PEARL GLOBAL'S PROCESS AND PRODUCTS

Environmental, Social and Economic Benefits Assessment

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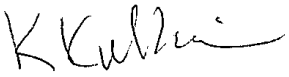
Kapil Kulkarni		23 August 2022

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EXECUTIVE SUMMARY

Pearl Global is a tyre recycling and circular economy company that also delivers substantial emission reduction benefits.

The sustainability benefits delivered by Pearl Global are broad. The benefits delivered are aligned with some of Australia's biggest sustainability priorities set out in legislation and national strategies, as well as industry's own drive to be more sustainable.

The tyre derived fuel oil (TDFO) and carbon char recovered by Pearl Global's thermal process from used tyres can be used in asphalt production to produce a low-carbon asphalt product.

RPS undertook a triple-bottom-line assessment of benefits associated with the use of Pearl Global products in asphalt production which found that:

- The process is estimated to reduce GHG emissions by ~**23 kgCO_2-e** per tonne of asphalt[1] (a 24% reduction in the embodied emissions of the asphalt produced) or **61,777 tonnes of CO_2-e** per year
- Economic transport benefits associated with avoided fatal accidents and reduced road maintenance are estimated to total **$320 million** in Present Value (PV), or **$73.5 million per year** by 2054
- Pearl has the potential to contribute to Australia's circular economy goals by recycling **~29%** of Australia's waste tyre stream.

In addition to these quantified benefits, the process:

- Avoids environmentally and socially damaging tyre disposal methods like burning tyres abroad or burying them in the ground, which releases hazardous emissions into the atmosphere
- Allows for a lower mix temperature during the production of asphalt
- Eliminates the need to use diesel from virgin fossil fuel sources, which has significantly higher embodied emissions
- Lowers the required amounts of bitumen and lime, both of which have large embodied emissions
- Enhances worker safety and visibility for drivers
- Utilises the partial biomass content of tyres to recover energy and aid in the generation of sustainable energy.

RPS also conducted an Economic Impact Assessment (EIA), which included first and second round economic impacts only and excluding household consumption impacts to be conservative, to measure the flow on impacts associated with the construction and maintenance of additional recycling facilities.

It was estimated that given a capital expense of $108 million during the construction phase:

- overall direct and indirect Gross Value Added (GVA) was projected to reach **$125.4 million** and
- construction would induce **268 direct and indirect jobs per year over 2 years** inclusive of and stemming from construction.

Additionally, given an annual operational expense of $36 million per annum during the operation and maintenance phase, the economic pacts during operation are expected to include:

- overall direct and indirect Gross Value Added (GVA) of **$46.3 million**
- operation would induce **234 direct and indirect jobs**.

[1] With reduced Scope 1 and 3 accounting for 14.4 and 8.2 kgCO_2-e respectively

1 INTRODUCTION

Pearl Global is an Australian tyre processing company that converts end-of-life tyres into energy and high value raw materials. These outputs include tyre derived fuels oil (TDFO), and recyclate products with a variety of applications, most notably the application of carbon char in asphalt.

1.1 End-of-life tyres in Australia

According to Tyre Stewardship Australia, over the past five years Australia has generated on an average annual basis, an estimated 450,000 tonnes of end-of-life tyres[2], equivalent to 56 million equivalent passenger units. Previously in Australia, in 2013-14, only around 5% of end-of-life tyres were recycled locally, with another 32% exported, and the remaining share landfilled, stockpiled, illegally dumped or 'lost'[3].

If end-of-life tyres are not managed properly they can create economic, health and environmental issues. These include taking up valuable landfill space, causing damage to landfill liners or releasing toxics gases and chemicals when burnt.

Since then, there have been significant improvements in the resource recovery sector for tyres. In 2020, the Australian Government, with the support of state and territory governments and the Australian Local Government Association, published legislation titled the *Recycling and Waste Reduction Act 2020*, which regulates the export of waste tyres. In accordance with the act, from December 2021 onwards, the export of waste tyres was banned without possession of a waste export license.

This change is part of a broader commitment by the Australian Government to reduce waste, increase recycling rates and build capacity in Australia's recycling industry. The benefits to the environment will be significant and will help Australia reach its waste-related targets as outlined in the National Waste Action Plan.

Instead of being exported, the resource value contained in tyres, including steel, energy and carbon, can be retained within the economy and avoid the environmental impacts associated with extracting virgin non-renewable resources.

