KPMG

Ministry for the Environment

Waste Tyres Economic Research: Report 3

Intervention options to promote investment in on-shore waste tyres recycling

May 2015

Table of Contents

Contents

Document review and approval

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This document has been reviewed by

	Reviewer	Date reviewed
1	Jack Carroll – Partner, KPMG	29 May 2015
2		
3		

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1 Key Findings

With one billion End of Life Tyres (ELTs) generated each year globally, sustainable reuse and disposal of waste tyres is a global issue. A significant amount of work has been completed abroad and in New Zealand to understand the options for alternative tyre uses, and to support market development for waste tyre collection and processing. Yet, an estimated 70% of New Zealand waste tyres are still disposed in landfills or otherwise unaccounted for[1], compared with less than 5% in Europe, and less than 20% in the United States (US) and Japan. At present about 4 million car and 1 million other waste tyres are generated annually in New Zealand which need disposal.

The Tyrewise project in 2013 brought together industry representatives and made detailed recommendations for a tyre product stewardship scheme, in order to increase the rate of on-shore recycling[2].

This research builds on the Tyrewise analysis and focuses on:

- Understanding the economic drivers and barriers to investment.
- Identifying and evaluating potential government interventions to address the barriers to investment and increase the level of waste tyre recycling in New Zealand.
- Recommending strategies to implement the suggested government interventions.

There is a lack of formal data available regarding the New Zealand market for end-of-life tyres, therefore our report has been informed by interviews, financial and operational metrics provided by local market players, and international research.

1.1 Current barriers to investment

The current waste tyres market is served by regionally fragmented and subscale collectors and processors. The largest collector has about 15% market share. Based on our research, investment in recycling is hampered by three principal barriers:

A) Limited addressable end-use market size

- There is a limited local market for recycled rubber products (e.g. mats, equestrian turf), and access to international markets is uncompetitive due to volatile demand and freight costs.

B) Business model requiring scale

- There are high upfront costs and no local track record for establishing large-scale alternative end uses (e.g. rubber in roads and energy recovery). Lack of scale also limits investment in waste tyre processing.
- It is uneconomical to collect tyres outside the main centres due to high freight costs and competition from local disposal alternatives (such as landfilling, farm use).

C) Insufficient funding

- Generators, such as tyre retailers and garages, seek low cost tyre disposal options and competition limits collection fees to approximately $2 per equivalent passenger unit

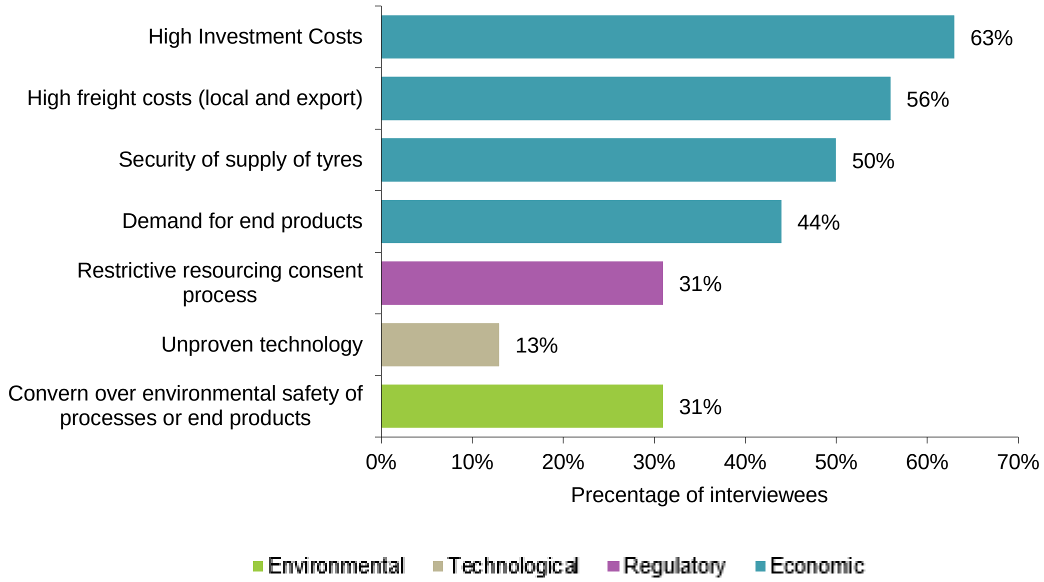
[1] Based on Tyrewise Summary Report 7 and KPMG analysis
[2] Project details and deliverables included at http://tyrewise.co.nz/

(EPU). This is insufficient to fund recycling options that require a higher level of processing.

- Disposal fees paid by consumers, at an average of $4 to $5 per EPU, are not passed on to collectors, processors and manufacturers. Disposal fees are typically 'bundled' with the purchase and fitting of new tyres, and consumers choose a provider mainly on the value of the new tyres, not the cost of disposing their used tyres. Excess profit from disposal fees remains with the retailer, potentially subsidising the sale of new tyres.

Interview feedback from market participants, summarised in the chart below, confirm the above barriers to investment.

Interview feedback: What are the main reasons for the current under-investment in waste tyre recycling[3]



Current end-uses and illustrative return profiles are summarised in the following table. This shows that at the current level of funding, profitable end-uses for waste tyres are limited to niche recycling markets or low cost disposal to landfill and farms. Alternative large-scale applications, used overseas in material and energy recovery and construction, would produce a negative commercial return in the current New Zealand market.

[3] Interviewees on average have provided more than one reason for under-investment therefore the total is greater than 100%. The feedback is represented at an organisational level, i.e. the views of multiple interviewees from the same organisation count as one.

Estimated net income from current end uses of waste tyres

Current end uses	Net income/(cost) from recycling by stage in $/EPU					
	1. Disposal fee income	2. Collection cost	3. Processing cost	4. End Use net income[4]	Net Total Return	Observations
Whole tyres sent to farm	1.8	(1.2)	-	-	0.6	Simple business model, but limited by seasonal demand
Cut tyres for landfill	1.8	(0.5)	(0.3)	(0.5)	0.5	High volume, low margin business
Baled whole tyres for export	1.8	(1.2)	(0.5)	0.1	0.2	Marginal profit with volatile demand – not sustainable by itself
Tyre derived fuel (TDF) for export	1.8	(1.2)	(0.8)	0.1	(0.1)	
Powder for roads (export)	1.8	(1.2)	(3.7)	3.2	0.1	
Granulate for Equestrian turf	1.8	(1.2)	(2.7)	3.6	1.5	Good margin, but low volume niche markets
Granulate for sports field	1.8	(1.2)	(3.0)	5.0	2.6	
Granulate for mats	1.8	(1.2)	(3.0)	6.0	3.6	
Powder for adhesives	1.8	(1.2)	(3.7)	6.0	2.9	

Source: interviews and data sourced from stakeholders

1.2 Future drivers and enablers of investment

A future market that successfully overcomes the current barriers needs to:

1. *Expand waste tyre collection nationwide.* This requires incentives for operators to service remote areas, and making collection competitive versus landfilling. If collection was expanded nationwide, the current estimated cost of $1.00 to $1.30 per EPU around main centres would increase to an average $1.70 to $1.90 per EPU (including over $2.50 in the South Island).

2. *Increase utilisation of existing processing capacity and establish capacity in the South Island.* Increased processing volumes would reduce processing unit costs for granulated and crumb rubber by approximately 35%, from $2.70 to $3.70 per EPU. Investment assumes sufficient profitable demand that covers the cost of processing.

[4] End-use net income equals the price of the end product less any production cost

3. *Invest in scalable new manufacturing options (end uses).* This is likely to require financial support, given the low commercial return from large scale recycling.
4. *Develop an effective funding mechanism that covers the full cost of collection, processing and manufacturing.* Current collection revenues of approximately $2 per EPU can only support a limited range of recycling options.

Accordingly, a successful market with better funding and higher collection rates may afford a more diverse, large-scale, local recycling industry. Potential new end uses and illustrative return profiles are shown in the following table. Key drivers and assumptions are discussed in the supporting analysis included later in this report.

Estimated net income from potential future uses of waster tyres

Potential new end uses	Net income/(cost) from recycling by stage in $/EPU					Observations
	1. Disposal fee income	2. Collection cost	3. Processing cost	4. End Use net income[5]	Net Total Return	
TDF in cement production (20k tonnes)	5.0	(1.7)	(0.5)	(0.5)-(1.6)	1.2 - 2.3	Good economic case but faces consenting and public relations challenges
Chip seal roads (30k tonnes)	5.0	(1.7)	(2.3)	(0.7)	0.3	Marginal case, requires all roads to be converted (unlikely to be realistic)
Asphalt roads (2k tonnes)	5.0	(1.7)	(2.3)	(0.2)	0.8	Smaller scale and has operational challenges
Material recovery (small scale)	5.0	(1.7)	(0.3)	0.1	3.1	Risk of unproven technology and end-product quality, and volatile market value
Material recovery (large scale)	5.0	(1.7)	(0.3)	1.6	4.6	

Source: interviews and data sourced from stakeholders

Overall, increased and more effective funding is a key enabler for the development of a diverse on-shore tyre recycling industry. A further principal enabler is an appropriate commercial model, which allocates funding efficiently and in line with desired outcomes.

These enablers can make new large-scale end uses economically viable. Nevertheless, non-economic barriers, such as technological, commercial and environmental issues are also relevant and discussed further in the supporting analysis included in this report.

[5] End-use net income equals the price of the end product less any production cost

1.3 Intervention options

Potential options to overcome investment barriers were identified through stakeholder interviews and research of similar sectors overseas and in New Zealand. The following table sets out a long-list of options (which includes features of broader market models) and their relevance to the three investment barriers described above.

Key levers	Intervention options	Main barriers addressed		
		I. Market size	II. Scale	III. Funding
1) Additional regulation and enforcement	a) Landfill ban/disincentives for landfilling b) Investment in enforcing existing legislation on illegal disposal, stockpiling and export controls c) Introducing licenses to collect waste tyres		✓	
2) Market organisation	a) Mandatory product stewardship b) Voluntary product stewardship c) Bounded Free Market model	✓	✓	✓
3) New funding model	a) Price controls b) Advanced disposal fee/levy c) Tax system d) Deposit refund e) Trading scheme	✓	✓	✓
4) Investment and risk mitigation	a) Supply chain incentives b) Investment in infrastructure c) Procurement – off-take agreements d) Investment in R&D	✓	✓	✓

1.4 Option evaluation

The evaluation of the option long-list was carried out using criteria agreed with the Ministry for the Environment (MFE). The evaluation criteria is based on the Treasury 'Better Business Case' guidance[6], with revisions to reflect the specific aims of this project. The criteria are as follows:

- *Ability to deliver environmental and economic outcomes*: increasing recycling, waste minimisation, on-shore waste tyre industry growth, and reduction in waste crime.
- *Affordability*: sufficient funding can be sourced (from government and the private sector).

[6] Source: www.infrastructure.govt.nz/publications/betterbusinesscases

- *Alignment with existing policies*: fit with relevant policies and ongoing programmes, e.g. environmental, trade, procurement, funding and international obligations.
- *Achievability*: government and the market have the capability and willingness to deliver the required changes within time and budget constraints, and execution risks are manageable.
- *Equity*: arrangements are fair to all stakeholders, and support competition and market entry.
- *Value for money* (assessed for short-listed options): the incremental benefits of intervention exceed the incremental costs (also referred to as the 'net benefit test').

The following table summarises the evaluation and highlights the long-list items taken forward for short-listing. The description of the long-list and its evaluation is set out in detail in the supporting analysis.

	Outcomes	Affordable	Policy fit	Achievable	Equity	Taken fwd for short-listing
1a) Landfill ban/ disincentives	Partial ('P')	✓	✓	✓	✓	yes
1b) Invest in enforcement	P	✓	✓	P	✓	yes
1c) Collector licensing	P	✓	✓	✓	✓	yes
2a) Mandatory product stewardship	✓	✓	✓	P	✓	yes
2b) Voluntary product stewardship	P	✓	✓	-	-	no
2c) Bounded Free Market model	✓	✓	✓	P	✓	yes
3a) Price controls	✓	-	-	-	✓	no
3b) Advanced disposal fee	✓	✓	✓	✓	✓	yes
3c) Tax system	✓	✓	✓	✓	-	no
3d) Deposit refund	-	✓	✓	✓	✓	no
3e) Trading scheme	✓	-	✓	-	✓	no
4a) Supply chain incentives	✓	✓	✓	✓	✓	yes
4b) Infrastructure investment	P	✓	P	P	P	yes

	Outcomes	Affordable	Policy fit	Achievable	Equity	Taken fwd for short-listing
4c) Procurement support	✓	✓	P	P	✓	yes
4d) R&D investment	P	✓	✓	✓	✓	yes

Options taken forward to the short-list were grouped into three categories. They involve increasing levels of intervention (from Option A to C), aimed at driving improved outcomes.

Options	A) Enhanced Status Quo	B) Free market with further regulatory protections (“Bounded Free Market”)	C) Mandatory Product Stewardship
Overview	‘Quick wins’ focused on the enforcement of existing legislation	Additional disposal limitations and reporting obligations with market-led delivery	Co-regulatory approach with producers, per the Tyrewise proposal
Examples	Builds on the existing system in New Zealand	UK, Ireland, Germany	Canada, South Africa, France
Key features	• Increased disincentives for landfilling nationally • Investment in enforcing existing legislation on illegal disposal, stockpiling and export controls	• Investment in enforcing existing legislation on illegal disposal, stockpiling and export controls • New legislation to introduce nationwide landfill ban • Introduction of collector licensing • Mandatory reporting to track the movement of waste tyres • Sponsored initiatives, e.g. consumer education	• Investment in enforcing existing legislation on illegal disposal, stockpiling and export controls • New legislation to introduce nationwide landfill ban • Advanced disposal fee paid by producers • Supply chain incentives to distribute advanced disposal fee to specific points in the supply chain • Investment in R&D, information sharing and public education • Procurement off-take agreements and infrastructure investments subject to appropriate business case
Long-list items included	1a, 1b	1a-1c, 2c, 4d	1a-1c, 2a, 3b, 4a-4d

Cost-benefit analysis (CBA)

KPMG's analysis was prepared in line with Treasury CBA guidance[7]. The analysis quantifies the economic impact of intervention options and enables comparison relative to the base case 'Status Quo' scenario, which assumes no intervention.

Costs and benefits are projected over 10 years from 2015 to 2024, and discounted to their Net Present Value (including the terminal value of net benefits beyond year 10). For discussion of the modelling approach and assumptions on tyre-flow volumes, and costs and benefits, see the supporting analysis in the following sections of this report. The table below summarises the incremental Net Present Value (NPV) of the short-listed options.

Present Value of Incremental Costs and Benefits vs Base Case ($m)		**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Costs	a) Scheme related	10	51	66
	b) Transport	17	70	91
	c) Processing	11	23	25
	d) End use	16	37	38
	e) Incremental costs	*53*	*181*	*220*
Benefits	f) Market value of products and services	49	132	149
	g) Environmental benefits	18	64	87
	h) Incremental benefits	*67*	*196*	*236*
Net Present Value ($m) (=h-e)		**14**	**15**	**16**
NPV sensitivity range (see Section 6.5.2)		7-37	5-53	6-51
Net industry benefit (pre-incentives) (=f-b-c-d)		5	2	(5)

Key points to note:

- Each option produces a positive NPV (i.e. meets the net benefit test), and the difference between the NPVs is immaterial. Therefore, the options are equivalent from an economic 'value for money' perspective, under the assumptions used. Key differences are in the options' effectiveness in addressing the current investment barriers, and their ability to deliver environmental outcomes (e.g. increased rate of on-shore waste tyre processing).

[7] Source: Cost Benefit Analysis Primer v1.12

- Options B and C incur a progressively higher share of scheme related overheads compared to Option A, which is balanced by an increasing share of environmental benefits. Incremental regulatory costs are primarily underpinned by non-commercial benefits.
- In Option C the net benefit to the waste tyre industry is negative, which means that the industry requires financial incentives (funded by a levy) beyond regulatory intervention. Increasing recovery rates assumed in Options B and C produce diminishing commercial returns.
- Sensitivity analysis suggests that key assumptions impacting the NPVs include the tyre recovery rate (i.e. the efficiency of intervention) and changing raw material prices (i.e. opportunity costs for material and energy recovery). Variations in these assumptions have a higher impact on Options B and C (due to their larger overhead costs) than Option A.

1.5 Short-list comparison

The table below provides an overall assessment and ranking of the short-listed intervention options based on their fit with the agreed criteria. Evaluation scores for the relative ranking are detailed in the supporting analysis.

Option	**Key changes to the current model**	**Relative ranking**	**Key advantages/ disadvantages**	**Net benefit**
A) Enhanced Status Quo	Investment in enforcement Increased disincentives for landfilling	3rd	✓ Lowest cost, lowest implementation risk (incremental approach) × Limited ability to address economic and environmental outcomes	$14m
B) Bounded Free Market	Landfill ban Collector licensing Increased industry reporting and regulatory oversight	2nd	✓ Market-led approach × Does not assign accountability for outcomes, or remove incentives for illegal dumping	$15m
C) Mandatory Product Stewardship	Landfill ban Advanced disposal fee Supply chain incentives Mandatory product stewardship participation	1st	✓ Clear accountability, sector coordination, and incentives aligned with outcomes × Higher cost to establish and operate	$16m

Based on this evaluation, Option C provides the best overall fit with the agreed criteria. The net economic benefits are not materially different. The key trade-off is affordability (i.e. cost) against ability to deliver environmental outcomes. Options A to C offer progressively higher waste tyre recovery and on-shore recycling rates (i.e. increasing environmental benefits) but diminishing commercial returns and increasing administrative overheads.

1.6 Suggested way forward

Based on our analysis and interviews, enduring investment barriers, and insufficient capacity and willingness to invest underpin the need for government intervention. Nevertheless we note that the economic analysis presented here is just one input into future policy development; the Ministry will need to take into account additional factors and considerations before developing any new policies related to waste tyres. Additionally, risks and uncertainties related to non-economic factors, such as the introduction of new technologies and stakeholder's resistance to change, should also be considered and mitigated. These non-economic barriers and risk factors and highlighted in more detail in the supporting analysis of this report.

We recommend a two-phased approach outlined in the following chart. A phased approach enables continued progress on the implementation of the option that offers greatest value to stakeholders, while facilitating more detailed regulatory design, organisational planning and technology trials, and further consultation before the proposed changes 'go live'.

Proposed phased approach

Market Model Development

Phase 1: Confirm Approach for Intervention
(next 6-12 months)

- **Complete due diligence** of non-economic barriers and confirm intervention strategy
  - Research / trial new-end uses
  - Review enhanced enforcement options
  - Complete policy analysis and impact assessment
- **Progress the development of the recommended intervention option**
  - Consider priority product consultation responses and incorporate the wider policy direction on waste minimisation
  - Develop scheme design
  - Update business case based on trial results and scheme design

Consultation & Agreements
(next 12 months)

- **Consult with stakeholders** on intervention strategy and scheme design
- **Agree Memorandums of Understanding** (eg with New Zealand Transport Agency, Ministry of Transport, TDF user(s), local councils)

Phase 2: Implement chosen scheme
(next 12-18 months)

- **Introduce enabling regulation**
- **Scheme accreditation and launch**
  - Subject to the outcome of consultation

KPMG's economic research, and evaluation of alternative options, indicates that introducing a mandatory product stewardship scheme is an attractive intervention path. Nevertheless, additional non-economic factors should also be considered in deciding on an intervention strategy.

KPMG recommends that in Phase 1, MFE gathers further evidence on non-economic barriers and the technical feasibility of large-scale end uses, such as rubber in roads, TDF, and material recovery. In parallel we suggest the continued development of a mandatory product stewardship scheme, given the supporting evidence gained to date - including the Tyrewise project and our analysis.

The key elements of Phase 2 are the introduction of enabling regulation, and the accreditation and launch of the chosen scheme. Phase 2 development involves stakeholder engagement and public consultation on the scheme design. Also during Phase 2, support from key government and industry participants would be sought, potentially in the form of Memorandums of Understanding.

If mandatory product stewardship is considered appropriate following consultation, different aspects of this option may be introduced gradually over time. In particular, a landfill ban may be phased in over time as production capacity and demand for new end-uses increases.

2 Supporting Analysis: Introduction

The following sections provide further detail behind the key findings summarised previously, including:

- An assessment of the drivers and barriers to investment in on-shore waste tyre recycling.
- An overview and evaluation of intervention options including cost-benefit analysis.
- Recommendations on potential intervention strategies.

2.1 Approach

This study builds on a significant amount of work undertaken by the Tyrewise project to bring together industry representatives and make detailed recommendations for the establishment of a waste tyre product stewardship scheme[8]. Our work has leveraged the existing Tyrewise analysis and the industry knowledge and relationships built up in the course of the Tyrewise project.

Further, this report was informed by interviews and financial and operational metrics provided by local market players, and secondary research of New Zealand and international resources. Altogether, 19 industry organisations (listed in Appendix A), the 3R Group (the project manager of Tyrewise) and the Ministry for the Environment (MFE) provided information and feedback for our work. Views and information gained through the interviews were invaluable in developing our analysis, due to the lack of formal data on the New Zealand waste tyre recycling market.

In addition to financial and operational metrics, stakeholders offered views on intervention options that may contribute to increasing waste tyre recycling in New Zealand. The intervention options gathered from stakeholders, combined with options sourced from research into overseas schemes, formed a long-list of potential options.

The evaluation of these options followed Treasury's 'Better Business Case' guidance. Evaluation criteria were established using Treasury's framework and incorporating the industry and policy context of this project. The long-list was assessed against the criteria and the items carried forward were combined to create a short-list of options.

