cm	4011.94.00
Tyres, pneumatic, used or retreaded, of rubber	4012
Retreaded tyres	4012.1
Motor cars (including station wagons and racing cars)	4012.11.00
Buses and lorries	4012.12.00
Aircraft	4012.13.00
Other	4012.19.00
Pneumatic tyres, used	4012.20.00
Solid or cushion tyres of rubber, or Tyre flaps of rubber, or Tyre treads, interchangeable, of rubber	4012.90
Tyre cord textile of high tenacity yarn of nylon or other polyamides, polyesters or viscose rayon	5902

Source: URL: http://www.apectariff.org/tdb.cgi/ff3139/apecfind.cgi?form_name=CHAPTER&max_chapter=10&Country=AU&chapter=40&csearch.x=91&csearch.y=10

Tariff Headings for Chapter 87, Chapter Description, Vehicles other than Railway or Tramway Rolling-Stock, and Parts and Accessories Thereof

Commodity Description	Code
Tractors	8701
Motor vehicles for the transport of ten or more persons, including the driver	8702
Motor cars and other motor vehicles principally designed for the transport of persons (other than those of 8702), including station wagons and racing cars	8703
Motor vehicles for the transport of goods	8704
Special purpose motor vehicles	8705
Works trucks, self-propelled	8709
Motorcycles (including mopeds) and cycles fitted with an auxiliary motor	8711
Carriages for disabled persons	8713
Trailers and semi-trailers	8716
Other aircraft (for example, helicopters, aeroplanes)	8802

Source: URL: http://www.apectariff.org/tdb.cgi/ff3139/apecfind.cgi?form_name=CHAPTER&max_chapter=10&Country=AU&chapter=87&csearch.x=68&csearch.y=21

The PRO will need to refer to additional commodity classifications to those in Appendix G, as the descriptions above are limited and there are a number of other tyre classifications to be included under the proposed Scheme.

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