1.2 Objective

Pearl Global is seeking to expand its tyre recycling capacity by constructing new tyre recycling facilities around Australia. Currently, Pearl Global operates one first generation plant in Stapylton QLD, with an estimated capacity of 20 kilotons of tyres per annum when in full operation.

With investment, Pearl Global plans to expand this capacity to include the construction and operation of four new second generation tyre recycling plants located in Sydney, Melbourne, Perth and Adelaide. Each second generation plant is expected to have a capacity of 27.5 kilotons of throughput per annum, significantly increasing the total volume of tyre processing capacity by Pearl Global, from 20 kilotons to 130 kilotons of tyres processed on an annual basis.

1.3 Approach

To identify opportunities for Pearl Global and leverage their strengths, RPS undertook a Policy Alignment and Benefits Assessment analysis. The Policy Alignment will first demonstrate where national, state and industry strategies and priorities lay, and their relevance to Pearl Global's service offering as a key resource recovery company. Secondly the Benefits Assessment provides an evidence base of the triple-bottom line impact Pearl Global can have in achieving circular economy policy targets and measures, as well as the wider economic benefit of expanding tyre recycling capacity around Australia.

[2] Tyre Stewardship Australia, 2018-19 Australia Tyre Consumption and Recovery Rate (2020).

[3] Hyder Consulting, Stocks-and-fate-end-life-tyres 2013-14-study, (2015)

2 POLICY ALIGNMENT

RPS has undertaken a review of public and private policy and strategy relating to recycling, waste and circular economy principles which align with Pearl Global's service offering. Pearl Global's activities strongly align with circular economy objectives, which include maximising the value of resource use while minimising environmental impacts. Encouraging circular approaches has become a crucial issue for Australian federal, state and local governments due to the increased pressure on resources, a tightening of waste export markets, and public concerns about climate change and the state of the environment. Pearl Global's recycling process enables the recirculation of valuable resources within the economy, retaining material value within the country, and adding to economic activity and employment.

2.1 Primary policies

The primary policies and strategies which directly align with Pearl Global and their activities are outlined in the table below.

Table 1 Policy Alignment review, primary policies

Policy / Strategy	Description	Targets. Measures and Actions
National Policy		
National Waste Policy Action Plan[4]	The 2018 National Waste Policy is being implemented through the National Action Plan, which includes targets and actions. These goals and initiatives are meant to direct national efforts and investment through 2030 and beyond. Additionally, it seeks to remove barriers to a circular economy for waste in Australia, assisting businesses and people in realising the full value of recyclable materials and pursuing more resource-efficient practises.	• Banning the export of unprocessed plastic, paper, glass and tyre waste • Phasing out problematic and unnecessary plastics by 2025 • A reduction in total waste generated in Australia by 10% per person by 2030 • An 80% average recovery rate from all waste streams by 2030 • Halving the amount of organic waste sent to landfill by 2030 • A significant increase in the use of recycled content by governments and industry • Making comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions.
Circular Economy Roadmap for plastics, glass, paper and tyres[5]	The Australian Government is informed by this roadmap regarding how Australia's industry and the innovation system are prepared to create opportunities for waste innovation and a circular economy for plastics, glass, paper, and tyres throughout their supply chains. For each waste item, the roadmap outlines prospects for a circular economy along the material supply chain. Opportunities for avoidance, substitution, and good design are emphasised, as these are essential for a circular economy. It lays out a circular economy strategy that is integrated and attempts to meet Australia's social, economic, and environmental needs.	It presents five linked actionable strategies aimed at: • Improving product design, collection and sorting outcomes to retain the quality and value of materials and prevent material loss • Building capacity for reprocessing and manufacturing of recycled products nationally aimed at increasing the ability to create wealth from waste domestically • Encouraging and facilitating market development to grow the circular economy including boosting market demand for recycled products and products that contain recycled content

[4] Australian Government, State and Territory Governments & Australian Local Government Association, National Waste Policy Action Plan, 2019