Further, a cost-benefit analysis (CBA) was undertaken of the short-list to assess the economic impact of interventions compared to the status quo involving no intervention. The qualitative and quantitative evaluations were synthesised to assess the relative merits of each option.

Our concluding recommendations on intervention strategies summarise the suggested key objectives, risks and enablers, and implementation path for government to facilitate investment in on-shore waste tyre recycling.

[8] Project details and deliverables included at http://tyrewise.co.nz/

3 Overview of current investment drivers and barriers

The current market can be divided into four segments along the value chain: waste tyre generation, collection and transport (referred simply as 'collection' in this report), processing, and manufacturing. The table below gives a short overview of each segment and presents examples of businesses active in each. The following sections discuss the key economic drivers of investment at each stage along the value chain.

Market segment	Overview	Examples of market players
Generation	Waste tyres are generated by business that sell and replace new tyres for old ones	• Bridgestone/Firestone • Goodyear/Dunlop
Collection	Waste tyres are collected and transported from tyre retailers, garages, car wreckers, transfer stations, and other collection sites to processors	Most collectors are also processors, although there are some operators who focus on either collection or processing. Examples of collectors who also act as processors include: • J&J Laughtons • Tyreless Corporation • Pacific Rubber.
Processing	Processors convert waste tyres into secondary products. Processes include cutting, shredding and granulation to form different grades of rubber (TC1 - TC5)	
Manufacturing	End uses of waste tyres in the current market include: • Rubber mats • Adhesives • Artificial turf for sports arenas.	• Matta Products • Numat • Rubber Solutions

3.1 Generation

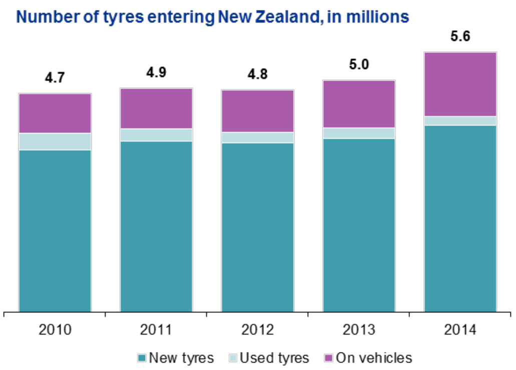
3.1.1 Source of tyres

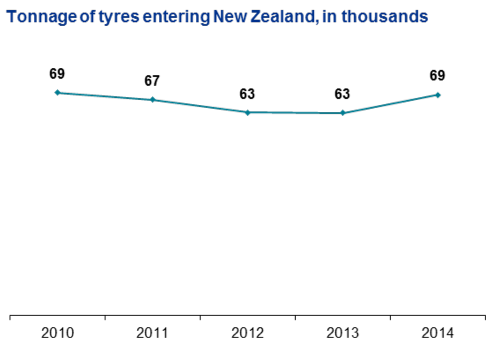
Tyres enter New Zealand as loose tyres (new, used, re-treaded) and tyres on vehicles (including spare tyres). To update the number of tyres, and tonnage, entering New Zealand we used the same approach as Tyrewise (refer Appendix B). Accordingly the number of tyres entering New Zealand in 2014 is estimated at 5.6 million based on the data sourced from the Statistics New Zealand InfoShare database. Since 2010, approximately 5 million tyres have been imported per annum.

The first graph below illustrates the volume of tyres entering New Zealand over the past five years. During this period, new loose tyres represented the largest proportion of imported tyres followed by tyres on vehicles. The proportion of new, used and on-vehicle tyre imports by quantity has remained relatively constant between 2010 and 2013 with a noticeable increase in new and on-vehicle tyres entering New Zealand in 2014. The total number of tyres entering New Zealand has increased by 22% between 2010 and 2014.

The second graph illustrates the weight in tonnes of the tyres entering New Zealand. Accordingly, approximately 69,000 tonnes of tyres arrived in New Zealand in 2014, compared to approximately

63,000 tonnes in 2013. The weight varies depending on the type of tyres imported, and the variation in weight and volume is in part driven by the changing proportion of industrial, commercial, and passenger tyres that were imported.





3.2 Collection

About a dozen larger waste tyre collectors operate in New Zealand according to the Tyrewise project[9]. Additionally there are 40-50 smaller operators who collect tyres; some on an ad-hoc basis. Collectors charge a fee and collect waste tyres from tyre retail outlets, garages, car wreckers, illegal dumps, city or regional council sites. Collected waste tyres may then be transported to a site for further processing, to be baled for exporting, or transported directly to a landfill. Some collectors dispose of waste tyres through landfill and exporting only; others combine collection activity with processing.

The key economic drivers for collection are summarised in the following table and the text below.

Key economic drivers for collection

Drivers		Value	Overview
A) Cost drivers	Upfront investment costs	L	Trucks to collect and transport waste tyres and a site for storage
	Production costs: % fixed	L	Maintenance, lease, on-road and administration costs
	Production costs: % variable	H	Fuel, labour
B) Revenue drivers	Volumes needed	L	Low volume is sufficient

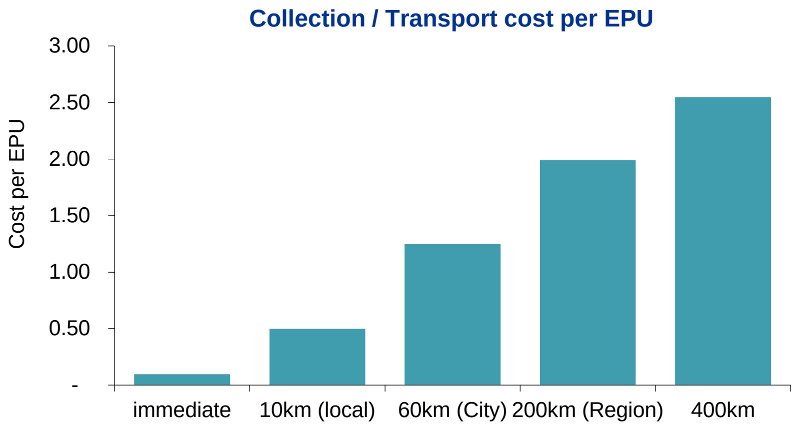
[9] Source: Tyrewise Scoping Report 1

Drivers		Value	Overview
	Price stability	M	Dependent on the end use e.g. export prices are volatile. However, most collectors are also processors, which provides price stability (i.e. collectors are internal customers of their own delivery)
C) Supply volumes and costs	Volumes required	L	Low volumes needed as set out above
	Price stability required	L	As outlined above many collectors are also processors which provides price stability

Collection businesses have low investment requirements to establish an operation and has low fixed costs once established. Therefore the financial barriers to entry are relatively low, with annual breakeven volumes of around 50 tonnes according to interviewees. However existing markets in main urban centres are well served and established relationships between collectors and their customers represent a notable barrier to new entrants.

3.2.1 Cost drivers

As well as the costs described in the table above, a key driver of cost for collectors is the volume of tyres carried (e.g. cargo) and distance travelled for the transport of waste tyres. The graph below outlines the estimated cost of transport in five distance bands: immediate (i.e. minimal transport required), average 10km distance (local), 60km (around a city), 200km (regional) and 400km (wide area). In the current market, waste tyres are typically transported within the first three bands up to 60kms from the depot site. As the graphs outlines, the cost of transport increases broadly proportionally with the average distance travelled.



3.2.2 Revenue drivers

Collectors typically charge a fee ranging from $1.50 to $2.20 per EPU including GST. The collectors-processors interviewed highlighted the challenge of competing with collectors who bale and export waste tyres or transport them directly to local farms and landfills at a cut price.

Several collectors are also processors which expands the potential end-use markets and provides some protection from demand volatility. Interviewees indicated that the fee charged per EPU has remained broadly stable for the last 10 years and therefore collectors have focused on developing new markets and end-uses to increase revenue.

3.2.3 Supply volumes

The generation of waste tyres is reasonably stable all year around. However availability of supply to collectors is dependent on generators paying for recycling, rather than seeking lower cost disposal. Whilst volumes and market shares of established local markets (Auckland in particular) have been stable, there is periodic increase in low cost competition depending on access to export markets and seasonal demand for tyres on farms. For example during busy periods for farmers the supply of waste tyres available for collectors is reportedly reduced.

3.3 Processing

Processors convert waste tyres into secondary products. As highlighted above, processors often also collect and transport waste tyres. Processing of waste tyres include baling, cutting, shredding, granulation and production of rubber powder (crumb). These secondary products are then used directly (e.g. for equestrian turf and in-fill in sports arenas) or used in manufacturing of other end products (e.g. rubber mats and adhesives).

The key economic drivers for processing are summarised in the following table.

Key economic drivers for processing

Drivers		Value	Overview
A) Cost drivers	Upfront investment costs	M	Processing site and equipment: tyre balers, cutters, shredders, granulators, conveyors, sorters
	Production costs: % fixed	M	Labour, maintenance, administration and site rent
	Production costs: % variable	M	Energy and freight costs
B) Revenue drivers	Volumes needed	M	Medium throughput is required to cover fixed costs
	Price stability	L-M	Dependent on the end use e .g. export prices are volatile
C) Supply volumes and costs	Volumes required	M	Medium volumes needed as set out above
	Price stability required	M	Medium price stability required to cover fixed and variable production costs

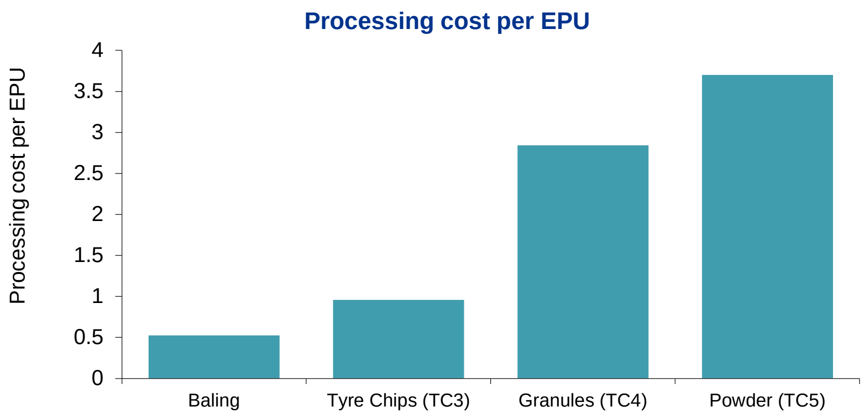
Entry cost for processors is higher than in the collection market, due to investment required for plant and equipment. Fixed costs are also higher and include labour, maintenance, and site rent.

Depending on the type of product and cost of equipment, interviewees estimated breakeven volumes of 200,000 to 1 million tyres per annum depending on the grade of the processed product.

3.3.1 Cost drivers

Investment and production costs are driven by the scale of operation and the level of processing required for the end product. Upfront and ongoing costs are shown in the table above.

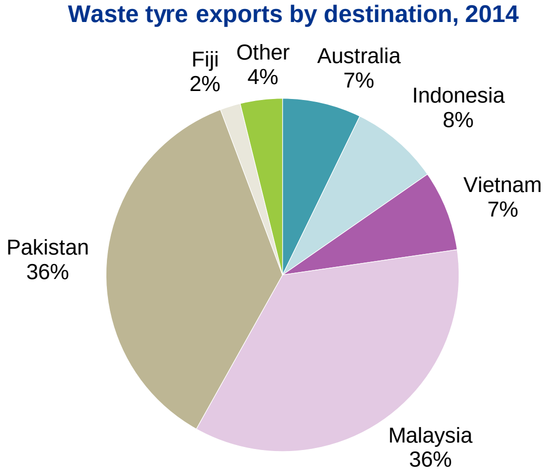
The following chart presents the estimated processing costs per EPU for baling waste tyres for export and processing of waste tyres into tyre chips (TC3), granules (TC4) and powder (TC5). As the TC number of rubber increases the level of processing and the cost per EPU increases from below $0.50 per EPU for baling to over $3.50 per EPU for powder.



3.3.2 Revenue drivers

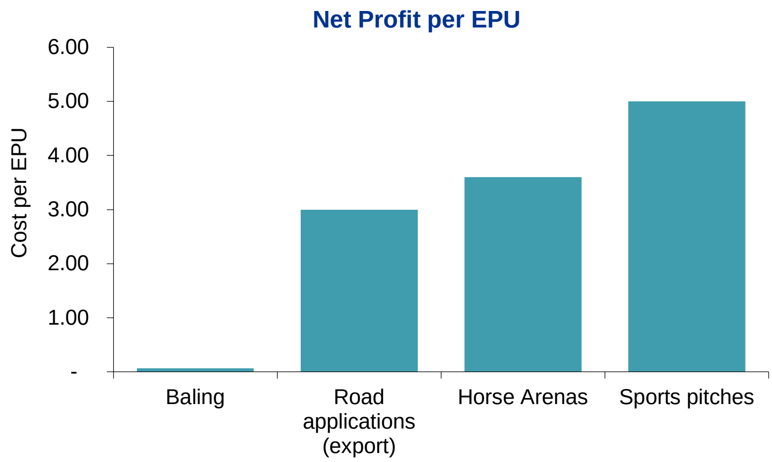
Product price is broadly driven by the level of processing. Baling and production of tyre derived fuel for export require lower levels of processing and incurs lower production costs; however, net export revenue is marginal and subject to volatility in exchange rate and freight costs. Higher grade granulates and powder generate higher income, however, the size of the local market is limited and export costs significantly erode margins.

- *Exports:* net revenue from exporting baled tyres is volatile and can fluctuate from processors receiving $500 per container exported to paying $200 per container exported; with an average receipt of approximately $150-180 per container. This is driven largely by demand volumes, fluctuating exchange rates and the cost of freight per container on the required routes. According to Statistics New Zealand and Customs, 7,200 tonnes of waste rubber, parings, powder and granules, and whole tyres were exported from New Zealand in 2014. The graph below outlines the key destination countries; Appendix B provides further detail.



- *Tyre derived fuel:* Tyre derived fuel is not currently used in New Zealand and all local tyre derived fuel is exported. While the landed price of tyre derived fuel is reported by interviewees to be stable, fluctuation in exchange rates and freight costs have a significant impact on the profitability of this product. The price received for exported tyre derived fuel is in the range of $120 to $200 net per container.
- *Roading applications:* Currently rubber is not used in New Zealand roads. However some rubber is exported to Australia for roading applications. Waste rubber produced in New Zealand has no market advantage over rubber produced in-country and has the added cost of freight to reach the target market. As a result, the supply of New Zealand rubber for Australian roads is opportunistic and procured only to fill gaps when local Australian rubber is unavailable. The net price is around $3 per EPU, and is similar to the cost of production.
- *Filling for sports pitches, horse arenas, bowling clubs, gun clubs:* filling for these applications are sold for between $350 and $500 per tonne. Some New Zealand product is exported, however imported product also competes in the New Zealand market according to interviewees.

The following graph summarises the net income per EPU achieved for the above products.



3.3.3 Supply volumes and cost

Given the upfront investment and ongoing operating costs, high throughput of waste tyres and security of supply are key for economical operation. Interviewees stated that hundreds of thousands (some indicating up to a million) of waste tyres are required yearly for breakeven. Processors compete with collectors who send tyres to landfill, and therefore have low operating costs. Higher throughput of processing volumes are expected to increase economies of scale in production and reduce the unit production costs.

3.4 Manufacturing

In the current market manufacturing of end products is limited; processed waste tyres and buffings from tyre retreading are used for applications such as the production of adhesives and mats. Projects to establish material recovery facilities (pyrolysis and devulcanisation) are at various stages of development pre-commercial launch.

Drivers		Value	Overview
A) Cost drivers	Upfront investment costs	H	Investment in plant and equipment
	Production costs: % fixed	M	Labour, maintenance, site rental and administration
	Production costs: % variable	M	Energy and freight costs
B) Revenue drivers	Volumes needed	H	High throughput is required to cover fixed costs
	Price stability	M	Medium dependent on the market value of the end-product
C) Supply volumes and costs	Volumes required	H	High volumes needed as set out above
	Price stability required	H	High to reduce investment risks and to cover fixed costs

3.4.1 Cost drivers

Investment and production costs are driven by the capacity and complexity of end-product manufacturing. The main upfront costs for manufacturers is purchase and installation of equipment, ongoing costs are summarised in the table above.

3.4.2 Revenue drivers

- *Mats:* Rubber mats are manufactured for application in playgrounds to provide a cushioning effect and minimise the impact of falls. Rubber mats compete with a variety of other products, including bark, wood chip, and rubber wet pore. Rubber mats are sold at a premium as they provide more effective absorption properties. Demand for the product depends on customers' requirements and available budget.

- *Adhesives:* Rubber powder is used as an additive in adhesives and offers benefits such as increased coverage and reduced weight. Net profit from processed rubber sold for adhesive applications is approximately $6 per EPU.
- *Pyrolysis trials*: Several companies in New Zealand have undertaken pyrolysis trials over the past two to three years. The purpose of the trials has been to investigate the technical feasibility of pyrolysis within the New Zealand environmental and health and safety context, and to determine the quality of the products from pyrolysis, particularly oil and carbon black.

3.4.3 Supply volumes and cost

As for processing, security of supply is a key consideration for investment in manufacturing using waste tyres. Stable volumes and prices are critical to provide return on investment and to cover fixed costs.

Based on our interviews, a large proportion of existing manufacturing of mats and adhesives uses buffings from tyre retreading processes, instead of processed waste tyres. Rubber crumb from buffings is less expensive as the process of separating steel and fabric from rubber is simpler.

3.5 Current barriers to investment

The current market is served by regionally fragmented and subscale collectors, transporters and processors. Less than 15% of waste tyres are processed on-shore although processors interviewed have indicated that they have significant spare capacity. Despite an estimated $20 million being paid by consumers on disposal fees (broadly $4-5 per EPU according to Tyrewise) more than 85% of collected waste tyres are exported, placed in landfills, used on farms, or illegally dumped. Given the cost of collection and transportation, we estimate that potentially over half of this amount is not used to fund the recycling of waste tyres.

Based on the net cost and income drivers discussed above, the following table summarises the main tyre flows and indicative return profiles in the current market.

Estimated net income from current end uses of waste tyres

Current end uses	Net income/ (cost) from recycling by stage in $/EPU					
	1. Disposal fee income[10]	2. Collection cost	3. Processing cost	4. End Use net income[11]	Net Total Return	Observations
Whole tyres sent to farm	1.8	(1.2)	-	-	0.6	Simple business model, but limited by seasonal demand
Cut tyres for landfill	1.8	(0.5)	(0.3)	(0.5)	0.5	High volume, low margin business

[10] The disposal fee income is the income that collectors receive (approximately $1.8 excluding GST). A disposal fee of $4 to $5 is the fee paid by consumers on new tyres.
[11] End-use net income equals the price of the end product less any production cost.

Baled whole tyres for export	1.8	(1.2)	(0.5)	0.1	0.2	Marginal profit with volatile demand – not sustainable by itself
TDF for export	1.8	(1.2)	(0.8)	0.1	(0.1)	
Powder for roads (export)	1.8	(1.2)	(3.7)	3.2	0.1	
Granulate for Equestrian turf	1.8	(1.2)	(2.7)	3.6	1.5	Good margin, but low volume niche markets
Granulate for sports field	1.8	(1.2)	(3.0)	5.0	2.6	
Granulate for mats	1.8	(1.2)	(3.0)	6.0	3.6	
Powder for adhesives	1.8	(1.2)	(3.7)	6.0	2.9	

The table shows that profitable routes for recycling are limited to small niche markets. Waste tyre generators choose the cheapest route to dispose of tyres, which often involves landfilling or export to emerging markets.

In summary investment in new forms of recycling is hampered by three principal barriers:

1. Limited addressable end-use market size
2. Business model requiring scale
3. Insufficient funding.

3.5.1 Limited addressable end-use market size

There is a limited local market for recycled rubber products (e.g. mats, equestrian turf) and access to international markets is uncompetitive due to volatile demand and freight costs.

Whilst there is no formal data on the local market size, our interviews indicate that on-shore end-use of recycled tyres is up to 10-13% (6,000 - 9,000 tonnes) of the total waste tyre volume, which is in line with Tyrewise estimates. This is in part due to the lack of large scale industry using rubber as input material. The largest global user of rubber is the tyres and broader motor industries, however these sectors are no longer active in New Zealand.

Formal export data indicates that 7,200 tonnes of recycled and waste rubber left the country in 2014, which is equivalent to approximately 10% of waste tyres generated. Industry participants believe that actual exports may be higher, as undeclared and mis-coded waste tyres may add to total exports. Nevertheless, exports are considered by interviewees to be unreliable and unpredictable as demand volumes and net prices fluctuate with freight costs and exchange rates.

Overall, current local markets for recycled rubber products and exports appear insufficient to drive steady, large scale demand for waste tyres.

Business model requiring scale

There is high upfront cost and no local track record to establish large-scale alternative end-uses, such as rubber in roads and energy recovery. Construction and cement industry participants stated that their respective industries are aware of the potential of waste tyres in manufacturing, and have considered the investment case but are reluctant to commit large upfront capital. This is due to:

- commercial uncertainties of demand (for roading and pyrolysis products for example)
- security of tyre supply (for large scale manufacturing)
- question over technology maturity, and workplace safety (for pyrolysis)
- other non-economical considerations, such as consenting and public relations.

The lack of scale also impacts waste tyre processing. Breakeven volumes of 200,000 to 1 million EPU have been cited by interviewees, depending on the level of processing required. However, it is currently uneconomical to collect tyres outside the main centres due to high freight costs and competition from local disposal options such as landfilling, farm use. This restricts the availability of tyre supply to about 45% of total tyres generated (excluding heavier tyres), based on New Zealand's population distribution.

3.5.2 Insufficient funding

The current income available to collectors, processors and manufacturers is insufficient to fund higher level of processing and large scale recycling investment. This appears to be due to market and competitive drivers that impact the flow of money along the value chain, rather than insufficient expenditure by consumers.

A) Generators seek low cost tyre disposal options and competition limits collection fees to approximately $2 per EPU, which is insufficient to fund recycling options that require a higher level of processing.

Based on the costs drivers set out earlier, the current market appears to respond rationally to price incentives as retailers seek the lowest cost service to dispose waste tyres.

The table below summarises the principal disposal choices and costs for waste tyre generators.

Disposal	Indicative direct cost	Considerations
Provide for farm use	~$0 per EPU May yield income in some cases	Seasonal/ volatile demand for tyres on farms
Illegal dumping	$0 - $0.50 per EPU Small cost of transport incurred	Penalties may be difficult to enforce therefore the additional risk weighted cost is limited
Landfilling (cut tyres)	~$1 per EPU	Retailer needs tyre cutter at $5k-10k investment
Low cost collector	~$1.50 per EPU	Likely to be baled and exported, or dumped
Full service collector/ processor	~$2 per EPU	Whole tyres transported and processed, or baled and exported

Additional indirect costs that are not included above relate to reputational risks. Tyre importers interviewed have stated that mitigating their risk of brand damage plays a part in working with reliable, environmentally conscious collectors.

Currently waste tyre processing provides limited additional revenue for collectors. It involves higher production costs but the local market for high value recycled products is small and does not justify investment in new processing and manufacturing capacity. Further export demand and prices are volatile and cannot support a significant ($1 million+) investment case.

A key hypothesis for the cost-benefit analysis, is that high volume recycling is only viable if disposal prices cover the full economic, environmental and societal costs of managing waste tyres. Currently, these broader costs are not reflected in market prices between generators and collectors, and this leads to market failure where the supply of waste tyre recycling does not meet latent demand.

B) Disposal fees paid by consumers, at an average $4-5 per EPU, are not passed on to collectors, processors and manufacturers.

Disposal fees are typically ‘bundled’ with the purchase and fitting of new tyres, and consumers choose a provider mainly on the value of the new tyres, not the cost of disposing old ones. Tyre disposal services appear to have a low price elasticity. Consumers are unlikely to dispose their end-of-life tyres at another retailer if they offer a lower price. Excess profit from disposal fees remains with the retailer, likely to subsidise the sale of new tyres where competition is stronger.

The following section provides an analysis of investment drivers and barriers to increasing the rate of waste tyre recycling. In particular, it examines the value chain and economics of a future market which facilitates a larger share of waste tyres to be processed on-shore.

4 Future drivers and enablers for investment

The following sections explore the key enablers for improving the effectiveness of waste tyre management in New Zealand, in particular:

- Diverse, and economically and environmentally sustainable set of end-uses. Such local 'demand pull' was identified by Tyrewise, our interviews, and overseas experience, to be critical for a sustainable future.
- Scalable collection, transport and processing systems covering substantially all waste tyres generated in New Zealand.

4.1 New end-uses: pyrolysis and devulcanisation

Pyrolysis and devulcanisation are emerging material recovery processes to create value added product from tyres and other waste streams. Whilst the technologies, processes and end-products are different, we cover pyrolysis and devulcanisation together for two main reasons:

- The broad investment drivers are similar, including the need for upfront investment in production capacity, certainty of input costs and volumes, and reliance on end-product demand and prices in order to make a compelling investment case.
- Information was provided to us by interviewees on the basis that it is aggregated and anonymised in our analysis. This is best achieved through a combined presentation of pyrolysis and devulcanisation given the relatively few early adopters in New Zealand.

The key drivers of the business model are summarised in the table below and discussed subsequently.

Drivers		Value	Overview
A) Investment and production costs	Upfront investment costs	M-H	Cost of plant and equipment driven by capacity, end-product quality, and health, safety, and environmental measures
	Production costs: % fixed	H	Rent, staff and maintenance
	Production costs: % variable	L	Power costs, if production is phased in batches
B) Product demand and revenue streams	Volumes needed	H	High throughput is required to cover fixed costs
	Price stability	L-M	Volatile, in line with market price of rubber, oil and carbon black
	Volumes required	H	High volumes needed as set out above

Drivers		Value	Overview
C) Supply volumes and costs	Price stability required	M-H	Ideally input prices (i.e. waste tyre costs) should correlate with end product prices to mitigate the risk of margin squeeze

Given high fixed costs and variable end-product prices, the stability of input volumes is a key requirement for investment in pyrolysis and devulcanisation.

Environmental protection and health and safety measures add to fixed costs and increase the required tyre volumes for breakeven.

Further, a key trade-off is the cost of investment versus the value and marketability of the end-product. Interviewees contrasted lower cost emerging market production which is viable at a lower scale, and high cost, high volume approach seen in Western Europe for example.

Investment and production costs

Investment and production costs are broadly driven by production scale and end-product quality. Interviewees proposed the following range of models:

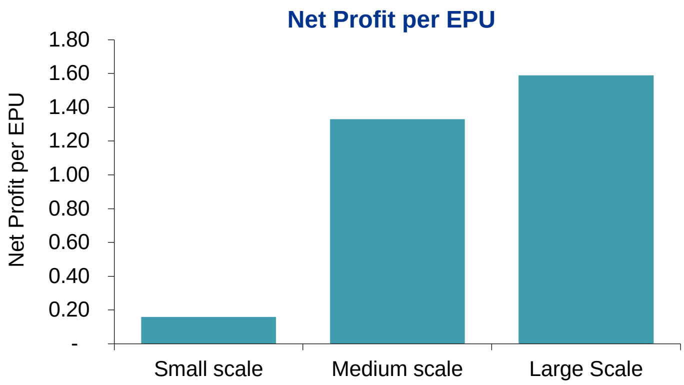
- Small scale, decentralised production using tyres at a local level. These facilities are proposed to operate from 250 tonnes of waste tyres per year.
- Medium size facilities, taking up to 5,000 tonnes of tyres a year, using regionally generated tyres (c. 50-100km radius area around major centres).
- Large scale facilities capable of processing over 30,000 tonnes of waste tyres per annum (close to half the volume generated nationally).

Investment costs for the above range from approximately $1 million to $12 million.

Product demand and revenue streams

The outputs of waste tyre pyrolysis are oil, carbon black and steel. Each have a traded value subject to the quality of the product manufactured.

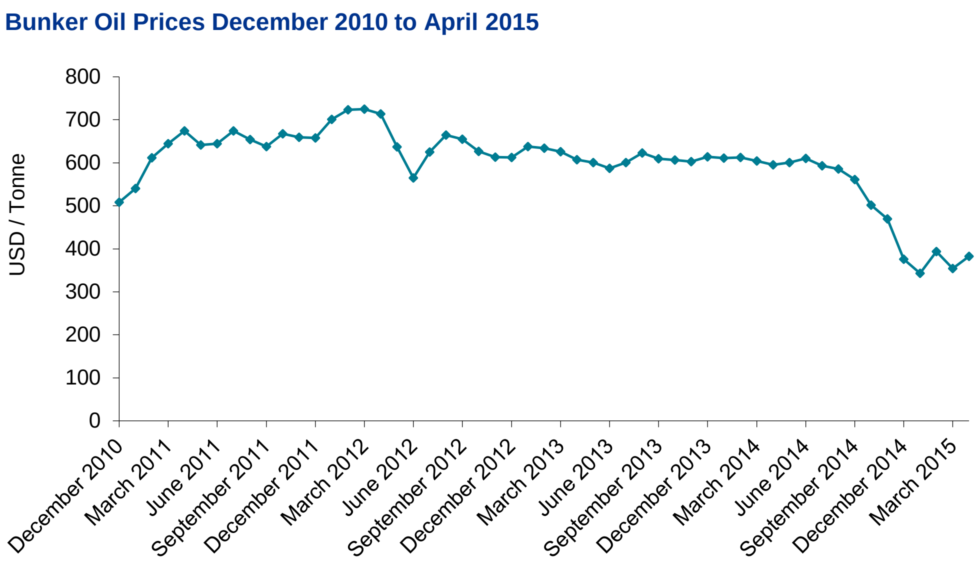
Annual net income after production costs is estimated between $0.16 and $1.59 per EPU. Per EPU cost figures are calculated at planned operating volumes indicated by interviewees. Unit costs are higher if throughput is lower, and vice versa.



The above figures exclude the initial tyre processing costs which are discussed in the section on processing below. Devulcanisation requires rubber granulates, and pyrolysis is operated using either whole or size reduced tyres according to our interviews.

Currently, New Zealand pyrolysis projects are at an early stage of development, some with ongoing trials, and others still on the drawing board. Therefore no product quality assessment is available at this stage. Based on research and limited market testing undertaken by interviewees the expected target markets and price ranges are as follows:

- *Oil*: 30-40% of weight recovered from pyrolysis is envisaged to be used as heating oil in commercial burners and boilers, and fuel oil in maritime vessels. The size of the relevant market in New Zealand is not defined but considered by interviewees to be well over the amount that can be produced from waste tyres. Subject to process efficiency, 3-4 litres of oil can be recovered per EPU. Interviewees' price expectations are in the **$0.8-$1 per litre** range, below the current price of diesel at ~$1.4 per litre, and above the price of heavier used oils and lubricants at ~$0.2-$0.4 per litre, as interviewees envisage that pyrolysis oil can be further refined into higher grade oil with higher market value. However current plans to refine at scale appear to be embryonic. The spot price of heating oil and lower grade maritime (bunker oil) as at November 2014 was $0.9 per litre and $0.65 per litre respectively. The price of heating and fuel oils is closely correlated to the price of crude oil. The following chart illustrates the recent heating oil price movements[12].

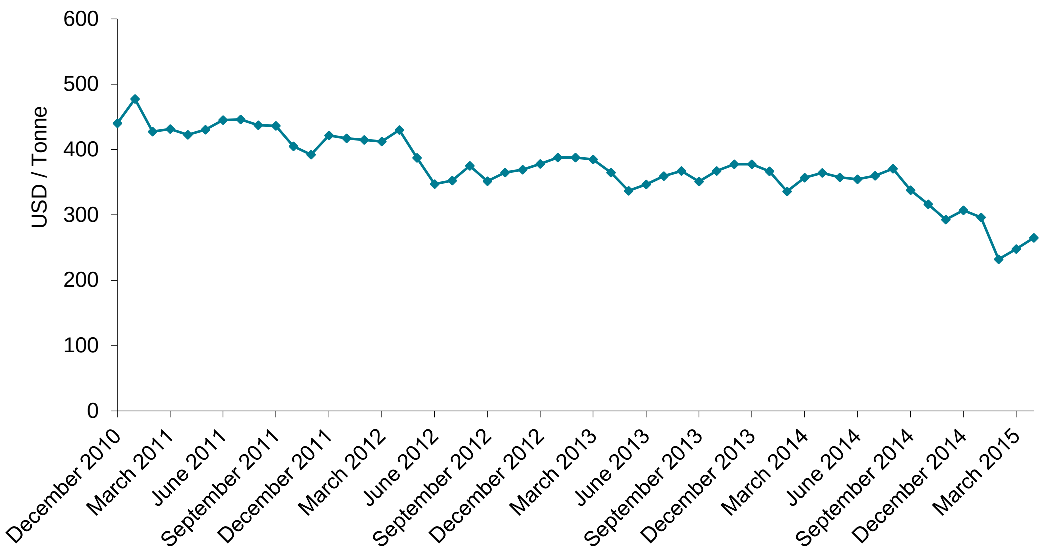


- *Steel*: ~10% of material recovered is scrap steel which is a tradable product with an established New Zealand market, and estimated price of ~**$150-$300 per tonne**, in line with advertised scrap steel prices in New Zealand as at November 2014. These prices fluctuate with

[12] Source: Bloomberg

international commodity prices and exchange rates. The following chart illustrates the recent movement of scrap steel prices[13].

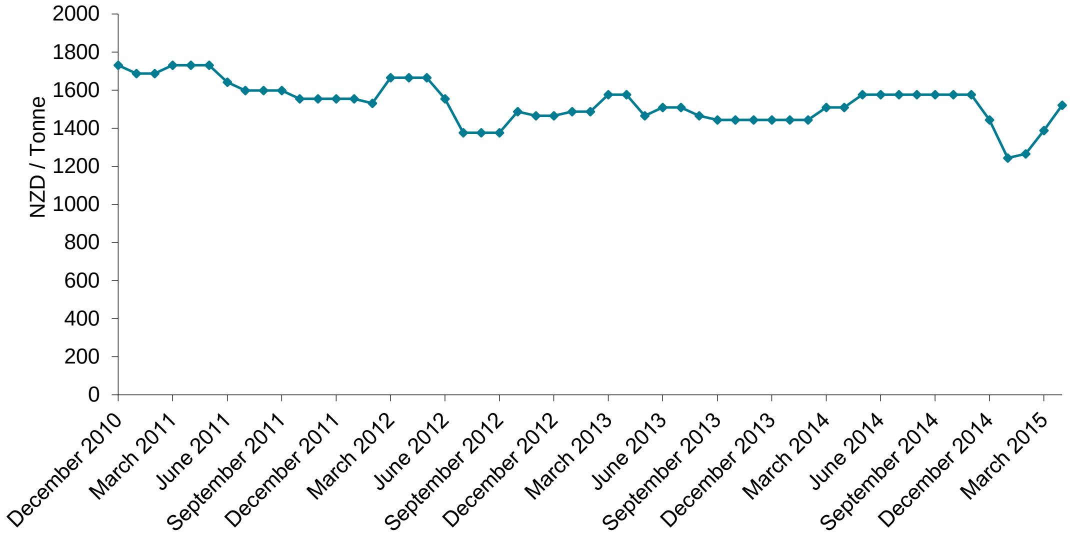
Scrap Steel Prices from December 2010 to April 2015



- *Carbon black*: ~30-35% of material recovered is carbon black. It is a traded commodity with active markets for over a dozen grades of carbon black. Prices vary significantly from the lowest quality non-graded carbon by-product used for burning, to the highest grade carbon black used in tyre treading. The majority of carbon black worldwide is currently used for tyre manufacturing (~65%), other rubber products (~25%), and ink and speciality products. The largest market is Asia (~2/3rd of the world total) including China (1/3rd of the world total)[14]. Other significant markets are the European Union (EU) and United States (US). Interviewees' price expectations varied significantly from **$200-300 per tonne for supply in New Zealand to international traders, to ~$2,000 per tonne for overseas delivery to end customers**, based on initial quotations and market prices. The market price is correlated with crude oil prices. The following chart illustrates the recent carbon black price movements[15].

[13] Source: Bloomberg
[14] Source: Phillips Carbon Black Limited
[15] Source: Bloomberg

Carbon Black Prices (N220) from December 2010 to April 2015



Overall there are large, established markets for the products of pyrolysis. The key demand side challenge is achieving consistently high quality oil and carbon black from pyrolysis.

The European Tyre and Rubber Manufacturers' Association's most recent annual report notes about pyrolysis: "The economic viability of this emerging recovery route is hampered by the fact that the quality, and prices of the obtained pyrolytic by-products often fail to justify the process costs. Despite the proliferation of new lab-scale reactor projects, the economic viability of industrial scale processes has yet to be demonstrated. Based on data from 14 ELTcos, about 15,000 tonnes of ELTs were used for pyrolysis in 2013, a year-on-year reduction of 25%"

The large shipping distance to end markets of higher grade carbon black in the EU and US add to the cost of pyrolysis in New Zealand. On lower cost shipping routes to Asia, New Zealand producers would face local low-cost competitors. Additionally one interviewee pointed to transportation issues with carbon black which absorbs water and degrades if not sealed correctly.

Overall the marketability of carbon black recovered in New Zealand appears challenging due to limited local end-use market size, and poor access and competition in international markets.

Other issues highlighted by interviewees include the cost of safe storage and transportation of oil products. Most business plans made available to us assumed that oil is produced in close proximity to end customers. This would mitigate storage and transportation issues, however would restrict where plants can be established and may make the large scale supply of tyres expensive.

An alternative material recovery process is devulcanisation which produces steel and rubber.

- *Steel*: ~15% of material recovered. It can be monetised similarly to the scrap steel produced by pyrolysis.

- *Rubber*: ~75% of material recovered. The value of rubber sheets produced following devulcanisation is $900-1200 per tonne (about half the value of virgin rubber, depending on quality)[16]. This can be used to make rubber products such as hoses and industrial mats or as an additive to lower quality tyre tracks. The value of recycled rubber changes with the market price of virgin rubber, which broadly correlates with the price of crude oil. The average price of rubber (RSS3) was approximately USD $1,900 over the period April 2014 to October 2014.

Overall, the main outputs of pyrolysis and devulcanisation are market commodities with a traded value that moves in line with crude oil and more broadly with energy prices. From the demand side, the economic attractiveness of these alternative production methods is closely linked with:

- the quality of oil, carbon black and rubber produced
- the open market prices of these commodities
- competitive access to the relevant markets from New Zealand.

Based on our limited primary and secondary research, both technologies appear relatively new and yet to produce large scale output at consistent and proven quality.

Supply drivers

Given the upfront investment and fixed operating costs, pyrolysis and devulcanisation relies on high capacity utilisation and security of tyre supply.

The implied breakeven volumes discussed with us varied considerably from sub-1000 to over 10,000 tonnes. However, interviewees consistently emphasised the importance of supply security to ensure optimal capacity utilisation.

Further, a key challenge for producers is reconciling the requirements of securing supply and securing demand for their products. Supply security currently requires close geographic proximity to tyre collectors and processors. The efficient delivery of end products, such as oil, carbon black and rubber, requires proximity to end users and transport hubs. This currently restricts viable areas of operation to geographies around the main urban centres, particularly Auckland.

In a desired future state, scale producers need reliable and efficient access to tyres nationwide. Increased tyre flows should provide efficiencies to processors to reduce unit input costs (i.e. $ per EPU) for producers. These drivers are examined further in subsequent sections discussing future state collection and transport, and processing respectively.

Non-economic drivers

In addition to the above economic considerations, interviews pointed to three interdependent investment barriers for pyrolysis and devulcanisation.

- *Regulation*: Councils' consenting requirements primarily focus on emissions and air quality. They impact investment due to the additional time and cost of upfront and ongoing compliance. One interviewee indicated that several modifications were required for their Chinese made equipment to comply with New Zealand standards. Another ongoing trial also focuses on understanding and controlling emissions from pyrolysis.

[16] Source: www.carreddi.com, KPMG interviews

- *Health and safety*: Concerns relate to the safety of equipment that produces, processes and stores gas and oil in the course of pyrolysis. Interviewees have indicated varying perceived levels of risk over safety. Some consider the area to be well covered by appropriate compliance requirements, whilst others have expressed concern over the adequate level and cost of relevant safety measures.
- *Technology expertise*: Scrutiny over emissions and health and safety appears linked to the limited understanding of pyrolysis and devulcanisation in New Zealand. Currently, technology and know-how is imported from more established overseas markets, such as Germany and China. New Zealand engineering and scientific understanding appears to be limited and early adopters are in the initial process of 'learning by doing'.

4.2 New end-uses: rubber in roads

The Tyrewise project reported on the potential benefits of tyre-derived rubber in road construction and maintenance. Rubber in roads is used in overseas markets, such as the UK, South Africa, California and Australia, but not in New Zealand. Tyrewise engaged local industry participants to gain an initial understanding of local opportunities and challenges. A separate desktop literature study by Opus is currently underway to build on those findings. This report focuses on the economics of putting rubber in roads based on further primary and secondary research.

The key drivers of the business model are summarised in the table below and discussed subsequently.

Drivers		Value	Overview
A) Investment and production costs	Upfront investment costs	H	Cost of equipment (tanks, sprayers)
	Production costs: % fixed	H	Specialist crew and training (including initial and ongoing costs)
	Production costs: % variable	L	Incremental heating costs vs traditional construction
B) Product demand and revenue streams	Volumes needed	H	High volumes needed to cover investment costs
	Price stability	M-H	Driven by New Zealand Transport Agency's procurement criteria and raw material prices
C) Supply volumes and costs	Volumes required	H	High volumes needed as set out above
	Price stability required	H	Ideally input prices (i.e. waste tyre costs) should correlate with end product prices to mitigate the risk of margin squeeze

Given high initial equipment costs, economies of scale is key for investment in using rubber in roads. Conversely, road specifications and procurement approach are main drivers of volumes, according to industry stakeholders, as incentives for higher road quality and a longer useful life may justify investment in rubber-based construction techniques.

Rubber has two main applications in roads, each with distinct cost and volume profiles.

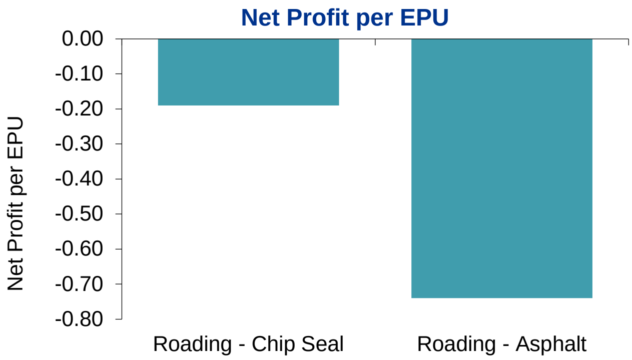
- *Chip seal* (~90% of New Zealand road kilometres): Rubber can be added to bitumen to improve surface life and breaking qualities, and to reduce tyre noise. Common blends contain about 20% rubber mass.
- *Asphalt* (~10% of New Zealand road kilometres): Rubber can displace imported SBS polymers used in 5-8% of roads, i.e. a subset of all asphalt roads. Asphalt mix usually includes 2.5% of rubber mass (5 times the mass of polymer).