[5] CSIRO, Circular Economy Roadmap for Plastics, Glass, Paper and Tyres,, 2021

		• Harmonising standards, regulations and messaging across jurisdictions to provide consistency in governance and create sustainable materials management capability in Australia • Facilitating systemic change from linear to circular material supply chains that foster sustainable consumption and production.
Recycling and Clean Energy National Manufacturing Priority Roadmap[6]	The Recycling & Clean Energy road map will help inform investment decisions that both Government and industry make over the next 10 years. The goal of the road map is to create businesses that capitalise on opportunities presented by clean energy transition, sustainability, and the global movement towards increased resource efficiency and waste reduction. It is built on utilising Australia's strengths in innovation, renewable and mineral resources, leadership in technology adoption, and enhancing the current industrial base's strengths. With the use of this road map, Australia will be introduced to new manufacturing sectors for recycling and sustainable energy.	To measure progress against the vision set out in the road map, the following will be monitored over 2, 5 and 10 year periods: • Number of new jobs • Increase in profitability • Growth in recycling & clean energy exports • Increase in the number of new products brought to market • Investment in the recycling and clean energy sector • Increase in adoption of recycling or clean energy in manufacturing processes • Increase in economic output per unit of material consumed (material productivity) • Reduced loss of materials from circulation in the economy Benchmarks for success will relate to the priority area's touch points with adjacent government policies. These include: • Achieving actions and targets for recycling and waste reduction under the National Waste Action Plan • Achieving economic stretch goals for priority low emissions technologies under the Technology Investment Roadmap • Helping businesses and communities capture the benefits and opportunities of low emissions technologies and commodities under Australia's Long Term Emissions Reduction Strategy.
State Policy		
NSW Waste and Sustainable Materials Strategy 2041[7]	Aims to transform how the NSW economy produces, consumes, and recycles goods and resources in order to reduce waste. With activities to be performed over the next six years aimed at achieving long-term goals, it lays forth a vision for the transition to a circular economy over the following 20 years.	The strategy includes actions under three focus areas: • Providing for future infrastructure and service requirements as waste volumes continue to increase and encouraging investment in innovation • Reducing carbon emissions through better waste and materials management as NSW transitions to a circular economy

[6] Australian Government, Recycling and Clean Energy National Manufacturing Priority road map, 2021

[7] NSW Department of Planning, Industry and Environment, NSW Waste and Sustainable Materials Strategy 2041, 2021

		• Continuing efforts to prevent waste pollution, such as littering, illegal dumping, and improper handling of hazardous wastes, by maintaining strict regulations and working with businesses and consumers to modify behaviour. • The strategy identified that significant new processing capacity is required for high level tyre recycling infrastructure to meet demand by 2030.
NSW Energy from Waste Infrastructure Plan[8]	This Infrastructure Plan serves as a strategic planning tool for future energy-from-waste plants, ensuring that the infrastructure is situated to best meet the state's waste management demands through the year 2041 and to maximise waste innovation, management, and energy recovery efficiencies.	'**Must**' outcomes identified include: • Increase community and industry confidence regarding appropriate sites and facilities • Follow the precautionary principle in locations where there is a higher risk of harm to human health due to proximity to densely populated areas (both now and in the future) and in regions where air quality criteria are routinely exceeded by existing sources. • Maximise efficiencies in infrastructure, waste management, innovation and energy recovery
Victorian Waste Resource Recovery Strategy 2030[9]	The strategy's overarching objective is to create a waste and resource recovery system that is both economical and environmentally responsible. The waste hierarchy and the circular economy are the foundations of the plan.	Key outcomes and targets of the Waste and Resource Recovery Strategy include: • 90% of waste diverted from landfill • 1.2Mt CO_2-e in greenhouse gas emissions avoided • 20% reduction in household waste produced • More efficient use of resources • Producing less waste • More effective recycling separation systems • Cities with high amenity • Food and green waste recovered • Resilient recycling sector • Waste to landfill minimised.
Recycling Victoria 2020: A new economy[10]	Recycling Victoria is the Victorian Government's 10-year policy and action plan for waste and recycling. It outlines reform to establish a circular economy based recycling system with reform to kerbside recycling, the introduction of a container deposit scheme, new investment in industry and the creation of waste management as an essential service.	Key actions included in the plan are: • A new four-stream waste and recycling system for all households across the state for better and more recycling and less waste • A cash for cans scheme that rewards return of used drink cans, cartons and bottles for recycling, and reduces litter • A stronger waste and recycling industry with new infrastructure and innovative waste management

[8] NSW Environmental Protection Agency, Energy from Waste Infrastructure Plan, 2021