Investment and production costs

Setting up mobile crumb rubber operations requires investment by the roading industry in specialist units, including tanks, stirrers and sprayers. Based on interviews, an estimated four to six units would be required to cover the country. Each unit is operated by a crew of 3.

- *Chip seal:* The total cost of equipment to lay chip seal with rubber is approximately $7 million. This is expected to provide capacity for New Zealand's total annual demand of 150,000 tonnes of bitumen and use up to 30,000 tonnes of rubber.
- *Asphalt:* The total cost of specialist equipment is $3.5 million, and the maximum demand volume is 2,000 tonnes of rubber.

Illustrative annualised net profit per EPU from using rubber in roads is shown in the chart below. In this context, the negative net profit (i.e. net loss) indicated below means that the overall cost of using rubber is greater than using alternative production methods.

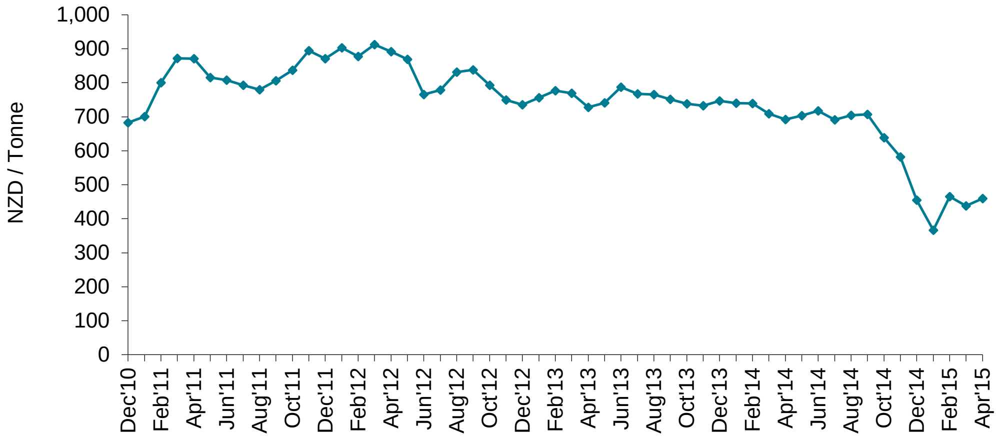


The costs included in the above chart consist of operating costs, and capital costs of specialist roading equipment amortised over five years of estimated (equipment) useful life. Per EPU costs are calculated at the maximum demand volume (30,000 tonnes of chip seal and 2,000 tonnes of asphalt). In reality only a proportion of this volume may be used due to technical, operational and other limitations yet to be considered by the literature review previously discussed.

Asphalt net costs are net of the avoided cost of displaced polymer based on price estimates of $5500 per tonne. These net costs would change inversely with the market price of polymers. The recent evolution of bitumen prices are shown in the following chart.

The figures for chip seal do not consider the cost of displaced bitumen, however they also exclude the financial and environmental cost of not recycling existing aggregate and bitumen for resurfacing. We understand that equipment used for in-situ recycling is not suitable to process rubberised roads. One interviewee identified this as a key reason for the limited adoption of this technology, particularly in the US. Other considerations relate to the safety of procedures and equipment for adding rubber into roads, which need to be operated at higher temperatures than current roading equipment[17].

Bitumen Prices from December 2010 to April 2015



Product demand and revenue streams

Interviewees indicated that improved qualities from rubber in chip seal and asphalt come at a premium price. Road specifications and procurement rules are driven by commissioning authorities, particularly the New Zealand Transport Agency (NZTA), and price is a key factor in awarding build and maintenance contracts. Without change to procurement rules and requirements, it is unlikely that contractors will invest in using rubber if the higher cost of construction does not offer competitive advantage. Changing procurement approaches may be protracted given the embedded practices, complex contracts and large expenditures involved. Alternatively roading contractors may be offered financial incentives (e.g. based on the volume of rubber used) that offset the higher cost of rubber in road, in order to drive product demand

Supply drivers

As discussed, economies of scale are key to supporting upfront investment and ongoing fixed operating costs. For example, assuming an affordable net cost of $1 per EPU used in roads, volumes of approximately 26,000 tonnes a year would be required.

The supply capacity of rubber powder in New Zealand is currently limited to a few thousand tonnes, based on our interviews and Tyrewise estimates. New Zealand produced rubber powder for roads is currently exported to Australia. Therefore, the introduction of large scale use of rubber in New Zealand roads will require significant increase in supply.

[17] Source: NZTA

Non-economic drivers

Non-economic considerations, such as procurement to drive demand and environmental issues related to recycling chip seal for road resurfacing, have been discussed earlier in the supporting analysis. Other operational challenges highlighted by interviews include:

- Initial training and embedding of new procedures
- Health and safety of working with rubber at roadsides at higher temperatures
- Not all types of bitumen is compatible with rubber, therefore supply chain modifications may be required.

Overall local contractors appear reluctant to change their existing approach without clear benefits to their operation or specific requirements from commissioning agencies.

4.3 New end-uses: tyre derived fuel

Tyre derived fuel (TDF) is currently produced in New Zealand for export to be used in cement in Asia, for example. TDF is the main end use of waste tyres in the US where cement kilns use about 40% of all TDF. Other users include pulp and paper mills and electric utilities. New Zealand has no history of using TDF. The country has one potential large scale user, which is the cement factory operated by Golden Bay Cement; it currently uses imported coal and waste wood as fuel.

The key economic drivers of investment in using TDF for cement kilns is summarised in the table below and discussed subsequently.

Drivers		Value	Overview
A) Investment and production costs	Upfront investment costs	H	Cost of equipment that feeds shredded or whole tyres into the kiln
	Production costs: % fixed	L-M	Maintenance, and staff cost of loading tyres which is lower if shredded tyres are used and higher for whole tyres
	Production costs: % variable	M-H	Other operating costs, such as power
B) Product demand and revenue streams	Volumes needed	-	High volumes needed to cover investment costs
	Price stability	-	Not applicable
C) Supply volumes and costs	Volumes required	H	High volumes needed as set out above
	Price stability required	H	Typically cement makers charge a fixed price for accepting tyres

Like other new recovery methods discussed above, using TDF is a high upfront investment and high production volume proposition. However, in contrast to those other methods, TDF operating costs are low compared to the upfront investment. A key economic consideration for investing in TDF is the relative price of comparable alternative fuels, particularly coal[18].

Investment and production costs

The main capital costs of enabling TDF use in cement factories include the cost of on-site storage, front loader equipment, and the feed system (conveyors and lifts) at the kiln. Additional upfront costs include public consultation, consenting, and any further pollution control devices required to meet emission standards.

Our interviews provided no new data on set up costs in New Zealand. A previous Tyrewise cost estimate was $15 million to establish Hotdisk technology to provide a mixed waste burning facility. However, our secondary research indicates that the upfront cost of simpler feeding systems may be significantly lower (c. $1million to $5million).

The investment case may also depend on the timing of broadly five-yearly investment cycles. Golden Bay Cement upgraded its fuel feeding systems about two years ago.

Operating costs of TDF equipment include relatively minor power and maintenance expenses, and the staff cost of handling loaders, which are approximately five staff operating in shifts. Staff costs may vary by loader technology and may be higher if whole tyres are used, or lower if the feeding system accepts rubber chips dumped from trucks. However, existing staff may be able to handle loading if the manufacturer already uses alternative fuels, such as the case we understand in New Zealand's cement production.

Product demand and revenue streams

Currently there is no local market for TDF in New Zealand. Overseas, it is an alternative fuel that competes principally with coal, and increasingly with other waste streams such as waste wood.

In New Zealand, electricity generation is the largest user of coal. Industrial coal use is primarily for cement, lime and plaster, meat, dairy and other food processing, wool, timber, pulp and paper products. Cement, glass and similar non-metallic mineral product manufacturing used 237,000 tonnes of coal in 2013[19]. Assuming 10% rubber additive to replace coal fuel, the maximum potential demand is 24,000 tonnes.

The value of TDF as an alternative fuel depends on the availability and price of comparable alternatives, particularly coal. The recent developments of the coal market price is shown in the chart below[20]. Nevertheless large coal users such as cement producers can achieve bulk discounts on spot prices.

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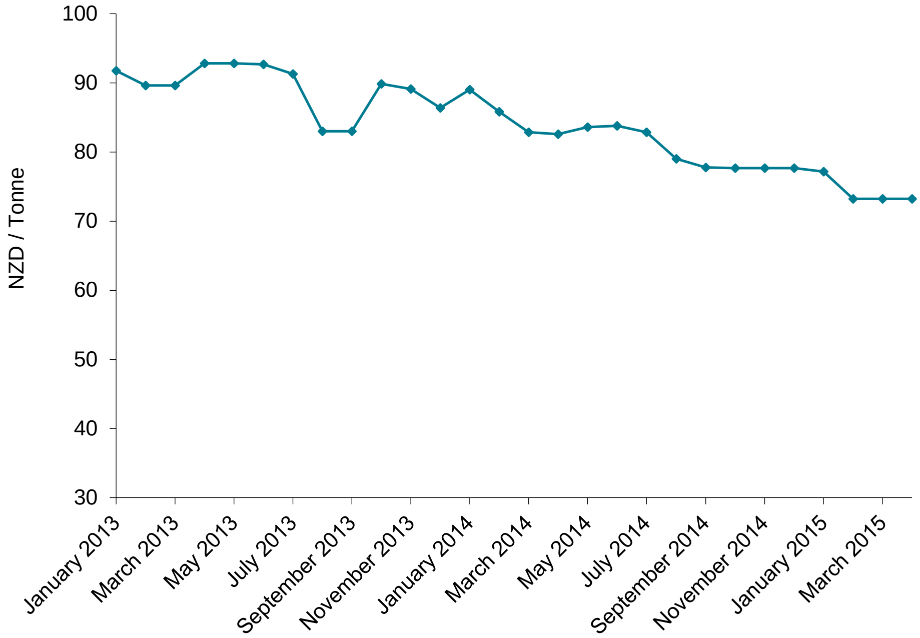
[18] The heating value of TDF is 25-50% higher than coal and 100-200% higher than wood, according to the Environmental Protection Agency (US)
[19] Source: Statistics New Zealand
[20] Source: Quandl.com

Coal spot prices, Central Appalachia 12,500 Btu, Jan 2013 - Apr 2015



Supply drivers

Only a few thousand tonnes of TDF is currently produced for export in New Zealand. However, capacity exists to supply over 20,000 tonnes, based on our interviews and Tyrewise estimates. Scaling supply would lead to a significant reduction in unit production costs.

Non-economic drivers

Interviews highlighted that environmental considerations are as significant as potential economic barriers for investment in TDF. The large scale burning of TDF at a single facility (~20,000 tonnes annually), raises two issues in particular:

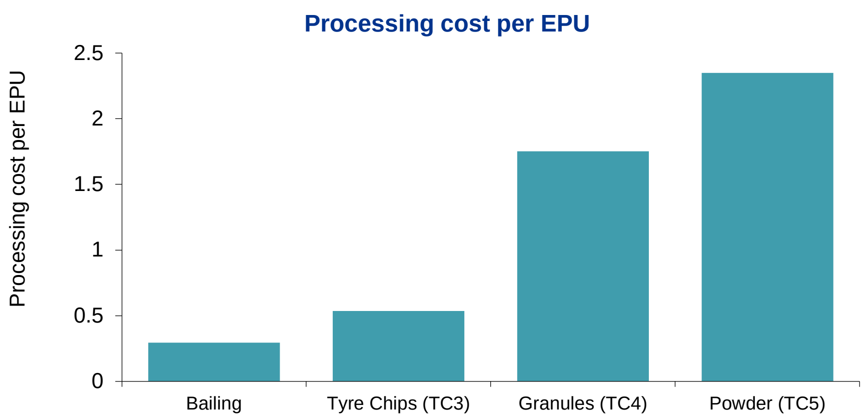
- *Consenting*: The process of satisfying emission requirements is considered time consuming and costly. The EPA in the US notes that TDF produced emissions are comparable to other conventional fuels, but points to the importance of properly designed fuel combustors, and robust combustion and add-on particulate controls. Overall, compliance costs are expected to be material by the industry (albeit no figures were made available to us).
- *Public relations*: TDF is largely unknown in New Zealand, and burning tyres are associated with serious pollution and as a health hazard by the public. Therefore, the industry expects that significant public education and consultation is required before the introduction of TDF in cement making.

4.4 Processing

Producers cite the lack of large scale local rubber product demand as a key barrier to investment. Export of processed rubber offers marginal return due to the high cost of shipping, and is used mostly to fill spare capacity.

The current capacity utilisation is not precisely known. However interviews point to significant headroom, with potentially over 70% available spare capacity in crumb rubber facilities. A key objective for a future processing sector is to increase supply for on-shore recycling volumes to grow from ~15% of waste tyres to above 90%, in line with leading markets.

Higher economies of scale would lead to lower unit costs as the cost base is largely fixed with the exception of power consumption. The chart below illustrates the impact of a two-fold volume increase in unit costs, based on high level modelling assumptions.

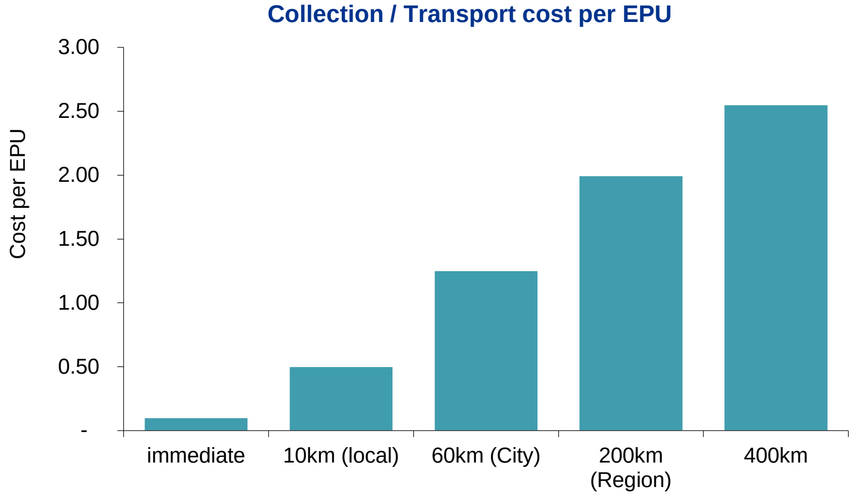


To expand waste tyre processing the geographical coverage of processing facilities, currently concentrated around Auckland and Wellington, needs to expand to the central North Island and to the South Island. This in turn requires reliable supply and economical transportation of waste tyres in these areas, which is discussed in the following section.

4.5 Collection and transport

Collection and transport incur limited upfront costs. Barriers to scaling these activities primarily relate to the amount waste tyre generators are willing to spend on disposal versus the cost of the service.

Service costs increase with the distance to processing facilities. For example the average cost of transport is estimated to double in the South Island, assuming that scale required for processing allows for up to two facilities. Conversely farms and landfills provide a potentially cheaper disposal for waste tyre generators. An illustration of transport costs is shown in the chart below.



Accordingly, we estimate that transport costs with four processing centres would average approximately $2.00 per EPU across New Zealand. Collection costs at retailers and transfer stations are incremental, at ~$5,000-10,000 per annum including set up and supervision costs.

4.6 Enablers of future investment

Previously we have described a current market which is constrained by:

- lack of economies of scale
- limited local demand for rubber products
- uncompetitive access to export markets due to demand and price volatility
- uneconomical collection from remote areas due to high freight costs and competition from low cost disposal options
- underfunded waste tyres processing and manufacturing.

Based on the analysis of market drivers, the key enablers to addressing these barriers can be summarised as:

1. *Expanding waste tyre collection nationwide.* This requires incentives for operators to service remote areas, and making collection competitive versus landfilling. If collection was expanded nationwide, the current estimated cost of $1.00-$1.30 per EPU around main centres would increase to an average $1.70-$1.90 per EPU (including over $2.50 in the South Island).
2. *Increasing utilisation of existing processing capacity and establishing capacity in the South Island.* Increased volume throughput would reduce unit production costs from $2.70-$3.70 per EPU by ~35%. Investment assumes sufficient demand to cover the cost of production.
3. *Investment in scalable new manufacturing options (end uses).* As discussed in previous sections this may require financial support given the low commercial return from recycling as well as overcoming regulatory, technological and public relations barriers.

4. *Developing an effective funding mechanism that covers the full cost of collection, processing and manufacturing.* Current collection revenue streams of approximately $2 per EPU can only support a limited range of recycling options.

The following table summarises the main tyre flows and indicative return profiles in a future state market which addresses the above barriers. Accordingly, a successful future market with better funding and higher collection rates may afford a more diverse, large-scale local recycling industry.

Estimated net income from potential future uses of waste tyres

Potential new end uses	Net income/(cost) from recycling by stage in $/EPU					
	1. Disposal fee income	2. Collection cost	3. Processing cost	4. End Use net income[21]	Net Total Return	Observations
TDF (20k tonnes)	5.0	(1.7)	(0.5)	(0.5)-(1.6)	1.2 - 2.3	Good economic case but faces consenting and public relations challenges
Chip seal roads (30k tonnes)	5.0	(1.7)	(2.3)	(0.7)	0.3	Marginal case, requires all roads to be converted (unlikely to be realistic)
Asphalt roads (2k tonnes)	5.0	(1.7)	(2.3)	(0.2)	0.8	Smaller scale and has operational challenges
Material recovery (5k tonnes)	5.0	(1.7)	(0.3)	0.1	3.1	Risk of unproven technology and end-product quality, and volatile market value
Material recovery (36k tonnes)	5.0	(1.7)	(0.3)	1.6	4.6	

The achievement of such a future state relies on overcoming a number of non-economic barriers set out in sections 4.1-4.3, relating to:

- New technology adoption, skills transfer and training
- Consenting and regulatory approaches for establishing new end-uses
- Public education of the benefit and safety of new recycling technologies

Further work is required to test the technical, operational and commercial viability of large scale use cases such as pyrolysis, rubber in roads and TDF in a New Zealand context. That analysis is not within scope of the current study, but should be covered in further due diligence as appropriate.

[21] End-use net income equals the price of the end product less any production cost

5 Intervention options

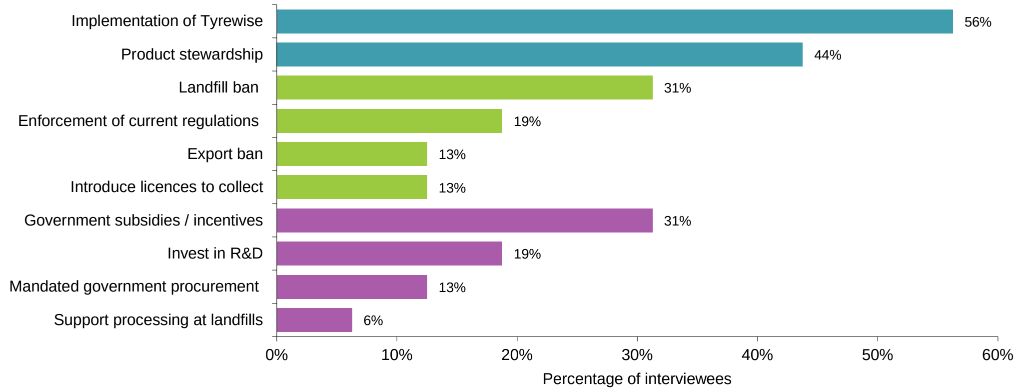
This section outlines and evaluates a set of intervention options and provides a short-list of preferred interventions to facilitate investment in waste tyre recycling.

5.1 Overview of intervention options

Our interviews with industry participants and research of similar markets have identified a broad range of distinctive intervention options, ranging in scope and scale to address the three principle barriers relating to limited end-use market size, lack of scale and insufficient funding.

Stakeholders consulted include tyre retailers, industry associations, waste tyre collectors, processors and manufacturers using waste-tyre products. They have identified a number of intervention options, set out in Appendix A and summarised in the chart below, to improve recycling and address current investment barriers.

Intervention Options Suggested by Interveiwees



Secondly, we researched overseas waste tyre recycling and other environmental schemes. They include free market models working within boundaries of landfill bans and licencing, for example in Ireland and the UK, and stewardship schemes such as those used in Korea, South Africa, Canada, and several EU countries. Further options were drawn up based on approaches for managing other waste streams such as packaging and e-waste.

A long-list of options based on the key features of these schemes and stakeholder input was developed and grouped into four categories, together with a baseline ‘do nothing’ option as follows.

Key levers	Options	Main barriers to address
Do nothing	Do nothing, or status quo, is maintained as a baseline comparator	None

Key levers	Options	Main barriers to address
Additional regulation and enforcement	a) Landfill ban / disincentives for landfilling b) Investment in enforcing existing legislation such as illegal dumping, stockpiling and export controls c) Introduce licenses to collect waste tyres	Business model requiring scale
Market organisation	a) Mandatory product stewardship b) Voluntary product stewardship c) Bounded Free Market	Business model requiring scale Limited addressable end-use market size Insufficient funding
New funding model	a) Price controls b) Advanced disposal fee / levy c) Tax system d) Deposit refund e) Trading scheme	Insufficient funding Limited addressable end-use market size
Investment and risk mitigation	a) Supply chain incentives b) Investment in infrastructure c) Procurement – off-take agreements d) Investment in Research & Development (R&D)	Limited addressable end-use market size Business model requiring scale Insufficient funding

In subsequent sections, the options long-list is described in further detail, including the advantages and disadvantages of each option. The evaluation framework used to assess the long-list is also described and the outcome of the evaluation is presented.

5.2 Evaluation criteria

The options evaluation focuses on:

- *The options' ability to address the investment barriers*, e.g. limited addressable end-market size, business model requiring scale and insufficient funding;
- *Broader success factors*, e.g. ability to deliver environmental and economic outcomes, affordability, fit with existing policies, achievability, equity, and value for money.