[9] City of Melbourne, Waste and Resource Recovery Strategy 2030

[10] Victorian Department of Environment, Land, Water and Planning, Recycling Victoria: A new economy, 2020

		solutions for better and more recycling and reuse, and less waste • New recycling laws and governance to support best practice waste management, resource use and recycling • A statewide ban of single-use plastics and promotion of reusable items that reduce waste and pollution for a cleaner and healthier environment.
Statewide Waste and Resource Recovery Infrastructure Plan[11]	Victoria's waste and recycling infrastructure will be improved over the course of 30 years according to the Statewide Waste and Resource Recovery Infrastructure Plan. The goal of the plan is to establish an integrated waste and recycling system that maximises the potential for recycling and the use of recovered materials, decreases the demand for raw materials, and reduces the amount of waste sent to landfills.	Identifies 4 clear goals to achieve within 30 years. 1. Landfills will only be for receiving and treating waste streams from which all materials that can be viably recovered have been extracted. 2. Materials are made available to the resource recovery market through aggregation and consolidation of volumes to create viability in recovering valuable resources from waste. 3. Waste and resource recovery facilities including landfills are established and managed over their lifetime to provide best economic, community, environment and public health outcomes 4. Targeted information provides the evidence base to inform integrated state wide waste and resource recovery infrastructure planning and investment. Also: • Tyres are included as a priority material for recovery. • Identifies opportunities to investigate the use of recovered tyre materials, build end markets and investigate local WtE opportunities using TDFO. • Managing and recovering tyres is prioritised as they pose a risk to the community when stored (whole tyres are banned from landfill). • Gippsland and Grampians Central West are identified as requiring additional capacity within 1-5 years to meet needs.
Industry Policy		
Tyre Product Stewardship Scheme Strategic Plan 2020-2023[12]	The Tyre Stewardship Scheme offers an ACCC-approved, industry framework for efficiently reducing the effects of end-of-life tyres in Australia on the environment, human health, and safety. The Strategic Plan intends to promote circular economy concepts within the industry by raising awareness, facilitating the commercialisation of	The effectiveness of the Scheme in achieving its objectives is to be measured as follows, by reference to the following aspirational targets: • Tyre importers contributing to 80% of market share, measured by sales of new tyres applicable to the Scheme levy)

[11] Sustainability Victoria, Statewide Waste and Resoure Recovery Infrastructure Plan, 2018

[12] Tyre Stewardship Australia, Strategic Plan 2020-2023, 2020

	better opportunities afforded by end-of-life tyres, offering accreditation, and stimulating innovation.	• Vehicle manufacturers / importers participating to 75% of market share, measured by total new vehicle sales) • Tyre retailers participating to 75% of market share, measured as market share of passenger tyre sales by retailers) • Tyre recyclers participating to 85% of market share, measured as market share of available EOLT for recycling – excluding the recovery and export of whole tyres) • The destination of all Australian end of life tyres is known
Boral Asphalt Environmental Product Declaration[13]	This asphalt EPD includes the range of typical Boral asphalt products that adhere to criteria set by governing bodies and frequently contain reclaimed asphalt. Innovative substitutes are also used, such as Boral Asphalt INNOVO, a system of product that accepts a variety of recycled materials, including plastic, slag, rubber, toner, and glass.	• Overarching goal is a Zero Harm Today policy. Minimise injuries and eliminates adverse environmental impacts. Achieved via: • Reducing greenhouse gas emissions from processes, operations and facilities • Reducing waste in all forms including through the use of efficient use of energy, conservation of water, minimising and recycling waste materials and energy, prevention of pollution, and effective use of virgin and recovered resources and supplemental materials. • Protecting biodiversity at and around facilities • Openly and constructively engaging with communities surrounding operations.
Downer Group[14]	Downer Group has set science based targets to reduce their Scope 1 and 2 emission intensity, as well as total Scope 1 and 2 emissions. The company also included setting a target for Scope 3 emissions by FY22 in its strategy.	Targets include: • Reduction in absolute Scope 1 and 2 GHG emissions by 45-50 per cent by 2035 from a FY18 base yea • Pledging to be net zero by 2050.
Fulton Hogan[15]	Fulton Hogan's sustainability strategy includes people, planet and prosperity. The planet component of this strategy is focused on carbon emission reductions.	Targets include: • 30% emission reduction by 2030 (off a 2021 baseline) • Net Zero Carbon by 2050

[13] Boral, Boral Asphalt Environmental Product Declaration, 2021

[14] https://sustainability.downergroup.com/2021/environment-decarbonisation.html

[15] https://www.fultonhogan.com/our-story/sustainable-future/

2.2 Other policies

A number of other policies and strategies were also identified which, whilst not directly related to Pearl Global's Activities, reflects government initiatives to focus on the waste and recycling sector.

Table 2 Policy Alignment review, other policies

Policy / Strategy	Description	Targets. Measures and Actions
	State Policy	
NSW Waste Less, Recycle More[16]	Initiative providing grants and funding for waste and recycling projects. The initiative is funded through the waste levy and was the largest waste and recycling funding program in Australia. The initiative was extended until June 2022, with no further announcement yet on future extension.	• The initiative has invested $802.7 million in waste and recycling projects since 2012, to a total of 2,976 projects. • The program is accompanied by an Education Action Plan which outlines strategic directions to: • Develop and use consistent messaging • Integrate education • Build capacity • Promote excellence • Provide resources and tools • Work with and support stakeholders.
NSW Net Zero Plan 2020 – 2030[17]	The plan aims sets out how NSW will halve its carbon emissions by 2030 on the way to net zero emissions by 2050. A number of initiatives focusing on energy, hydrogen, electric cars, primary industries, technology, the built environment, carbon financing, and organic waste will be supported under the plan.	• Achieve the State's objective to deliver a 50% cut in emissions by 2030 compared to 2005 levels. • As part of the plan, the NSW Government committed to setting a target of net zero emissions from waste to landfill by 2030.
NSW Illegal Dumping Strategy 2017–21[18]	The policy concentrates on all types of illegal dumping and offenders, but particularly where problematic waste is involved, such as asbestos, construction and demolition, household, green, and used tyres.	The strategy outlines 6 approaches and 36 corresponding actions. • Building an evidence base • Stakeholder engagement and capacity building • Education and awareness • Prevention, infrastructure and clean up • Regulation and enforcement • Evaluation and monitoring.
Victorian Market Development Strategy for Recovered Resources[19]	A fundamental objective of implementing the Statewide Waste and Resource Recovery Infrastructure Plan was the introduction of the Victorian Market Development Strategy for Recovered Resources in 2016.	Identifies key statewide priority materials for attention including: • organics (including timber) • rubber (tyres) • e-waste

[16] NSW Environmental Protection Agency, Waste Less, Recycle More, 2021

[17] NSW Department of Planning, Industry and Environment, Net Zero Plan 2020-2030, 2021

[18] NSW Environmental Protection Agency, Illegal Dumping Strategy 2017-21, 2017

[19] Sustainability Victoria, Victorian Market Development Strategy for Recovered Resources, 2016

	The Strategy provides a coordinated strategy for government involvement in market development for recovered resources over the following 30 years, with a review every five years, within the framework of Victoria's integrated waste and resource recovery system.	• flexible plastics • glass fines • concrete and bricks. The Strategy presents government interventions to address supply and demand challenges that aim to: • improve the quality of recovered resources to support manufacturing • improve consolidation and aggregation of recovered • materials to support growth in manufacturing • improve the performance of products incorporating • recovered resources • increase the use of products incorporating recovered resources.
Victorian Waste Education Strategy[20]	The Victorian Waste Education Strategy was released in 2016 as a key priority of delivering the Statewide Waste and Resource Recovery Infrastructure Plan (SWRRIP). The Victorian Waste Education Strategy provides a coordinated, statewide approach to waste and resource recovery education.	Includes goals and outcomes for the framework of the education strategy: • Waste management is seen as an essential service • Reduce Victoria's waste generation rates • Improve resource recovery and reduce contamination of waste streams • Reduce littering and illegal dumping • Waste and resource recovery education initiatives being implemented at schools • Efficient and effective program delivery with partners.
Recycling Industry Strategic Plan[21]	The Recycling Industry Strategic Plan aims to provide a pathway to a resilient and efficient recycling system in Victoria. Although the focus of the Strategic Plan is on kerbside recycling, the actions set out in this plan will benefit the entire recycling sector.	Identifies four goals designed to deal with immediate issues • Stabilise the recycling sector • Increase the quality of recycled materials • Improve the productivity of the recycling sector • Develop markets for recycled materials.

[20] Sustainability Victoria, Victorian Waste Education Strategy, 2016

[21] Victorian Department of Environment, Land, Water and Planning, Recycling Industry Strategic Plan, 2018

3 BENEFITS ASSESSMENT

3.1 Benefits assessed

RPS' undertook a triple-bottom line (environmental, social and economic) assessment of using diesel oil and char from recovered tyres to produce asphalt, based on a scenario where the company completes and expands from its current processing of 20 kt/year of tyres to 130 kt/year through an additional four plants in Sydney, Melbourne, Perth and Adelaide.