The evaluation criteria was developed using Treasury's Better Business Case framework, and was adapted for the requirements of this project based on stakeholder feedback and consultation with MFE on policy objectives. All criteria carry equal weight in the assessment.

Evaluation criteria	Description
1. Ability to deliver environmental and economic outcomes	How likely is the option to: a) increase recycling b) achieve waste minimisation c) increase waste tyre-derived business on shore d) reduce illegal dumping of waste tyres
2. Affordability	How well the option can be met from likely available funding, and matches other funding constraints. How well the option aligns with affordability for tyre consumers and other key stakeholders.
3. Alignment with existing policies	How well the option aligns with existing policies (e.g. environmental, trade, procurement, funding, international obligations) and integrates with other strategies, programmes and projects.
4. Achievability	How well the option is likely to be delivered given government and the market's ability to respond to the required changes, fit with required skills and need for legislative change. Relevant existing legislation includes the Litter Act, Resource Management Act, National Environmental Standards for Air Quality Regulations, Local Government Act and Waste Minimisation Act.
5. Equity	How fair is the option for all stakeholders, support for competition and market entry.
6. Value for money (assessed for short-listed options)	How well the option optimises value for money (i.e. the optimal mix of potential benefits, costs and risks) – which is relevant for all options. Specifically, how well the option meets the net benefit test in the Waste Minimisation Act (WMA) ss 22)(b)(iii) and 23(3)(b)(ii) – which is relevant for regulatory options, i.e. before recommending the making of regulations the Minister must be satisfied that the benefits expected from implementing the regulations exceed the costs expected from implementing the regulations. (Detailed cost-benefit analysis to inform a value for money assessment has been carried out on the shortlisted options only).

5.3 Evaluation of the long-list of options

5.3.1 Do Nothing

The 'do nothing', or 'status quo', option is used as a baseline comparator. It assumes that the current free market model is retained including regulation and enforcement approach, commercial and funding model, and incentives. The market would likely remain regionally fragmented with sub-scale players. The level of disposal fees and collection charges, and the volume of recovered waste tyres would likely remain unchanged.

Advantages

- No additional costs are incurred; no implementation risks.

Disadvantages

- Retaining the status quo will not address any of the current investment barriers. The challenges of limited market size, lack of funding and scale are likely to remain.
- Our interviews suggested that the current market does not offer equity for all participants, it is prohibitive for new businesses to enter the market and those that pursue responsible recycling are at commercial disadvantage to lower cost operators.
- Under the status quo, waste tyre recycling rates have been static. Additionally interviewees expressed a concern that the use of tyres on farms may saturate, thus increasing the number of tyres destined for landfills and illegal dumps.

Evaluation

The Do Nothing/Status Quo option does not address any of the current investment barriers (limited market size, lack of funding and scale) which have prolonged a low rate of on-shore recycling of waste tyres in New Zealand.

Further, this option fails to meet two evaluation criteria given:

- it is unlikely to increase recycling and waste tyre-derived business on shore;
- does not offer equity for all participants (as mentioned above).

Nevertheless the Status Quo option is retained as the baseline option in the cost-benefit analysis.

5.3.2 Additional regulation and enforcement

There is existing legislation in place to safeguard the environment and support waste recycling. Examples include the Litter Act, Resource Management Act, National Environmental Standards for Air Quality Regulations, Local Government Act and Waste Minimisation Act. About a fifth of our interviewees considered better enforcement of existing legislation to be key to improving waste tyres recovery rates. Further, stakeholders and international research pointed to potential new regulation to support investment in on-shore waste tyre processing.

1a Landfill ban/disincentives for landfilling

Currently a number of New Zealand landfills only accept cut tyres or no tyres at all. Other landfill operators continue to accept whole tyres and charge a premium compared to general waste. A landfill ban would formalise and extend the disposal limitations to all types of tyres (whole or processed) at all landfills. A precedent for introducing an outright ban includes the European Union's landfill directive in 1999[22]. The intent of this directive is to prevent or reduce the adverse environmental effects of hazardous waste disposed in landfills.

[22] http://europa.eu/legislation_summaries/environment/waste_management/l21208_en.htm

Alternatively, commercial disincentives may be introduced such as increased landfill fees and levies on tyres. This could be introduced under existing legislation and require appropriate monitoring and enforcement arrangements by councils and central government.

1b Increased focus on enforcing existing legislation.

This option would focus on enforcing existing legislation related to illegal waste tyre disposal, stockpiling and exports.

Waste tyre dumping is illegal under the Litter Act on public and private property without the owner's permission. Further enforcement of the Litter Act may target waste tyres and other waste streams, for example by investing in specialist teams dealing with illegal waste sites, and information resources and hotlines to tackle fly-tipping. Similar arrangements are in place in the UK operated by the Environment Agency, for instance.

Stockpiling of waste tyres can be currently controlled under the Resource Management Act and the Local Government Act, which allows local authorities to take action to reduce public nuisance, and maintain public health and safety standards. Stockpiling may be reduced by requiring deposits to cover clean-up liabilities and by limiting the allowable storage volumes. Similar arrangements are already used by some councils according to our interviews and the approach could be extended nationwide.

Increased export controls may include a complete ban, or setting quotas on the export of waste tyres. New Zealand is a signatory to the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (set up in 1989) [23]. This restricts the export of end-of-life tyres to countries which officially declare them to the Basel Secretariat as hazardous waste. Exports of tyres from New Zealand to these countries can be prohibited under the Imports and Exports (Restrictions) Prohibition Order (No.2). It is understood that Vietnam and China have declared waste tyres to be hazardous, but may also have an exemption for particular industries importing tyres for fuel.

Many countries accept imports of end-of-life tyres, including key export destinations in South-East Asia such as Japan, Korea, and Malaysia. We understand that some tyres are declared at customs as 'used tyres', despite being baled and unusable again as tyres. Increased focus on existing restrictions may reduce the illegal movement of waste tyres. We understand that a complete export ban would require new legislation.

1c Introduce licenses to collect waste tyres

An option of collector licencing was raised by a number of interviewees. Licensing collectors would provide a mechanism for controlling and auditing the movement and end-use of tyres. Some stakeholders suggested that quotas could be imposed on collection tonnage to stimulate competition in the market.

Advantages (1a-1c)

- A key benefit of additional regulation and enforcement is expected to be the diversion of waste tyres from landfill and illegal disposal towards recycling. Additionally, these options

[23] www.mfe.govt.nz/more/international-environmental-agreements/multilateral-environmental-agreements/key-multilateral-2

would contribute to increasing the scale and reliability of waste tyre supply for collectors and processors.

- Whilst collector licensing alone would not stop disposal at landfills, it may reduce the incidence of illegal dumping and exports. Consequently increased scale and security of supply may improve funding for investment in on-shore recycling, through self-funding or access to third party equity or debt.

Disadvantages (1a-1c)

- New legislation may be time consuming to implement, and would introduce additional compliance requirements. For example in Ireland, the Waste Management (Tyres and Waste Tyres) Regulations requires suppliers and collectors to submit quarterly information on tyre movements, prepare waste management plans and reports when submitting applications for registration and submit a report to the Environmental Protection Agency (EPA) each year.
- Effective enforcement of illegal disposal would require investment in systems and processes.
- Expanding export controls beyond of the scope of the Basel Convention may be seen as contrary to free trade policies, and face opposition from industry and within government.
- New regulation and enforcement, as discussed above, would focus on increasing recovery rates and would have limited impact on the size of end-use markets. This may create oversupply with unintended consequences, such as incentives for illegal exports and dumping.

Evaluation

On balance, all Additional Regulation and Enforcement options were assessed to be meeting the evaluation criteria (fully or partially) and address at least one investment barrier. All of them were taken forward as a potential part of a shortlisted option, as outlined in the following table.

		1: Additional Regulation and Enforcement		
	Barriers	1a: Landfill ban / disincentives for landfilling	1b: Increased focus on enforcing existing regulation	1c: Introduce licenses to collect waste tyres
1	Limited addressable end-market size	No	No	No
2	Business model requiring scale	Yes	Yes	Yes
3	Insufficient funding	Partial	Partial	No
	Evaluation Criteria			
1	Ability to deliver environmental/ economic outcomes	Partial	Partial	Partial
2	Affordability	Yes	Yes	Yes
3	Alignment with existing policies	Yes	Yes	Yes
4	Achievability	Yes	Partial	Yes
5	Equity	Yes	Yes	Yes
	Taken forward to short-listing	Yes	Yes	Yes

5.3.3 Market organisation

2a Mandatory product stewardship

Under mandatory models of product stewardship, tyre producers are responsible for ensuring collection and disposal of waste tyres in an environmentally responsible manner. Producers would be required to join and cover the cost of a stewardship scheme. In New Zealand, mandatory schemes can be created under the Waste Minimisation Act for priority products that cause significant environmental harm, and benefits from increasing reuse, recovery, recycling or treatment; and can be effectively managed under a product stewardship scheme. In 2014, MFE completed consultations about the prospective declaration of tyres as a priority product[24]. The scheme would need to be accredited by the Minister for the Environment under the Waste Minimisation Act.

Examples of countries where mandatory product stewardship schemes operate for tyres include Belgium, France, Hungary, Italy, the Netherlands, Canada, South Africa, Korea and Taiwan.

Advantages (2a)

- A well designed mandatory product stewardship scheme, supported by appropriate funding, would address the key current investment barriers (improve demand, scale and funding through the value chain).
- Waste tyre recovery rates in countries with mandatory product stewardship schemes are consistently high.
- A mandatory scheme, versus a voluntary one discussed below, would improve equity in the market as all participants would play by the same rules.

Disadvantages (2a)

- Mandatory product stewardship schemes can be costly to establish and operate. For example the administrative costs of Canadian schemes in Ontario, British Columbia and Manitoba represent 6-8% of tyre disposal fees (e.g. NZD $1.7m spent in 2013 in British Columbia which has a similar population than New Zealand). International research suggest that the cost of a scheme does not necessarily correlate with its effectiveness. There are effective systems that are relatively inexpensive, and some that are relatively costly. [25]
- As intended, stewardship programs intervene in the market, typically by making significant pricing and funding decisions. This may be mismanaged (e.g. due to lack of clear direction, poor planning and execution) and cause unintended consequences such as creating dominant providers.

2b Voluntary product stewardship

Voluntary product stewardships can have a similar organisation and intended outcomes as a mandatory scheme. Voluntary product stewardship does not require regulation as participation is not mandated. New Zealand currently has 11 accredited voluntary product stewardships schemes, for paint, glass packaging and agricultural plastics and chemicals for instance. The key challenge

[24] Summary of submissions are available at www.mfe.govt.nz/publications/waste/priority-waste-streams-product-stewardship-intervention-summary-submissions
[25] Monier et al, European Commission – DG Environment; Development of Guidance on Extended Producer Responsibility, 2014

with voluntary schemes is related to low participation and recovery rates. Current schemes have achieved less than 36% reduction in their targeted waste stream to date[26].

A national voluntary product stewardship scheme has recently been approved by the Australian Commerce Commission, but effectiveness data is not yet available. There is not currently a voluntary product stewardship scheme for waste tyres in New Zealand, although one (Tyre Track) was attempted 2004-2009 and discontinued following no change in tyre recovery rates. The participants in the Tyrewise industry consultation process in 2013, and tyre generators interviewed during our project, stated that they would not participate in a product stewardship scheme for tyres without a regulatory framework ensuring a level playing field.

Advantages (2b)

- No new legislation or regulation is required to establish a voluntary scheme.

Disadvantages (2b)

- Moderate track record as discussed above
- Lack of 'level playing field' and 'free-rider' issues cited as a key objection to voluntary schemes in our interviews. Producers are free to opt-out and gain commercial advantage by working with low-cost collectors who may not adhere to the same standards as scheme participants.

<u>2c Bounded Free Market</u>

The current New Zealand system is effectively a free market model with light regulation which has not achieved high waste tyre recovery rates.

Under 'free market' conditions operating within boundaries for collection and disposal, for example in the UK and Ireland, regulators set the requirements for waste recycling and leave the market to organise the delivery of those obligations collectively (i.e. without assigning responsibility to producers as in 2a and 2b above). The government monitors and enforces the relevant regulations, such as landfill bans, export controls, collector licensing and reporting.

Advantages (2c)

- Pricing and supply-demand dynamics are market-led, and less prone to potential mis-management by a centralised organisation (although still at risk of market failure).

Disadvantages (2c)

- The model in itself does not deal with competition to recycling from illegal and low cost disposal methods. It requires new regulation to establish the regulatory safeguards (e.g. restrictions on landfilling) that make a free market approach effective in meeting environmental outcomes.

Evaluation

Each Market Organisation option, combined with other regulation, is capable of improving current economies of scale, funding, and the development of end-markets based on overseas experience. However, interview participants, particularly producers questioned the effectiveness of voluntary arrangements based on recent New Zealand experience. They have also raised concerns over the equity of voluntary arrangements, since under a voluntary product stewardship

[26] Priority waste streams for product stewardship interventions. Ministry for the Environment, 2014.

scheme producers could elect not to participate and gain a competitive advantage over participating producers. Therefore voluntary product stewardship did not meet two evaluation criteria and has not been taken forward, while the other two arrangements were considered further as part of the shortlisted options.

		2: Market Organisation		
	Barriers	2a: Mandatory product stewardship	2b: Voluntary product stewardship	2c: Free market
1	Limited addressable end-market size	Yes	Yes	Yes
2	Business model requiring scale	Yes	Yes	Yes
3	Insufficient funding	Yes	Yes	Yes
	Evaluation Criteria			
1	Ability to deliver environmental/ economic outcomes	Yes	Partial	Yes
2	Affordability	Yes	Yes	Yes
3	Alignment with existing policies	Yes	Yes	Yes
4	Achievability	Partial	No	Partial
5	Equity	Yes	No	Yes
	Taken forward to short-listing	Yes	No	Yes

5.3.4 New funding model

3a Price controls

Setting regulated prices for disposal fees and collection charges would align payment from the consumers to the full cost of collection and disposal. This approach is used in regulated industries such as utilities, and is aimed to mitigate market failures and mispricing in a given market. In principle it would address the underfunding of waste tyre recycling. However, it is likely to offer poor value for money given the cost of establishment and operation. It is used in larger industries where the potential benefits justify the overheads. This option is not used in waste tyre management abroad, based on our research.

3b Advance disposal fee/levy

Mandatory advance disposal fees or levies are often applied overseas in conjunction with product stewardship schemes, for example in British Columbia, Canada[27]. The fee is collected at the point of tyre purchase or importation, and covers the cost of recycling end-of-life tyres. Under product stewardship, the programme is responsible for the distribution of the funds to achieve the desired outcomes of the scheme.

3c Tax system

A tax system for waste tyres recycling is in operation in some European countries, including Denmark and the Slovak Republic[28] and some US states. To the extent tax is imposed on tyre production and imports, tax funding is similar to 3b (a levy system) above, but it is administered and managed by government rather than an industry sponsored body. Currently no specific taxes

[27] http://www.tsbc.ca/
[28] http://www.etrma.org

apply to tyres in New Zealand however the waste levy or general taxation may be a source of new funding. Nevertheless funding a specific industry from general taxation may not be seen as equitable and may be challenged on economic and competition policy grounds.

3d Deposit refund

A deposit refund uses part of the purchase price to offer a refund once the product is returned to an approved collection point. Deposit refunds are used overseas for products including batteries, beverage containers and electronics. It incentivises consumers to return end-of-life products, instead of collectors covering the most expensive 'last mile' of transporting waste. It is currently not used in waste tyre recycling, partly as tyre users tend to return their end-of-life tyres for replacement without any incentive. Also, a deposit system primarily aims to fund the collection of waste, covering the full cost of processing would rely on additional sources, such as funding from unclaimed deposits.

3e Trading scheme

The most widely used trading scheme in New Zealand and the world is employed in trading carbon emissions. Theoretically a similar system could be applied to waste tyres, although its original intent to cap generation would need to be adapted with a focus on producers trading credits for recycling. Currently there is no precedent for trading schemes in waste tyre recycling but it is used in the UK for packaging and e-waste. It would require new legislation to introduce one in New Zealand.

Advantages (3a-3e)

- Each of the Funding Model options would provide a new source of funding that can be set in line with the full cost of delivering the desired environmental outcomes.
- Each option would contribute to meeting or partially addressing the current investment barriers.
- There are New Zealand and/or overseas precedents for each funding approach which could be adapted for waste tyres.

Disadvantages (3a-3e)

- Key draw-backs relate to affordability and achievability risks given the complexity, need for new legislation, likely high costs and lack of industry support (for options 3a, 3e).
- Lack of equity and lack of effectiveness in addressing investment barriers are the key disadvantages of general taxation and deposit refund (3c and 3d respectively).

Evaluation

The following table outlines the evaluation of Funding Model options. On balance, advance disposal fees appear to meet all criteria, whereas the other options were not considered further due to the disadvantages described above.

	Barriers	3: Funding Model 3a: Price controls	3b: Advance Disposal Fee/ Levy	3c: Tax system	3d: Deposit-refund	3e: Trading scheme
1	Limited addressable end-market size	Yes	Yes	Yes	No	Yes
2	Business model requiring scale	Yes	Yes	Yes	No	Yes
3	Insufficient funding	Yes	Yes	Yes	Partial	Yes
	Evaluation Criteria					
1	Ability to deliver environmental/ economic outcomes	Yes	Yes	Yes	No	Yes
2	Affordability	No	Yes	Yes	Yes	No
3	Alignment with existing policies	No	Yes	Yes	Yes	Yes
4	Achievability	No	Yes	Yes	Yes	No
5	Equity	Yes	Yes	No	Yes	Yes
	Taken forward to short-listing	No	Yes	No	No	No

5.3.5 Investment and risk mitigation

4a Supply chain incentives

Under this option financial incentives are paid to providers to encourage participation in environmentally responsible disposal of waste tyres. The Tyrewise project suggested a framework for incentive payments in its report Scoping Report 4. Product stewardship schemes, e.g. in Canada and South Africa, provide incentive payments to collectors, processors and other users of waste tyres.

4b Investment in infrastructure

Investment in infrastructure could take the form of:

- Co-investment – where government provides investment matched, or exceeded, by the waste tyre recycling business.
- Low cost loans – to reduce the risk associated with investment in plant and equipment.
- Grants – while waste minimisation grants are already available, this option may increase the scope, available funding and accessibility of grants.

4c Procurement – off take agreements

The attractiveness of government sponsored off-take agreements were cited by interviewees in relation to the procurement of recycled waste tyres for use in roads, based on similar arrangements in Australia and some US states. Given the significant up-front investment and fixed cost base for using rubber by roading companies, stakeholders considered it key that purchasers (NZTA and councils) commit to predictable, high volume take up of the product. We understand that the full operational and commercial benefits and cost of such arrangements have not yet been fully considered in New Zealand.

4d Investment in R&D, knowledge sharing and public education

The focus of R&D, information sharing and public education would be to demonstrate the achievability and safety of new recycling and material recovery technologies. Examples raised by stakeholders included enhancing the New Zealand knowledge base on emissions and best practice controls for tyre-derived fuel (TDF), studies on the achievability of pyrolysis on a commercial scale and feasibility studies to determine the technical and economic benefits of using rubber in roads.

Direct government investment or procurement from selected industries would need to proceed with suitable processes to ensure alignment with market-led economic policies. Such decisions would also need to be coordinated across a number of government agencies, as is done currently with transport planning and multi-agency procurement contracts.

Advantages (4a-4d)

- Each option would be capable of addressing current investment barriers, and meet the broader evaluation criteria (in part or in full).

Disadvantages (4a-4d)

- Whist 4a and 4d aim to support the broader waste tyre sector, 4d and 4c would involve more targeted investments in certain services or companies. This may face resistance from competitors, and would need to be supported by sound policies, investment criteria, and contestability.

Evaluation

All Investment and Risk Mitigation options are taken forward to shortlisting, with Supply Chain Incentives (4a) having the best fit with the evaluation criteria, as summarised below.

		4: Investment and Risk Mitigation			
	Barriers	4a: Supply chain incentives	4b: Investment in infrastructure	4c: Procurement – off take agreements	4d: Investment in R&D, knowledge sharing, and PR
1	Limited addressable end-market size	Yes	Yes	Yes	Yes
2	Business model requiring scale	Yes	Yes	Yes	Partial
3	Insufficient funding	Yes	Yes	Yes	Partial
	Evaluation Criteria				
1	Ability to deliver environmental/ economic outcomes	Yes	Partial	Yes	Partial
2	Affordability	Yes	Yes	Yes	Yes
3	Alignment with existing policies	Yes	Partial	Partial	Yes
4	Achievability	Yes	Partial	Partial	Yes
5	Equity	Yes	Partial	Yes	Yes
	Taken forward to short-listing	Yes	Yes	Yes	Yes

5.4 Short-listed options

The long-list items discussed above represent potential features of a future market model for waste tyres. Those items taken forward following the evaluation were grouped to form part of three short-listed options, with increasing level of intervention, as follows:

A) Enhanced Status Quo: a collection ‘quick wins’ which do not require new legislation.

B) Free Market with additional regulatory protections (Bounded Free Market): introduction of additional regulation and market-led delivery of outcomes.

C) Mandatory Product Stewardship: co-regulatory approach underpinned by new regulation, per the Tyrewise proposal.

The following table outlines each shortlisted option, with reference to the long-list items included.