RPS assessed benefits through three separate elements of the assessment, which were:

1. GHG Emission Reduction Assessment
2. Monetised Transport Benefits, and;
3. Other quantified and qualified Environmental Benefits

These benefits were assessed through robust methodologies that align with best practice principles for carbon assessments and cost-benefit analysis. The results of these assessments showed that Pearl's processes are expected to deliver the following environmental, social and economic benefits:

Table 3 Triple-bottom-line assessment results summary

Benefit Category	Description
Environmental	In terms of GHG emissions, the process is estimated to reduce emissions by ~**23 kgCO_2-e** per tonne of asphalt (with reduced Scope 1 and 3 accounting for 14.4 and 8.2 kgCO_2-e respectively), which is a 24% reduction in the embodied emissions of the asphalt produced) or **61,777 tonnes CO_2-e** per year (the same as taking about 28,000 cars off the road). Moreover, the use of char and recovered energy is expected to: • Contribute to Australia's circular economy goals by recycling ~29% of Australia's waste tyre stream • Contribute to renewable energy production through energy recovery from the partial biomass content in tyres.
Social	From a social perspective, the use of char recovered energy is expected to: • Improve driver visibility • Improve worker health & safety • Avoidance environmentally and socially harmful tyre disposal pathways, such as landfill, burying tyres underground or exporting them to countries for burning, which causes toxic emissions to pollute the atmosphere.
Economic	This same production would also see safety benefits from avoided road accidents and road maintenance benefits from more durable roads worth **$192 million** and **$128 million** in Present Value (PV) economic terms, estimated by applying standard economic parameter values recommended in Australian transport agency economic assessment guidelines.

3.2 GHG emission reduction

Drive to decarbonise Australian infrastructure

Research funded by the Queensland Government and the Clean Energy Finance Corporation (CEFC) found that infrastructure is directly or indirectly responsible for the lion's share of greenhouse-gas (GHG) emission in Australia, contributing to around 70% of Australia's total emissions.[22]

This is from emissions used to produce the materials or 'embodied' emissions, emissions used to operate the infrastructure, and emissions from the activity that the infrastructure supports (e.g. cars on roads). The research estimated that embodied emissions account for about **34.3 Mt CO_2-e**, or about 8.5% of Australia's total emissions. **Roads** are major contributor to total embodied emissions in infrastructure, making up an estimated **12.4 Mt CO_2-e** (32.7%) of total embodied infrastructure emissions.

[22] ISCA, ClimateWorks and ASBEC, Reshaping Australia's Infrastructure for a net zero emissions future, 2020

Methodology

The carbon assessment was conducted in accordance with The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.[23]

Figure 1 outlines the boundary definition for the GHG assessment.

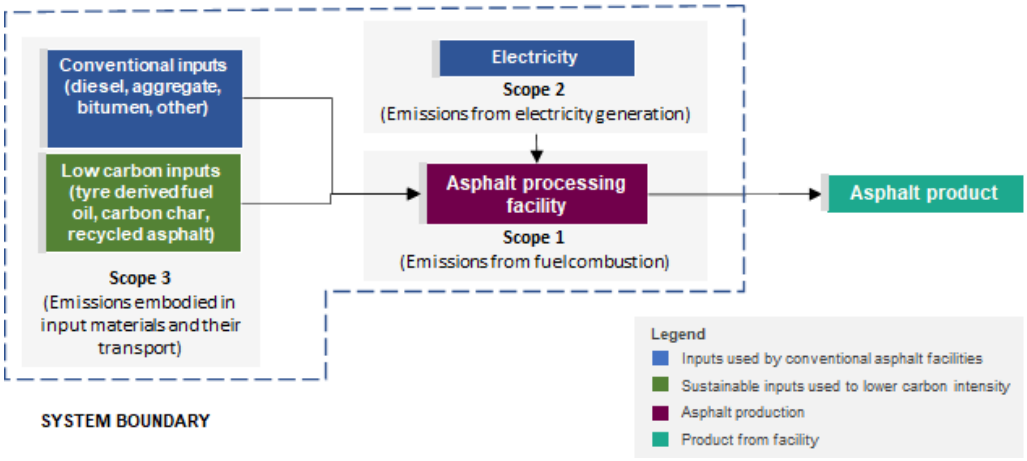

Figure 1 GHG assessment system boundary (asphalt production)

An asphalt plant using TDFO and carbon char is expected to consume lower quantities of lime, bitumen and quarry materials. In doing so, asphalt produced using Pearl Global products avoids the energy, GHG emissions and other environmental impacts from producing virgin material substitutes including diesel, bitumen and aggregate.

Moreover, based on actual production experience, asphalt production using Pearl Global products has enabled a lower mix temperature, saving on the amount of fuel needed in the process.