Option	Overview	Ref.
A) Enhanced Status Quo	Enhanced status quo would use existing legislation with an increased focus on enforcement of relevant laws and regulations, including: • Increase disincentives for landfilling nationally to encourage alternative disposal of waste tyres. • Investment in enforcing existing legislation such as illegal disposal, controlling stockpiling and export controls.	1a, 1b
B) Bounded Free Market	A free market model with increased regulatory protections would set waste tyre disposal limitations and recycling targets but would not assign specific responsibilities for delivery. The Bounded Free Market option has the following main features: • Investment in enforcing existing legislation such as illegal disposal, controlling stockpiling and export controls. • Enactment of new legislation to provide for a nationwide landfill ban for waste tyres over time. • Introduction of licenses to collect waste tyres. • Provision for regular reporting to track the movement of waste tyres through the supply chain. • Establishment of resources to oversee industry reporting. • Sponsored initiatives, e.g. consumer education projects.	1a-1c 2c 4d

Option	Overview	Ref.
C) Mandatory Product Stewardship	The Mandatory Product Stewardship option is based on the model proposed by the Tyrewise project and successfully used overseas in a number of jurisdictions. This model would assign responsibility to the producers for management of the collection and recycling of waste tyres, and includes: • Investment in enforcing existing legislation such as illegal disposal, controlling stockpiling and export controls. • Enactment of new legislation to provide for a nationwide landfill ban for waste tyres over time. • Introduction of an advance disposal fee paid by producers to the accredited product stewardship scheme manager. • Establishment of supply chain incentives to distribute proportions of the advance disposal fee to specific points in the supply chain. The intention of supply chain incentives is to increase the rate of waste tyre recycling. • Investment in R&D to demonstrate the achievability and safety of technologies that could be used for new end uses of waste tyres. Resulting information would be used to inform regulators and to educate consumers. • Potentially, procurement off-take agreements and infrastructure investments subject to appropriate business case.	1a-1c 2a 3b 4a-4d

6 Cost-benefit analysis of the short-listed options

This section sets out the costs, benefits and net present value of the short-listed options.

6.1 Approach and general assumptions

The cost-benefit analysis (CBA) was prepared in line with Treasury CBA guidance[29]. It quantifies the economic impact of intervention options and enables comparison relative to the base case 'Status Quo' scenario, which assumes no intervention.

Costs and benefits are measured from the perspective of New Zealand society as a whole and where possible, quantified and discounted to their net present value. The projections cover a 10-year horizon from 2015 to 2024 and financial values are expressed in real terms, in 2015 NZDs. Tyre volumes are represented in EPUs.

General assumptions include the following:

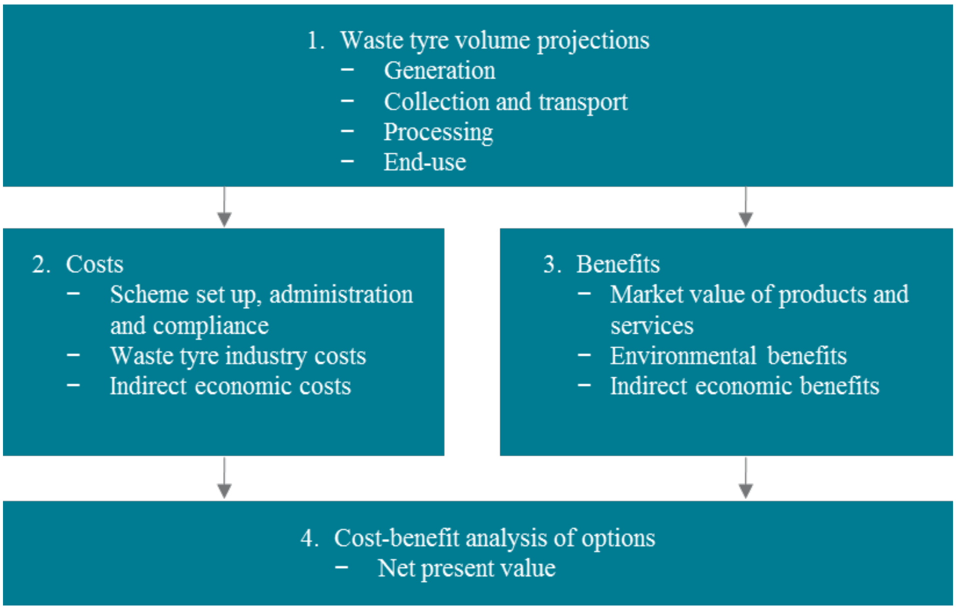
- The base year of appraisal is 2015
- The forecast period is 10 years and the terminal value assumes cost and benefit growth in line with inflation after year 10 (i.e. 0% growth in real terms)
- Discount rate is 8% in real terms, based on Treasury's default public sector discount rate[30]
- Market prices are projected forward at their current level (with the impact of variations captured in sensitivity analysis).

The short-listed options are assumed to require a period of set up as summarised in the table below. Initial implementation costs are distributed through this period, and no incremental benefits are assumed during this time.

Option	Set up period	Set up activities
A) Enhanced Status Quo	12 months	Develop plans and business case for investment in additional enforcement resources and systems Implement landfilling disincentives in consultation with councils and commercial operators
B) Bounded Free Market	24 months	Develop and implement regulations enabling a landfill ban and provider licensing Set up monitoring and enforcement functions
C) Mandatory Product Stewardship	24 months	Declare waste tyres as priority product under WMA 2008 Develop and gain accreditation for a product stewardship scheme Develop and implement regulations enabling a landfill ban and an advanced disposal fee

[29] Source: Cost Benefit Analysis Primer v1.12
[30] Source: www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis

An overview of the financial modelling logic is provided in the chart below.



The CBA is underpinned by waste tyre volume projections, and the costs and benefits of administrative and operational resources employed in increasing the level of waste tyre recycling.

The following sections introduce the key components of the CBA. Quantified figures are indicative and rely on the validity of a number of assumptions summarised below. Sensitivity analysis is undertaken to illustrate how the net present value of each option would change with adjustments in key assumptions. Non-quantified costs and benefits that cannot be reliably monetised, considered immaterial or would double-count impacts already captured elsewhere, are highlighted in the corresponding sections.

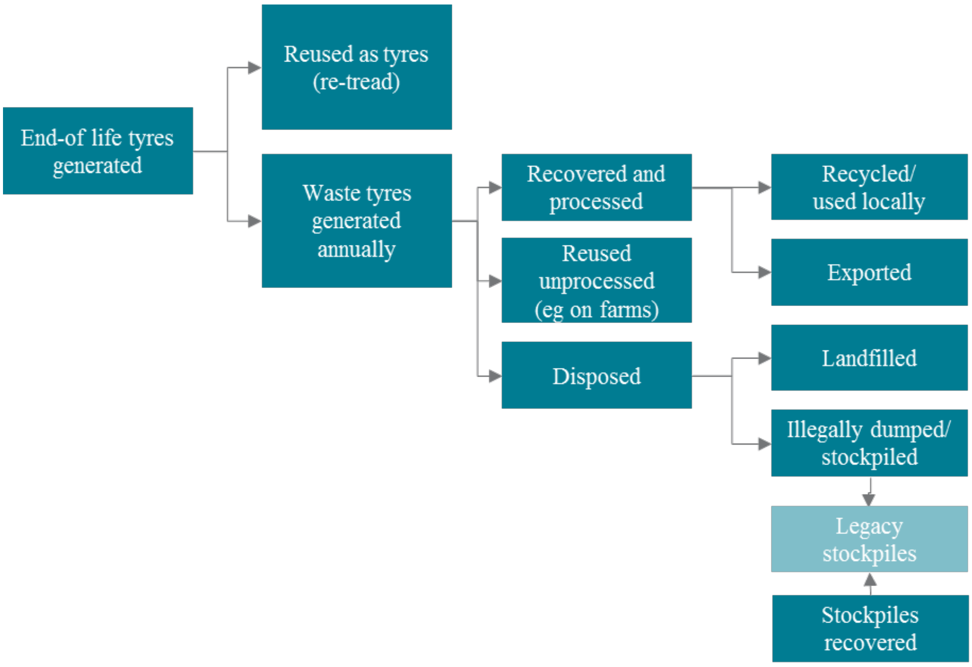
The overall approach for this CBA is similar to that adopted by the Tyrewise project, and involves the calculation of economic returns using the net present value of incremental costs and benefits[31]. However, there are differences in the definition of costs and benefits in the current analysis, principally related to excluding funding and transfer payments in line with Treasury's business case guidance. These differences are described in the following sections.

6.2 Waste tyre volume projections

Volume projections follow the waste tyre flows through the industry value chain: from the generation of end-of-life tyres, to collection and transport of recovered tyres, processing and manufacturing of end-use products, as illustrated in the following chart.

[31] Tyrewise Summary Report 7 (28 August 2013)

Waste tyre value chain



The sections below step through the volume assumptions for each option.

6.2.1 Generation

The projected volume of end-of-life tyres each year is the same in each option. Volumes are assumed to increase in line with population growth (1% Compound Annual Growth Rate (CAGR) 2015-24)[32]. Alternative drivers may include road vehicle kilometres travelled (which has been stable at c.40 billion kilometres from 2005 to 2013[33]) and the replacement rate of tyres per kilometre travelled (for which public data is unavailable). A sensitivity analysis of volume growth assumption is presented later in this report.

The starting point of the volume projections is 7.6m EPUs of end-of-life tyres in 2015, calculated based on 2014 volume data, the above growth assumptions and tyre volume conversions summarised in Appendix B3. Excluding reused tyres, waste tyre generation is projected to increase by 1.8% CAGR to 2024. This reflects a prediction by some stakeholders that reuse on farms will reduce with declining demand for use in silage.

The existing stockpile of waste tyres in New Zealand as at January 2015 is assumed to be 1 million EPU. This is an indicative figure in the absence of reliable data on existing stockpiles based on educated estimates of industry participants, and is tested in sensitivity analysis below.

6.2.2 Collection and transport

A key driver of the CBA is the assumed rate of waste tyre recovery under each option. The base case assumes a flat volume of recovery through the forecast period. This implies a slow decrease

[32] Source: World Bank, Statistics NZ, KPMG analysis
[33] Source: Ministry of Transport

in the proportion of recovered and processed tyres (from 32% in 2015) as the overall volume of waste tyres increases. The recovery rates under Options A, B and C are projected to increase in response to the proposed interventions as shown in the following table.

The assumed recovery rates are broad estimates based on international experience of the efficiency of similar interventions, qualitative feedback from New Zealand stakeholders, and demand estimates for exports and end-products that can be met economically. Nevertheless, we are not aware of conclusive evidence on the relative efficiency of these interventions, therefore the assumed recovery rates are key variables for our sensitivity analysis presented later in this document.

Recovery rate (% of waste tyres generated)	**Year 5**	**Year 10**	**Notes**
Base Case	31%	29%	Hindered by volatile and uncompetitive exports, and sub-scale and underfunded on-shore processing
A) Enhanced Status Quo	40%	45%	An increase is facilitated by partial diversion of tyres from landfills and illegal dumping, however still limited export and end-use demand
B) Bounded Free Market	60%	85%	Supported by increased barriers for tyre dumping and mandatory tracking arrangements; ~85% of tyre are generated within 200kms of population centres (see below), the recovery of the rest is likely to be uneconomical
C) Mandatory Product Stewardship	90%	95%	Supported by landfill ban, disincentives for illegal dumping and exports, and clear targets and accountability for outcome. High reported recovery rates overseas.

Transport costs are driven by tyre volumes and the distance that tyres are carried to processors and from processors to manufacturers. The estimated volume of generated tyres is broken down by bands representing the distance between the source of tyres and the nearest collection depot. This assumes, based on our interviews, that waste tyres are generated broadly in line with population distribution.

	0-10km	**11-60 kms**	**61-200 kms**	**200+ kms**
Collection distance (% tyres generated)	8%	38%	40%	14%

A proportion of illegally dumped and stockpiled waste tyres are projected to be cleared annually. Reduction in the remaining stockpile compared to Year 1 is shown in the table below.

% reduction vs 2015	**Remaining stockpile**		**Landfilling**		**Notes**
	Year 5	Year 10	Year 5	Year 10	
Base Case	5%	-8%	-7%	-15%	Negative percentage mean a growth in stockpile/landfill

% reduction vs 2015	Remaining stockpile		Landfilling		Notes
	Year 5	Year 10	Year 5	Year 10	
A) Enhanced Status Quo	17%	1%	14%	17%	Focused on preventing the increase in existing stockpiles and reducing landfilling
B) Bounded Free Market	40%	60%	100%	100%	Improved enforcement and funding to support clean up
C) Mandatory Product Stewardship	84%	93%	100%	100%	Collector incentives to rapidly reduce existing stockpiles

6.2.3 Processing

Projected processing volumes by rubber grade (TC1-5) are summarised in the table below. They are driven by the assumed demand for locally used and exported products. The type and volume of processing required by end-use product is set out in the following section. Additionally, landfilled tyres are assumed to be shredded (TC2).

EPU mn pa (Yr1-Yr10 avg.)	**Base Case**	**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
TC1 (baled)	0.5	0.7	1.4	1.4
TC3 (chips)	0.5	0.7	2.0	2.5
TC4 (granules)	1.0	1.1	1.3	1.3
TC5 (powder)	0.5	0.7	0.8	0.9
Total for recycling	**2.5**	**3.2**	**5.5**	**6.1**
TC2 (for landfill)	4.4	3.7	1.6	1.0

6.2.4 End-use

Volume projections for end-use products are the following[34].

EPU mn pa (Yr1-Yr10 average)	**Base Case**	**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Granules for sports fields, etc. (TC4)	0.5	0.5	0.5	0.5

[34] Excludes locally used powder for moulded products and adhesives as they are currently produced from tyre buffings, which is expected to continue

EPU mn pa (Yr1-Yr10 average)	**Base Case**	**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Material recovery (TC1/TC4)	-	0.3	1.0	1.0
TDF (TC3)	-	-	1.2	1.6
Exports (TC1-TC5)	2.0	2.4	2.8	3.0
Total	**2.5**	**3.2**	**5.5**	**6.1**
% of on-shore end-use	6.2%	12.1%	49.6%	52.2%

The projections assume that legacy local markets for processed rubber (for sports fields, equestrian turf, other applications as filling and insulation) are already economically served and largely saturated, and will not be effected by additional interventions.

New markets included in the analysis, are material recovery (e.g. pyrolysis) and locally used TDF (in cement kilns). Local roading applications using rubber powder have not been modelled as the economics, based on current information, is less attractive. The viability of new markets are dependent on factors detailed in the supporting analysis included in this report, such as marketability of end-use products (e.g. pyrolysis oil and carbon black) and overcoming environmental compliance and public relation barriers. These non-economic barriers are detailed in sections 4.1-4.3 of this report. Nevertheless the increased funding and security of tyre supply afforded under Options B and C are assumed to facilitate investment in these end markets.

Given the value of incentives required to support on-shore end-use markets at scale (TDF and roading in particular) it was assumed that exports will continue to be required to sell processed rubber into larger overseas end-users, e.g. Australia and South-East Asia. However, the proportion of recycled tyres used locally increases from ~6% of the total in the base case to over 50% under Option C.

6.3 Cost assumptions

There are a range of incremental costs to government, businesses and consumers associated with the options. They are summarised in the table below.

Cost		**Overview**
Scheme related costs	Set up	Upfront costs such as regulatory design and implementation of required administrative systems and processes, and scheme management and monitoring arrangements.
	Administration	Ongoing costs to administer the scheme, e.g. operation of approved schemes, fee collections, audits, and enforcement.

Cost		Overview
	Compliance	Upfront and ongoing costs for businesses to join a new scheme and adhere to new legislation.
	Sponsored initiatives	Programs that support the objectives of any scheme, e.g. R&D, customer education, information sharing.
Production costs		Capital and operating costs related to waste tyre collection, transport, processing and end-uses.
Indirect economic costs (not quantified)		Flow-through costs to the broader economy due to any increase in tyre prices.

A key difference between the current analysis and the Tyrewise financial model is the removal of the levy as a cost consideration, as the levy represents a source of funding rather than cost incurred. Additionally the current analysis includes the operating costs of production, which was excluded from the Tyrewise analysis.

6.3.1 Scheme set-up costs

Scheme set up costs cover the introduction of new regulation, organisational set up, and implementation of administrative systems and processes (e.g. for enforcement, collector licensing and managing levies). It also includes the tendering and establishment of any product stewardship body.

Option	Total cost ($m)	Notes
A) Enhanced Status Quo	$0.7m	$0.3m for regulatory design and implementation, plus $0.4m for compliance systems and processes (assumes existing systems can be customised).
B) Bounded Free Market	$1.5m	$1.1m for regulatory design and implementation – similar to product stewardship costs per Tyrewise; $0.4m for compliance systems, processes (as above).
C) Mandatory Product Stewardship	$1.5m	$1.1m for regulatory design and implementation (mid-point of MFE estimate - per Tyrewise); $0.4m product stewardship organisation set up (tendering, accreditations, IT costs - KPMG estimate).

6.3.2 Scheme administration costs

These include incremental ongoing costs (compared to the Status Quo[35]) to manage relevant industry schemes, and the government's oversight and enforcement activities.

[35] In 2012/13, $12.5m was allocated from waste disposal levy income to Territorial Authorities and $10.2m to the Waste Minimisation Fund, to promote and achieve waste minimisation across all waste streams

Option	Annual cost ($m)	Notes
A) Enhanced Status Quo	$0.8m	No levy collection or financial incentives to manage. Includes government's compliance monitoring systems and processes – estimated based on Option C below, with reduced management and governance costs.
B) Bounded Free Market	$1.2m	
C) Mandatory Product Stewardship	$2.7m	Based on Tyrewise estimates, covers programme management ($1.4m, ~4% of assumed levy income), administrative overheads ($0.8m for legal, accounting, IT, insurance, governance), and levy collection expenses ($0.5m for NZTA and Customs fees)

6.3.3 Business compliance costs

Compliance costs relate to any upfront registration costs and ongoing resource requirements in accordance with legislation such as reporting and certification costs.

Option	Annual cost ($m)	Notes
A) Enhanced Status Quo	-	No additional requirements for businesses.
B) Bounded Free Market	$2.7m	Covers similar reporting obligations on movement of tyres. Overall similar costs are assumed. Whereas Option C incurs additional effort in managing incentive payments, compliance systems are expected to be centralised and managed by the Product Stewardship Organisation (PSO), therefore more cost effective than in Option B. $2.7m estimate is based on the Tyrewise proposal.
C) Mandatory Product Stewardship	$2.7m	

6.3.4 Sponsored initiatives

Sponsored initiatives include new R&D, public education and information sharing projects for instance, in addition to what is currently available from the waste disposal levy (through allocation to Territorial Authorities and the Waste Minimisation Fund[36]). They exclude costs related to the collection of legacy tyre stockpiles which are modelled separately.

Option	Annual cost ($m)	Notes
A) Enhanced Status Quo	-	No new initiatives assumed due to limited increase in industry funding.

[36] Approximately $600k has been allocated to waste tyre projects from the WMF over 4 years (2010-2013) according to MFE's "Review of the effectiveness of the waste disposal levy, 2014"

Option	Annual cost ($m)	Notes
B) Bounded Free Market	$1m	Supported by increased industry funding and targeted activities to stimulate the market. Funding is assumed to be from levy income in Option C, or industry organisations and government grants under Option B.
C) Mandatory Product Stewardship	$1m	

6.3.5 Production costs

Production costs represent the costs involved in waste tyre collection, transport, processing and making end-use products.

The relevant types of costs by end-use product and their drivers are detailed in the supporting analysis. They include capital costs of equipment and facilities (e.g. for transport and manufacturing) and the operating costs (such as staff and power). Transfer charges between industry participants are excluded to avoid double counting.

The assumed unit production costs are summarised by option in the following table. Variation in similar cost types by option are due to different volume assumptions. Increasing transport costs compared to the base case are due to higher recovery rates and longer average transport distances. Increasing TC2 processing costs (cutting and shredding) are due to lower volume of landfilling which is the main source of demand for tyre cutting. Finally, decreasing processing and end-use production costs are due to increasing volumes and economies of scale.

Unit Production Cost (2015-24 avg, $/EPU)		**Base Case**	**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Collection and transport		1.05	1.20	1.44	1.56
Processing	TC1	0.46	0.30	0.29	0.27
	TC2	0.38	0.40	0.47	0.58
	TC3	0.61	0.56	0.48	0.45
	TC4	1.70	1.66	1.55	1.52
	TC5	2.86	2.47	2.35	2.26
End-uses	Material recovery	NA	3.79	2.69	2.69

6.3.6 Indirect economic costs

Additional costs for the broader economy may be incurred through an increase in tyre prices should the industry pass on its increased costs (e.g. levy payments) to customers. This could have a flow-through impact, for example in increased costs of vehicles, transport, logistics and travel. However, such additional costs are likely to be immaterial compared to the current retail price of tyres and would be balanced by indirect benefits set out in the corresponding section below. Therefore the CBA does not quantify any indirect economic costs.

As an illustration, a levy of ~$5/ EPU incurred by importers and retailers (under option C) would increase their cost base by $3/ EPU as the levy would cover the existing approximately $2/ EPU waste tyre collection fee. Given an average $100-$300/EPU retail price of new tyres, if increased costs are fully passed on by retailers, customers would see 1% to3% higher tyre prices. This is under the materiality threshold suggested by Treasury's CBA guidance for indirect economic impacts. Further the perceived price increase would be lower in the context of a vehicle purchase. Options A and B would incur lower costs and more marginal potential price increase.

6.4 Benefit assumptions

Incremental benefits to government, businesses and consumers associated with the options are summarised in the table below.

Benefit		**Overview**
Market value of products and services	Collection	Market price paid by waste tyre generators (e.g. retailers) for collection and transport to processors.
	Recycled waste tyres	Whole and processed waste tyres sold for alternative uses, e.g. silage covers, artificial turf, mats and moulded products, tyre derived fuel, road building.
	Recovered materials	Raw materials extracted from waste tyres, e.g. steel, textile, revulcanised rubber, oil, carbon black.
Environmental benefits	Avoided landfill operating costs	Reduced cost of disposing waste tyres in landfills.
	Avoided landfill externalities	Reduced indirect costs to third parties, e.g. green-house gas emissions, leachate, health risks, and negative amenity impact for local communities.
	Avoided cost of illegal dumping and tyre fires	Reduced cost of dealing with illegal dumping and fires of tyre stockpiles.
Indirect economic benefits		Benefits for the wider economy, e.g. better roads, 'clean green NZ' brand reputation.

The key difference in the current analysis compared to the Tyrewise cost-benefit modelling is the removal of value chain incentives provided from the levy[37]. These are considered transfer payments associated with funding rather than the measure of economic return.

The following sections set out the benefit assumptions used for each option.

[37] Captured under the 'new industry and employment' benefit in the Tyrewise model, per Summary Report 7

6.4.1 Market value of products and services

This is the market price paid for the collection service and recycled tyre products and recovered materials. Landfill is a cost of disposal and the cost is incorporated in the analysis. The extent that the landfill owners will reduce profits is not included in the analysis since this is a transfer of funds from one part of the value chain to another. The following table summarises the assumptions by type of product and service. Negative values represent incentives to be paid for customers to accept the product, for example in the case of TDF where the cost of using coal is lower than using rubber chips.

Market value of products and services		**Avg. value** (excl GST)	**Notes**
Collection		$1.60/ EPU	Based on estimated current average prices; Assumes that the relevant market price is the pre-intervention price, rather than prices impacted by new regulations (e.g. landfill ban).
Recycled waste tyres	Granules for sports fields, etc.	$3.60-$5.00/ EPU	Values are based on industry interviews. The figures opposite are average prices which may vary by level of local and export demand, product specifications, and exchanges rates and freight costs (if applicable). Export prices are net of international freight costs (for delivery at New Zealand port). Local TDF prices are based on the estimated incentive required to make the substitution of coal economically viable. TDF price varies by delivery volumes and assumes delivery at the factory gate. Excludes products currently made from buffings (e.g. mats, adhesives).
	Baled tyres for export	$0.07/ EPU	
	TDF (local)	$(0.40)-$(0.70)/ EPU	
	TDF for export	$0.10/ EPU	
	Granules for export	$2.10/ EPU	
	Rubber powder for export	$3.00/ EPU	
Recovered materials	Oil	$0.80/ litre	Values are based on industry interviews. Average prices per assumptions set out above. Assumes New Zealand delivery, net of international freight (e.g. for carbon black).
	Carbon black	$200/ tonne	
	Scrap steel	$300/ tonne	
	Re-vulcanised rubber	$900/ tonne	

6.4.2 Environmental benefits

Environmental benefits include the avoided cost of dealing with waste tyres, and comprise the following:

- Reduced landfilling costs – operating costs and transport to landfill
- Reduced landfill and stockpiling externalities – indirect costs from environmental pollution and hazards, and decreased utility and property value of adjacent neighbourhoods
- Avoided cost of dealing with illegally dumped or stockpiled tyres (e.g. clean up and enforcement), and tyre fires.

Environmental benefits: avoided waste management and pollution costs	Average value	Notes
Landfilling costs	$163/ tonne	$100/tonne for landfill operating costs – based on a range of Australian and New Zealand studies adjusted for inflation and exchange rate.[38] $63/tonne (~$0.5/EPU) for transport; applied as a flat cost for all options (equivalent to ~30% of the estimated national collection cost of whole tyres due to the reduced volume of shredded/ cut tyres).
Landfill externalities	$15/ tonne	Based on international studies of amenity loss due to landfilling/litter[39]. The figures represent the mid-point (for landfilling) and high point (for stockpiling) of the estimated cost range, adjusted for inflation and exchange rates.
Stockpiling externalities	$30/ tonne	
Site clean-up/ remediation	$62/ tonne	~$0.5/EPU to cover the clean-up of sites used for stockpiling and illegal dumping based on reported incidents in New Zealand and internationally[40]. Transport costs for the removal of tyres are captured elsewhere.
Enforcement and litigation	$55/ tonne	Based on recent New Zealand costs (e.g. $200k for the Huntly incident), and calibrated against UK experience (adjusted for market size).[41]
Tyre fires	$150/tonne	Based on estimated cost of recent New Zealand incidents (e.g. Hamilton, Wanganui and Tony's Tyres at Porirua, per Tyrewise). The costs are scaled over time in line with the projected size of the remaining legacy stockpiles under each option.

[38] Source: WCS/PWC, Packaging Cost Benefit Analysis (Australia, 2011); Hyder, Audit of Selected Rural Council Landfill Facilities (Australia, 2006); MFE, Landfill Cost Accounting Guide (NZ, 2004)
[39] Source: WCS/PWC, Packaging Cost Benefit Analysis (Australia, 2011)
[40] Reported clean-up costs (including transport and site remediation) range widely from $20 /EPU and $2 /EPU. The assumed $0.5 figure is based on the low-end of the range and excludes transport costs estimated at $1.5 /EPU
[41] Source: Environment Agency, Waste crime report 2012-2013 (UK, 2013); ESEAT, Waste Crime: Tackling Britain's Dirty Secret (UK, 2014)

6.4.3 Indirect economic benefits

Wider economic benefits from improved waste tyre management, cited by the Tyrewise project and our interviewees, included the value of a 'Clean New Zealand' brand, which support tourism and other export industries. The clean, environmentally responsible image also benefits corporate brands, such as tyre producers and importers, which conversely, would suffer from adverse association with any environmental damage caused by their products. These benefits were considered intangible and challenging to quantify reliably and were excluded from the current CBA.

Further non-quantified benefits would flow from better quality roads enabled by rubber additives. Overseas experience suggests that rubber in roads allows quieter travel, better cornering and braking performance, and more durable surfaces.

Additional unquantified social and economic benefits may flow from job creation in new waste tyre recycling industries, albeit many of the new roles would require low qualifications and may substitute jobs elsewhere in the broader economy.

6.5 Cost-benefit analysis

This section summarises the outcome of cost-benefit modelling, including the Net Present Value (NPV) of each option, and a sensitivity analysis of key variables.

6.5.1 Net present value of options

Based on the assumptions set out in the previous sections, the NPV of costs and benefits for each options is as follows.

Present Value of Incremental Costs and Benefits vs Base Case ($m)		**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Costs	a) Scheme related	10	51	66
	b) Transport	17	70	91
	c) Processing	11	23	25
	d) End use	16	37	38
	e) Incremental costs	*53*	*181*	*220*
Benefits	f) Market value of products and services	49	132	149
	g) Environmental benefits	18	64	87
	h) Incremental benefits	*67*	*196*	*236*

Present Value of Incremental Costs and Benefits vs Base Case ($m)	A) Enhanced Status Quo	B) Bounded Free Market	C) Mandatory Product Stewardship
Net Present Value ($m)	**14**	**15**	**16**
NPV sensitivity range (see Section 6.5.2)	7-37	5-53	6-51
Net industry benefit (pre-incentives): (=f-b-c-d)	5	2	(5)

Key observations:

- Each option produces a positive NPV, and the difference between the NPVs is immaterial. Therefore, the options are equivalent from an economic 'value for money' perspective under the assumptions used. Key differences are in the options' effectiveness in addressing the current investment barriers, and their ability to deliver environmental outcomes (e.g. increased rate of on-shore waste tyre processing).
- Option B and C incur a progressively higher share of transport and scheme related overheads compared to Option A, which is balanced by an increasing share of environmental benefits. In other words, incremental investment is underpinned by non-commercial benefits.
- For Option C, the net benefit to the waste tyre industry is negative, which means the industry requires financial incentives (funded by a levy), beyond regulatory support (e.g. landfill ban). Increasing recovery rates assumed in Option B and C, produce diminishing commercial returns.

6.5.2 Sensitivity analysis

To assess the impact of variations and uncertainties in key value drivers, sensitivity tests were undertaken in relation to:

- **Discount rate** to calculate the NPV: Higher discount rates represent a higher expected risk of meeting the forecasts.
- **Recovery rates**: This is a key assumption about the performance of each intervention.
- **Raw material prices**: The prices of coal, oil, carbon black, scrap steel are volatile and would impact the attractiveness of material and energy recovery using processed tyres.
- **Existing stockpile of waste tyres** in Jan 2015: This figure is currently unknown and estimated based on anecdotal industry feedback.
- **Annual change in ELT generation volume**: Impacts the addressable market for waste tyres.

The NPV of each intervention option is summarised below for each sensitivity.

NPV under selected sensitivities ($m)		**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
Discount rate (% point change)	4%	36.9	53.2	51.3
	6%	21.4	27.3	27.3
	8%	**14.0**	**15.2**	**16.0**
	10%	9.7	8.5	9.7
	12%	7.0	4.5	5.9
Recovery rate (% point change in Yr10, phased in from Yr2)	-4pp	13.6	12.6	9.8
	-2pp	16.7	14.2	12.9
	-	**14.0**	**15.2**	**16.0**
	+2pp	15.5	16.6	19.0
	+4pp	18.2	18.1	18.5
Raw material prices (% change)	-10%	12.4	8.8	9.3
	-5%	13.2	12.0	12.6
	-	**14.0**	**15.2**	**16.0**
	+5%	14.8	18.3	19.4
	+10%	15.6	21.5	22.7
Existing stockpile in Jan 2015	0	12.5	12.6	14.4
	0.5m	13.3	13.9	15.2
	1m	**14.0**	**15.2**	**16.0**
	1.5m	18.4	16.5	16.8
	2m	18.7	17.8	17.5
Annual change in ELT generation volume	-1%	19.6	15.1	14.1
	0%	18.1	14.4	13.8

NPV under selected sensitivities ($m)		A) Enhanced Status Quo	B) Bounded Free Market	C) Mandatory Product Stewardship
	1%	**14.0**	**15.2**	**16.0**
	2%	12.4	15.7	16.7
	3%	15.7	19.9	21.6

Key observations:

- Each option produces a positive NPV within a broad range of discount rates
- The performance of interventions (in terms of recovery rates) has the highest impact on Option C which incurs the highest administrative overheads.
- As noted in the supporting analysis raw material prices, which are typically correlated with crude oil prices, impact the profitability of material and energy recovery end-uses. The sensitivity analysis confirms a notable impact on net benefits, which underlines the importance of long term arrangements and ability to mitigate price volatility in waste tyre supply for these end-uses.
- The assumption on the size of existing stockpiles does not appear to have a significant impact on the net benefits of the short-listed options.

7 Summary conclusions and recommendations

This section summarises the conclusions of our analysis. It outlines the rationale and objectives for intervention, potential strategies and key enablers, and a suggested way forward.

7.1 Rationale and objectives intervention

Our economic analysis and stakeholder feedback indicates that there is a case for government intervention in the waste tyre market.

Currently about 70% of end-of-life tyres are destined for landfill, stockpiles, illegal disposal or are otherwise unaccounted for.

Industry stakeholders state that competition from low cost disposal options, insufficient funding and lack of supply security restrict investment in waste tyre recycling.

Three principal and enduring barriers are summarised as:

- Limited market size for tyre derived products in New Zealand and uncompetitive access to international markets.
- Lack of scale to generate return on investment, particularly in processing and manufacturing.
- Insufficient funding mechanisms to raise and distribute funds across the value chain.

Given these barriers and the insufficient capacity and willingness to invest highlighted by our interviews, it is unlikely that the rate of recycling will materially increase in the next three to five years.

Government intervention is required to remove or reduce barriers to investment.

Based on the analysis of market drivers, our view is that the key enablers that should underpin interventions are as follows:

1. *Expanding waste tyre collection nationwide* – This requires incentives for operators to service remote areas, and making collection competitive versus landfilling.
2. *Increasing utilisation of existing processing capacity and establishing capacity in the South Island* – Increased volume throughput would reduce unit production costs from $2.70-$3.70 per EPU by ~35%. Investment assumes sufficient demand which can cover the cost of production.
3. *Investment in scalable new manufacturing options (end uses)* – As discussed in previous sections this may require financial and/or regulatory support given the low commercial return from recycling, as well as overcoming regulatory, technological and public relations barriers.
4. *Developing an effective funding mechanism that covers the full cost of collection, processing and manufacturing* – Current collection revenue streams of approximately $2 per EPU can only support a limited range of recycling options.

7.2 Potential intervention strategies

Through stakeholder interviews and international research we have identified a range of potential interventions, and short-listed three options that best fit the criteria agreed with MFE.

Overview of short-listed interventions options

Option	Key changes to the current model	Relative ranking	Key advantages/ disadvantages	Net benefit
A) Enhanced Status Quo	Investment in enforcement Increased disincentives for landfilling	3rd	✓ Lowest cost, lowest implementation risk (incremental approach) ✗ Limited ability to address economic and environmental outcomes	$14m
B) Bounded Free Market	Landfill ban Collector licensing Increased industry reporting and regulatory oversight	2nd	✓ Market-led approach ✗ Does not assign accountability for outcomes, or remove incentives for illegal dumping	$15m
C) Mandatory Product Stewardship	Landfill ban Advanced disposal fee Supply chain incentives Mandatory product stewardship participation	1st	✓ Clear accountability, sector coordination and incentives aligned with outcomes ✗ Higher cost to establish and operate	$16m

Based on the overall evaluation criteria, mandatory product stewardship ranks highest as its higher costs are off-set by ability to assign targets and accountability, and deliver greater environmental benefits.

The ranking of shortlisted options reflects a balanced assessment using scores against the evaluation criteria presented in the table below. Further detail on the evaluation of options is provided in Appendix C.

Summary assessment of short-listed options against the evaluation criteria

Criteria and scores (0: no fit, 4: highest fit with criteria)	A) Enhanced Status Quo	B) Bounded Free Market	C) Mandatory Product Stewardship
1. Ability to address investment barriers	Low (1)	High (3)	Highest (4)
2. Ability to deliver environmental and economic outcomes	Low (1)	High (3)	Highest (4)
3. Affordability	Highest (4)	Med (2)	Med (2)

Criteria and scores (0: no fit, 4: highest fit with criteria)	**A) Enhanced Status Quo**	**B) Bounded Free Market**	**C) Mandatory Product Stewardship**
4. Alignment with existing policies	High (3)	High (3)	High (3)
5. Achievability	Med (2)	Med (2)	Med (2)
6. Equity	High (3)	High (3)	High (3)
7. Value for money	Med (2)	Med (2)	Med (2)
Total score	**16**	**18**	**20**

Based on our evaluation, mandatory product stewardship provides the best overall fit with objectives, albeit marginally. The key trade-off is affordability (i.e. cost) against ability to deliver environmental outcomes.

Nevertheless, the achievement of benefits is not without risks. An initial consideration of key 'systemic' risk areas is illustrated in the following table. There are further financial, operational and reputational risks that a well-designed scheme should aim to mitigate.

Selected key risks of intervention through mandatory product stewardship

Risk areas	**Impact (H/M/L)**	**Likelihood (H/M/L)**	**Mitigation and comments**	**Residual risk**
Non-economic barriers prevent large-scale end uses being established; for example, lack of skills, unproven technology, lack of stakeholder support, public opposition	H Oversupply of waste tyres which leads to stockpiling and increased illegal disposal	M	Trials to confirm the commercial and operational feasibility of new end-uses, e.g. TDF, rubber in roads, material recovery Consultation with stakeholders to gain commitment or in-principle support Targeted public education and consultation (e.g. on environmental safety of TDF)	M/L
"Picking winners", i.e. supporting a selected few providers	H Stifling innovation and competition; creation of monopoly providers of waste tyre recycling	M	Robust scheme design that provides equitable incentives for similar services, and minimises barriers to entry for new providers	M/L

Risk areas	Impact (H/M/L)	Likelihood (H/M/L)	Mitigation and comments	Residual risk
Mispricing of incentive payments	M Inefficient use of disposal fees and inadvertent subsidy of selected providers	M	Availability of sufficient financial and volume information, and robust methodology to set and review prices	L
Depressed market prices, for oil and coal in particular	M Business case for using tyre-derived alternative energy and material is temporarily weakened	M	Long term supply and off-take commitments (3+ years)	L

7.3 Suggested way forward

Our analysis and stakeholder feedback point to the need for intervention. Nevertheless, we note that the economic analysis presented here is just one input into future policy development; the Ministry will need to take into account additional factors and considerations before developing any new policies related to waste tyres. Additionally, risks and uncertainties related to non-economic factors should also be mitigated. These non-economic barriers (highlighted in the above table and in sections 4.1-4.3) relate to:

- Introduction of new technologies (TDF, pyrolysis, rubber in roads): e.g. the time and cost of setting up equipment, transferring overseas operational expertise and training staff.
- Regulatory and consenting barriers: e.g. to mitigate potential environmental harm from emissions, and health and safety risks.
- Stakeholder’s resistance to change: e.g. industrial users and the general public perceive commercial, reputational and environmental risks, and require proof and reassurance of the viability and safety of new technologies in a New Zealand context.

Therefore we recommend a two-phased approach outlined in the following chart. A phased approach enables continued progress on the implementation of the option that offers greatest value to stakeholders, facilitates more detailed regulatory design, organisational planning and technology trials, and allows for further consultation before the proposed changes ‘go live’.

Proposed phased approach

Market Model Development

Phase 1: Confirm Approach for Intervention *(next 6-12 months)*	Consultation & Agreements *(next 12 months)*	Phase 2: Implement chosen scheme *(next 12-18 months)*
• **Complete due diligence** of non-economic barriers and confirm intervention strategy – Research / trial new-end uses – Review enhanced enforcement options – Complete policy analysis and impact assessment • **Progress the development of the recommended intervention option** – Consider priority product consultation responses and incorporate the wider policy direction on waste minimisation – Develop scheme design – Update business case based on trial results and scheme design	• **Consult with stakeholders** on intervention strategy and scheme design • **Agree Memorandums of Understanding** (eg with New Zealand Transport Agency, Ministry of Transport, TDF user(s), local councils)	• **Introduce enabling regulation** • **Scheme accreditation and launch** – Subject to the outcome of consultation

This economic research, and option evaluation summarised previously, indicate that introducing a mandatory product stewardship scheme is an attractive intervention path. Nevertheless additional, non-economic factors should also be considered in deciding on an intervention strategy.

KPMG recommends that in Phase 1, MFE gathers further evidence on non-economic barriers and the technical feasibility of large-scale end uses, such as rubber in roads, TDF and material recovery. In parallel we suggest the continued development of a mandatory product stewardship scheme, given the supporting evidence gained to date following the Tyrewise project and our analysis.

The key elements of Phase 2 recommendations include the introduction of enabling regulation, and the accreditation and launch of the chosen scheme. Phase 2 development involves stakeholder engagement and public consultation on the scheme design. It should also aim to gain formal support from key government and industry participants, potentially in the form of Memorandums of Understanding (MoUs).

If mandatory product stewardship is considered valuable after consultation, different aspects of this option may be introduced gradually over time. In particular, a landfill ban may be phased in over time as production capacity and demand for new end-uses increases.

In summary, MFE should undertake the following immediate actions in moving towards a potential new market model:

Immediate actions (Phase 1)

- **Complete due diligence** of non-economic barriers. Specific actions may include the following:
  - Complete New Zealand trials of rubber in road and TDF technologies used overseas
  - Work with selected councils to assess the operational feasibility of using transfer stations as waste tyre collection sites
  - Co-sponsor (with industry) further R&D into the marketability of material recovery products, for example refined/blended oils from pyrolysis
  - Work with selected councils to develop the requirements of enhanced monitoring and enforcement of illegal disposal and stockpiling.
- **Update the investment criteria for Waste Minimisation Fund applications to prioritise the following initiatives, noting that funded projects will need to meet the WMF's sustainability and financial return criteria:**
  - Development of enablers identified in this study, in particular:
    - Investing in scalable new manufacturing options (end uses)
    - Expanding waste tyre collection nationwide
    - Increasing utilisation of existing processing capacity and establishing capacity in the South Island.
  - Specific due diligence activities set out above.
- **Commission work to progress the recommended options**
  - Consider the priority product consultation responses and wider policy direction on waste minimisation
  - Complete policy analysis and regulatory impact assessment of the shortlisted intervention options
  - Complete work on product stewardship scheme design, subject to the above
  - Update the cost-benefit analysis based on the scheme design and due diligence activities.

Finally, we recommend that MFE undertakes further consultation and secures stakeholder support before implementing Phase 2.

Consultation ahead of Phase 2

- **Follow the requisite regulatory process ahead of intervention:**
  - Consult with the public on intervention options
  - Seek ministerial and cabinet approvals as required.
- **Additionally, gain formal support from key stakeholders**, for example through non-binding MoUs:
  - The MoUs may offer in-principle support for the proposed model, scheme objectives, roles of stakeholders, and commercial and operating models
  - Key stakeholders may include NZTA and Ministry of Transport regarding the use of rubber in road, Golden Bay Cement (or other industrial user) regarding the use of TDF, and key local consenting authorities.
- **Commence preparatory work on scheme accreditation**
  - For instance, develop application process, information requirements and due diligence approach.