The assessment completed by RPS estimated the GHG emissions 'With' and 'Without' Pearl's activities. The difference between the With scenario (i.e. the emissions from making the products using Pearl's process) and the Without scenario (i.e. the emissions from making products using a conventional process) represents the emissions saving. The assessment was based on the following equation:

$$GHG\ emissions\ reduced = \sum^{PRODUCTION} EF_{without}Q_{without} - EF_{with}Q_{with}$$

The methodology involved:

- Defining the system boundary (as above)
- Selecting emission sources to be included in the assessment
- Estimating the quantities of inputs and emission factors associated with their use (refer to the next page)
- Calculating total emissions from the sources
- Comparing the total emissions of the asphalt with Pearl's Global's products to the asphalt without Pearl Global's products.

The table below provides the estimated unit emissions ($kgCO_2$-e per tonne of asphalt production) for each input into the Roadmap (using Pearl Products) and the Benchmark (conventional) plant.

[23] World Business Council for Sustainable Development and World Resources Institute, The Greenhouse Gas Protocol, 2015

Table 4 Assumptions for Carbon Assessment (sources below)

Emissions Source	Scope	Roadmap Plant Emission Factor (kg/tonne) [a]	Benchmark Emission Factor (kg/tonne) [a]	Comment
Quarry material - production	3	2.8	2.9	
Quarry material - transport	3	16.5	16.8	
Other material - transport	3	2.1	2.1	
Bitumen - production & trans.	3	25.9	27.5	Bitumen use reduced through the use of additives, plastic and carbon char
Lime	3	9.1	13.0	
Reclaimed Asphalt Pavement	3	0.6	0.6	Greater use of RAP avoids emissions and other environmental impacts
Plastic - binder substitute	3	0.1	0.1	Reduces bitumen use
Glass - sand substitute	3	0.3	0.3	Avoids emissions and other environmental impacts
Char - binder substitute	3	1.1	0.0	
Electricity	2	1.6	1.6	
Diesel combustion (Scope 1)	1	0.0	24.1	
Diesel embodied (Scope 3)	3	0.0	3.5	
TDFO combustion (Scope 1)	1	9.6	0.0	Lower fuel consumption due to higher energy density and warm mix configuration
TDFO embodied (Scope 3)	3	0.3	0.0	Embodied emissions in TDFO much lower than in diesel production

[a] Key sources listed below

Key sources used in the assessment were:

- Al Adday, F. (2019). Study of reducing the environmental impact of CO_2 emissions of flexible pavement materials: a critical review. *International Journal of Development Research*,9(04), 26883-26889
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Emissions benefits from using Pearl Global products in asphalt

The process is estimated to GHG reduce emissions by ~**23 kgCO_2-e per tonne of asphalt**[24] (a 24% reduction in the embodied emissions of the asphalt produced) or **61,777 tonnes of CO_2-e per year**.

[24] with reduced Scope 1 and 3 accounting for 14.4 and 8.2 kgCO_2-e respectively