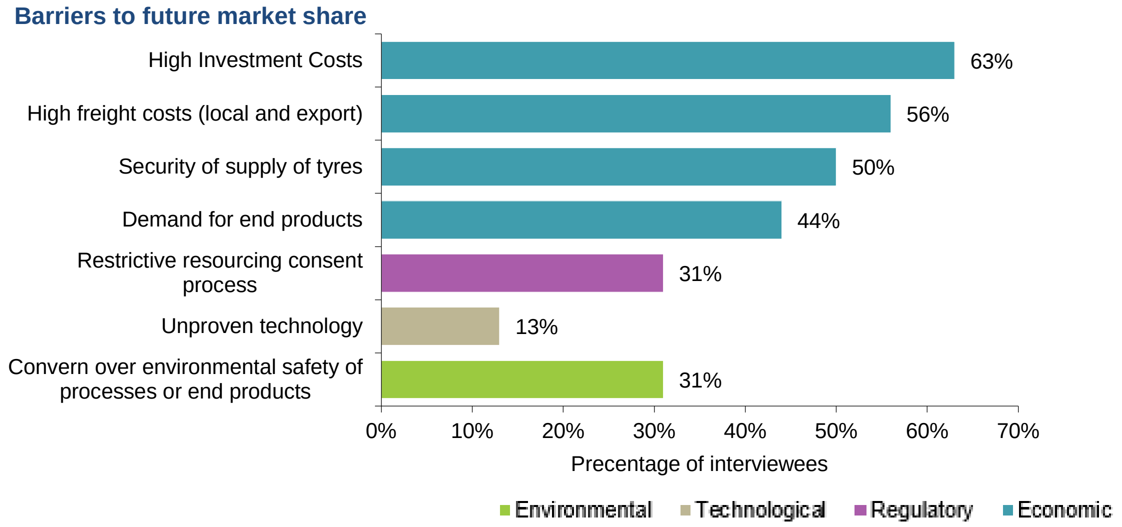
A Appendix A: Market feedback

A broad range of stakeholders across the value chain were interviewed to identify the barriers to investment in the current market. They were also asked to suggest potential government interventions to facilitate investment in waste tyre processing. Interviewees are listed in the table below. Views and information from interviewees were generally made available to us on the basis that they are aggregated and anonymised, therefore we have not attributed specific data and perspectives to interview sources.

Business / Organisation	Person interviewed
Blended Fuel Solutions	Leigh Ramsay and Simon Arnold
Bridgestone New Zealand	John Staples
Entyre	Reiner Wenzel and Elyse Taylor
Fulton Hogan	Peter de Goldi and Bryan Pidwerbesky
Golden Bay Cement	Danny Burke
Goodyear Dunlop Tyres (NZ)	Bill Prebble
Imported Motor Vehicle Industry Association	David Vinsen
J & J Laughtons	Jim and Janine Laughton
Resource Recovery Auckland	Roger Luo
Matta Products	Pauline Harris
Motor Industry Association of NZ	David Crawford
Numat	Mike Judd
Pacific Rubber	Stuart Monteith, Nick Hanson
Rubber Solutions Asia Pacific	Steve Matthews and Andrew Melbourne
Sustainable Equities Ltd	Alan Merrie, Angela Merrie, Steve Hawkins, Alan Copsey
Timaru District Council	Ruth Clarke
Tyre Removals	Rod and Dianna Lovegrove
Tyreless Corporation	Neil Mitchell
Waste Transformation	Mike Henare

A.1 Investment barriers

The graph below outlines the barriers to investment identified by interviewees and the percentage of organisations who identified each barrier. The barriers were categorised as economic, regulatory, technological or environmental.



Economic barriers

High investment costs

Significant capital outlay for plant and equipment was the barrier most frequently noted by interviewees (63%). Specialised equipment is required for processing and manufacturing products from waste tyres and if plant and equipment is procured overseas it often requires modification to meet New Zealand resource consent, environmental and health and safety requirements. Establishment of a pyrolysis plant can require investment of between $1 million for a small scale operation, and up to $12 million for a large scale plant.

Risks associated with return on investment are driven by a number of other barriers outlined below, including security of supply of waste tyres, demand for end products and unproven technology. Some interviewees also highlighted that until Government's decision on the nature of intervention in the waste tyre market is known it is unlikely that they will invest heavily in new plant and equipment.

High freight costs (local and export)

Freight costs, for collection of waste tyres, processed products and manufactured end-products are a key driver of cost and were emphasised as a barrier. In interviews, it was reported that freight costs range between $75 per tonne and $250 per tonne on typical routes within New Zealand. Freight costs are less of a concern for businesses that collect, transport, process, manufacture and transport end-products locally. However it is of particular concern for companies that operate regionally, nationally or export end-products.

Security of supply of waste tyres

Security of supply of waste tyres was identified as a barrier to further development of the waste tyre market by 50% of interviewees. Collectors highlighted that collection of waste tyres is a competitive market, where fees typically range $1.50 to $2.20 per EPU. Collectors involved in recycling stated that it is challenging to compete on price with collectors who send waste tyres to local landfill or export baled tyres at lower costs. Challenges in securing a consistent supply of waste tyres has two main implications:

- Higher throughput of waste tyres through processing and manufacturing plants drives economies of scale and allows businesses to drive efficiencies in production. Intermittent supply results in sub-par performance, low asset utilisation and increased production costs.
- Demand for waste tyres is driven by the market for end-products and some of those interviewed indicated that it can be challenging to sign supply contracts with customers if supply of waste tyres cannot be guaranteed.

Demand for end-products

Limited local demand for end-products of recycled waste tyres is a barrier to companies considering entering, or expanding operations. Interviewees cited a number of reasons for limited demand including:

- Insufficient cost advantage of recycled products to compete with non-recycled products that are perceived by consumers to be of higher quality.
- Lack of large-scale users of recycled rubber. In particular New Zealand has no local users of TDF and rubber for roads. Interviews suggested rubber for roading applications is suitable for only 5-8% of New Zealand roads given current road specifications. This is discussed further in section 4.2.
- New technologies, such as pyrolysis, are not well understood by the public who are concerned about the safety and performance of waste tyre products.

"Recycled products are undervalued"

"There is a perception that recycled products should be cheap"

"Transport costs are prohibitive both for raw and processed materials"

"The collectors who charge $1.50 per tyre are destroying the market"

Regulatory barriers

It was noted in interviews that resource consent processes vary by region in New Zealand. In some regions, the process is time consuming and expensive. Interviewees felt that this was driven by slow internal processes, lack of understanding of the underlying technology and lack of understanding of the environmental and health and safety risks. The time and cost involved, along with uncertainty whether consent will be granted is seen as a barrier to entry.

Once resource consent has been granted the terms of consent also vary by region. The terms can have a significant impact on operating costs, e.g. in some regions stockpiles of waste tyres must be kept under cover and away from the public's view which increases storage costs.

Technological barriers

Unproven technology and lack of local engineering and scientific expertise, particularly on a large industrial scale, was identified as a barrier to investment by 13% of interviewees. This relates specifically to technology which is not yet well established in New Zealand, such as pyrolysis and devulcanisation. Interviewees highlighted that while the underlying technology used in pyrolysis and devulcanisation is in operation overseas, the technology is yet to be proven at scale in a New Zealand regulatory and commercial context.

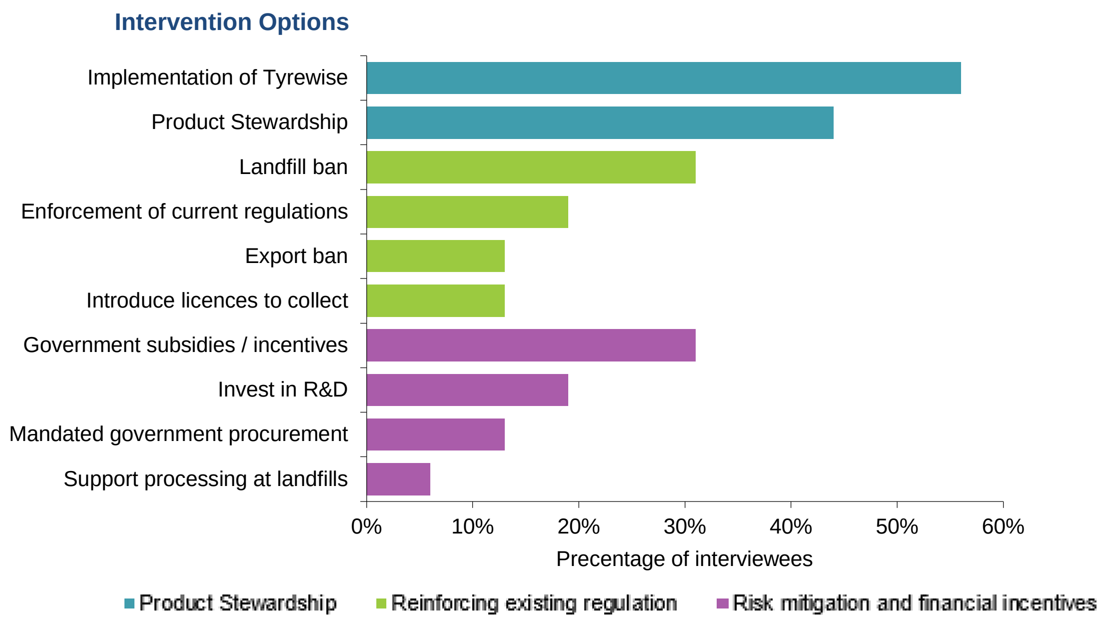
Environmental barriers

Concern over environmental and health and safety risks of production processes of end-products was identified as a barrier to investment by 31% of interviewees. Concerns included emissions, air quality, and health and safety for workers and the general public. In particular interviewees cited environmental and health and safety barriers in relation to using TDF (e.g. due to air quality concerns by the public) and pyrolysis (e.g. due to the safety of dealing with volatile, flammable end-products).

A.2 Intervention options

Interviewees offered suggestions on intervention options that government could implement to facilitate the development of waste tyre recycling.

The graph below presents the intervention options outlined by organisations interviewed and the percentage of organisations who identified each intervention option. Interviewees had the opportunity to identify more than one intervention option.



Product stewardship

<u>Implementation of Tyrewise</u>

Of those interviewed, 56% expressed support for the implementation of the Tyrewise proposals. The benefits of the Tyrewise model were discussed including driving incentives to increase recycling of waste tyres, distribution of the collection fee to the appropriate parts of the value chain and coordination of the development of the waste tyre market.

Interviewees who did not fully support the Tyrewise model cited that the proposed levy is too high and may inhibit the market. Others supported a ‘free market’ approach aided by better enforcement of existing export controls and a landfill ban.

Introduce product stewardship

Product stewardship as a concept of sharing responsibility of the environmental effects of waste tyres, albeit not specific to Tyrewise, was suggested as an intervention by 19% of interviewees. It was highlighted that one of the key problems in the current market is that retailers charge purchasers of new tyres about $5 per EPU, however they only pay between $1.50 and $2.20 per EPU to dispose of tyres. It is unknown how the surplus is used, but it is known that it is not used to support recycling of waste tyres. The supporters of a product stewardship system believe that it will direct money collected for the purposes of recycling towards those intended outcomes.

> *"Plenty of people in the market will take a free ride, so declaration of waste tyres as priority product is preferred"*
>
> *"We are committed to the Tyrewise model and frustrated that it hasn't been already implemented."*

Introduction of new regulation or reinforcement of existing regulation

Landfill ban

A landfill ban was favoured by 31% of interviewees who expected that a landfill ban would increase the security of waste tyre supply and redirect those tyres towards recycling.

We understand that a national landfill ban would require new regulation under the Waste Minimisation Act, however bans to individual landfills can be initiated through local authority bylaw or by private owner decisions. Further, disincentives for disposing of waste tyres in landfills can also be implemented under existing legislation, by extending the application of the existing waste disposal levy.

Enforcement of current regulations to reduce illegal dumping

Several interviewees (19% of all respondents) highlighted that better enforcement of current regulations would reduce illegal dumping and increase the supply of waste tyres for recyclers. However, interviewees were also conscious of the cost and potentially limited effectiveness of 'policing' the ban on illegal dumping.

International experience points to some successes, for example addressing fly-tipping as part of an overall litter minimisation effort across multiple waste-streams (e.g. in the UK) and campaigns targeted at tyre retailers in order to dispose tyres through reputable, accredited collectors (e.g. in Australia).

Export ban

A complete ban on the export of waste tyres, both whole and processed, was identified as an intervention option by 13% of interviewees. This was considered by interviewees to be in line with the Basel Convention which New Zealand ratified in 1994, imposing control of the export of hazardous waste and minimisation of the movement and generation of hazardous waste. However, we understand that an export ban can only be applied to countries which have officially declared end-of-life tyres as hazardous waste under the rules of the Basel Convention.

Those who identified this option considered that this would:

- Improve the supply of waste tyres, as collectors/transporters who currently export would supply waste tyres within the New Zealand market.

- Incentivise the adoption of new uses of waste tyres since one channel for end use would be removed.
- Increase environmental benefits globally as it is thought that many of the waste tyres exported are currently burned for fuel, perhaps in systems which are not environmentally safe.

However interviewees cautioned that an export ban in isolation may lead to increased illegal dumping. Therefore it was suggested that an export ban is more effective in conjunction with other measures.

Introduce licenses to collect waste tyres

An intervention option of licencing collectors was suggested by 13% of interviewees. Interviewees indicated that the expected benefits from this option include a mechanism of controlling and auditing the end use of waste tyres. For example, the licencing model could include payment at the point of recycling of waste tyres, rather than at the point of collection. This would drive behaviours to increase recycling of waste tyres. Limits could be imposed on collection tonnage to stimulate competition in the market.

> *"Landfill owners are not concerned with tyres entering the landfill"*

Risk mitigation and financial incentives

Government subsidies/incentives

Due to the significant capital requirement for plant and equipment to enter the waste tyre market, coupled with technological risks, 31% of interviewees stated that there is an opportunity for government to provide financial assistance. Interviewees suggested a number of different mechanisms for this support including:

- *Co-investment:* where government would provide investment to be matched, or exceeded by the private sector.
- *Low interest loans:* these would drive activity by reducing investment risk and market entry costs.
- *Grants:* interviewees suggested the process for applying for existing grants is streamlined.

Invest in R&D

Government sponsorship of feasibility studies into new technologies, such as tyre derived fuel, pyrolysis and rubber in roads, was suggested by 19% of interviewees.

The benefits interviewees seek include improving the understanding of the public and consenting authorities about the environmental safety of waste tyre recycling. Increased evidence base of the technical and commercial feasibility would also reduce investment risks and support funding.

As an example of one such study we understand that a literature review commissioned by NZTA is currently underway regarding the use of rubber in roads to inform policies and potential future investment in trials and commercial applications.

Mandated procurement by government of recycled waste tyre products

Interviewees have also advanced the view that government should facilitate the use of recycled rubber through its procurement policies, particularly for rubber in roads, as is done in Australia.

New Zealand processors supply rubber to Australian roading companies, however there is no New Zealand market for this product. Some interviewees suggested that off-take agreements or mandated use of rubber in roads would mitigate the investment risk and establish the on-shore recycling of waste tyres at scale. However, other interviewees pointed to the technical and operational challenges (e.g. with recycling rubber based aggregate) that are discussed earlier in this report.

Support processing at landfills

Establishment of processing at landfills was mentioned as an option by interviewees. This would seek to lower transport costs by processing waste tyres closer to the point of collection. However, it was recognised that significant additional investment would be required to change the current configuration of landfills to facilitate processing on site.

> *"Until we fully understand the costs of developing a commercial scale pyrolysis plant safely, we won't commit to investment"*
>
> *"Co-investment by government would allow us to begin to deal with the waste tyre problem much sooner than on our own"*

B Appendix B: Market data and basis of preparation

B.1 Tyre import and export data

The following table summarises the volume and weight of tyres imported to New Zealand as loose tyres (new and used), and imported on vehicles, based on Statistics New Zealand data.

Importation of tyres to New Zealand						
	2010	2011	2012	2013	2014	CAGR 2010-14
Quantity (millions)						
New tyres	3.5	3.7	3.7	3.8	4.0	4%
Used tyres	0.4	0.3	0.2	0.2	0.2	-13%
On vehicles	0.9	0.9	0.9	1.0	1.4	13%
Total quantity	4.7	4.9	4.8	5.0	5.6	4%
Tonnes (000s)						
New tyres	64.7	63.1	59.2	58.8	63.9	0%
Used tyres	3.0	2.3	2.0	2.2	1.9	-11%
On vehicles	1.7	1.9	2.0	2.2	3.0	15%
Total w eight	69.5	67.2	63.2	63.2	68.8	0%

The following information includes export volumes of processed waste tyres and whole used tyres based on Statistics New Zealand and Customs data respectively. Data for processed tyres includes waste rubber, pairings, scrap rubber, and powders and granules (code 4004). These figures exclude exports under $1,000 which are not captured by Statistics New Zealand. Whole used tyre exports are based on information from the CusMod database of the New Zealand Custom Service.

Waste tyre exports by destination, 2014			
Tonnes	Processed	Whole	Total
Australia	521	1	522
Indonesia	588	-	588
Vietnam	-	533	533
Malaysia	2,499	62	2,561
Pakistan	2,615	-	2,615
Fiji	-	135	135
Other	125	154	279
Total exports	**6,348**	**885**	**7,233**

B.2 Basis of preparation for cost analysis

The input data points for cost and revenue used in this report were collected from stakeholder interviews, publicly available information and KPMG market data.

The following assumptions were used in the preparation of indicative costs and revenue:

- Upfront costs were annualised based on the depreciation and cost of capital associated with plant and equipment.
- Cost of capital was assumed at 10% based on interviews.
- Capital costs for equipment were generally provided in US dollars and are subject to exchange rate fluctuations.

- Depreciation of equipment was calculated based on the expected economic life of the piece of equipment; the economic life ranged from 5 to 10 years.
- Unit production costs were estimated based on assumed utilisation of equipment and cross checked with top-down estimates provided in interviews and secondary research.

B.3 Basis of preparation for waste tyres market volumes

This report has used the same categories of tyres which were used in the Tyrewise Scoping Report 1: Investigation into the collection and disposal of used tyres in New Zealand and internationally (Tyrewise Scoping Report 1). Those categories of tyres that are in use in New Zealand can be defined as:

1 Motorbike
2 Passenger
3 Light and Medium commercials
4 Truck and Bus
5 Industrial
6 Tractor
7 Off Road
8 Aircraft
9 Trailers.

Tyre volume calculation

We have used the same assumptions to calculate the number of tyres entering New Zealand via imported vehicles (new and used) as the Tyrewise scoping report 1. The assumptions made are:

- Five tyres for Car, UTE, Motorhomes and Ambulances (given most have a spare)
- Two tyres per motorbike
- Three tyres per trailer
- Four tyres per tractor.

For large commercial vehicles, 2011 registration data was analysed by Tyrewise by gross weight category and percentage proportions calculated. An assumption for each weight category was made as to the number of tyres. For example, 89% of commercial vehicles registered in 2011 had a gross weight less than 1500 kilograms, so were assumed to have five tyres. Five-percent of commercial vehicles registered in 2011 had a gross weight of more than 20,000 kilograms and were assumed to have an average to the total number of percentages and corresponding tyre numbers were applied to the total number of Van/Truck/Bus that were imported each year to estimate the tyres entering New Zealand via these imported vehicles

Sources of tyres entering New Zealand

The data used to report on tyre volumes was obtained from the Statistics New Zealand Info-Share database in November 2014. The database provides data on new and used vehicles and the quantity of loose pneumatic (new and used) tyre imports. Note: Re-treaded tyres imported have been assumed to be used tyres and therefore included in the used tyre category.

Excluded from the data are unassembled motor vehicles, aircraft gliders or helicopters were also not included as we could not determine whether or not these imports included tyres. Also excluded were vehicles for off highway use such as dumpers for the transport of goods.

Data was collected on new and used loose tyres and on vehicles entering the country, a number of tyres were assigned to the vehicle based on the description provided by Statistics New Zealand using the tyre calculation on the previous page.

The data on new tyre imports includes new tyres suitable for: cars, tractors, motorbikes, aircraft, earthmovers, forklifts (solid industrial tyres).

The data for used tyre imports includes new tyres suitable for: cars, bus and truck, aircraft and other vehicles (not cars, truck, bus, aircraft, or light commercial).

The vehicle import data include: cars, utility vehicles, motorhomes and ambulances, trucks, buses and vans, motorcycles and tractors.

C Appendix C: Detailed evaluation of the short-list of options

The scores of the short-list options, by criteria, are detailed as follows.

1 Ability to address investment barriers

Option A	Aims to drive scale in collection and processing, but has limited impact on investment funding or on-shore demand for end-use products	Low(1)
Option B	Addresses all three investment barriers: drives scale by redirecting tyres from landfills and illegal disposal, and exports	High (3)
Option C	Increases funding by eliminating low cost disposal options, incentivises investment in end-markets through stability of supply, and builds alternative local market to hedge volatile export demand	Highest (4)

2 Ability to deliver environmental and economic outcomes

Option A	Facilitates reduction of landfilling, however limited by the scope of current legislation	Low (1)
Option B	Has more leverage through regulation to drive recovery, scale and investment	High (3)
Option C	As per Option B; additionally, more likely to reduce illegal dumping by offering incentives to collectors, and requiring no direct payment from generators	Highest (4)

3 Affordability

Option A	The lowest cost option vs B and C according to the cost benefit analysis	Highest (4)
Option B	Additional regulatory cost – incurred by government	Med (2)
Option C	Highest overhead, however incurred in part by industry participants	Med (2)

4 Alignment with existing policies

Option A	All options build on existing environmental and economic policies	High (3)
Option B		
Option C		

5 Achievability

Option A, B, C	Each option has implementation challenges, e.g. Option A): cost-effectively increasing the efficiency of enforcement, e.g. by pooling enforcement activities and investment across several waste streams; Options B) and C): risk of increased illegal dumping/exports if landfill ban is not matched with increased collection and processing capacity	Med (2)

6 Equity

Option A, B, C	No particular issues with equity and fairness; risks appear manageable	High (3)

7 Value for money

Option A, B, C	No material difference in the NPV of the options. NPVs are relatively low but positive.	Med (2)