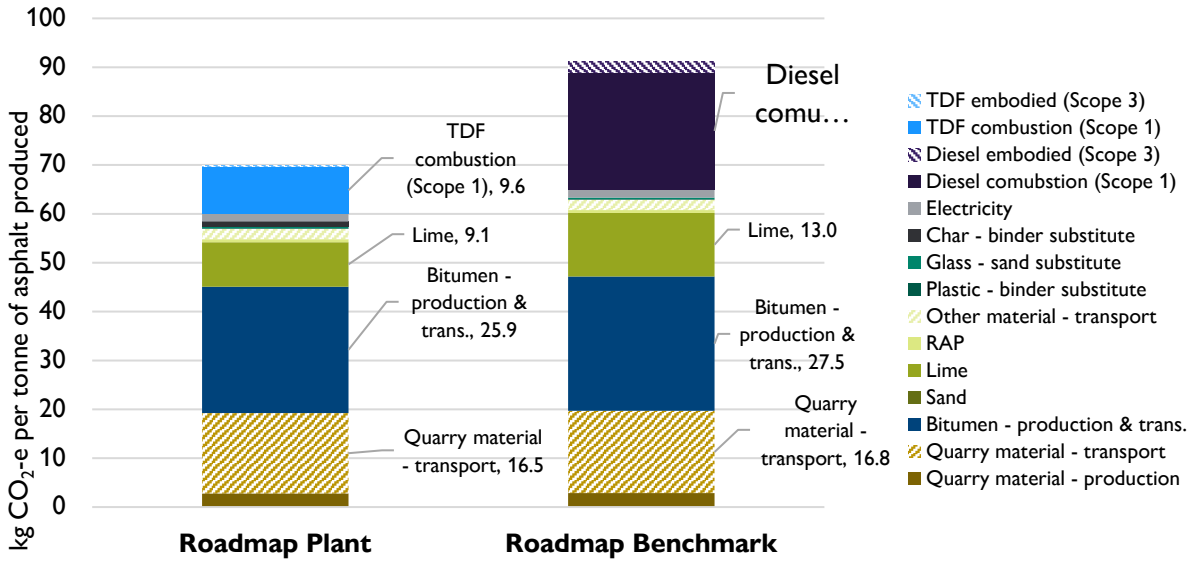

Figure 2 Results of GHG assessment

Full emissions benefits from Pearl Global processes

It should be noted that the above emission reductions are based on the emissions boundary being defined around the asphalt production process. As such, it excludes the other benefits from recycling tyres, including emission reductions from avoiding the:

- Shipping tyres or material made from tyres (e.g. granulated or shredded rubber) overseas
- Direct combustion of tyres
- Recovered the recycled steel and displacing the use of virgin materials in steel production.

Using the same method and assumptions, combined with previous analysis by RPS on the benefits of the Pearl Global recycling process, RPS estimated the full emission reduction benefits derived from using Pearl Global's process to recover material for asphalt and steel production, as well as emissions avoided from conventional tyre disposal pathways.

FIGURE shows the revised emissions boundary.

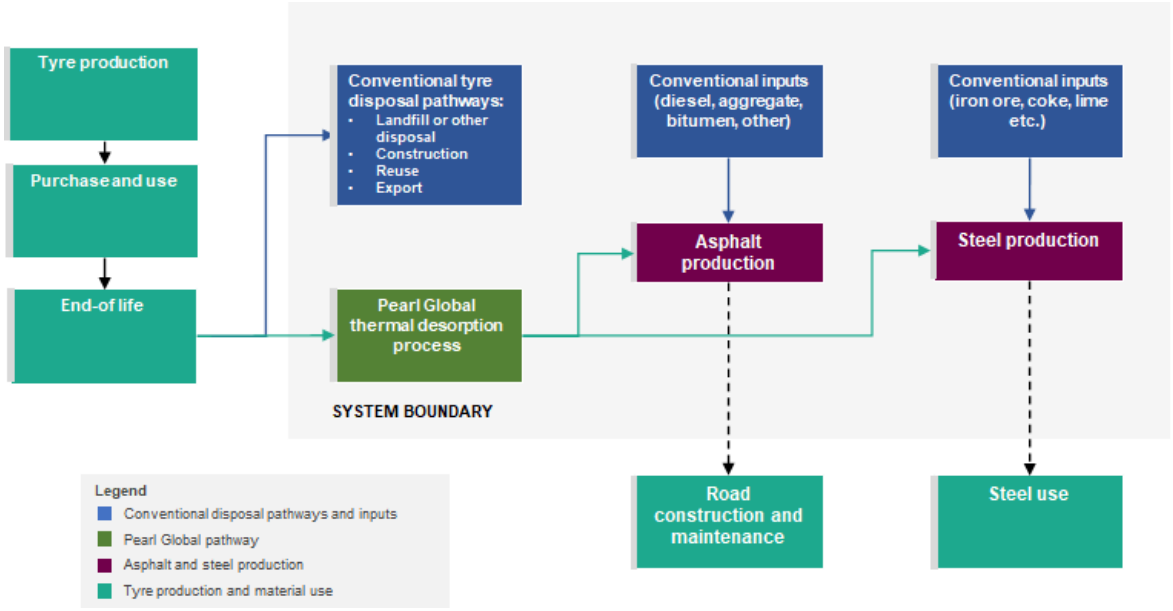

Figure 3 GHG assessment system boundary (full benefits)

Based on the expanded emission boundary, the Pearl Global process is estimate to:

- reduce GHG emissions by ~**805 kgCO_2-e per tonne of tyre**, equal to
- **104,607 tonnes of CO_2-e per year**, based on a production.

3.3 Monetised transport benefits

Maintenance and safety cost of Australia's roads

Australia's road infrastructure connects Australia's widely dispersed population and across vast geographical distances. Not only does road infrastructure contribute to a large proportion of Australia's emissions, it also carries a large cost borne ultimately by the Australian public. Two key costs in this regard are:

- The cost of road maintenance, which is borne by tax payers (for state and federal roads), rate payers (for Council maintained roads), the private sector (for privately owned roads)
- The life, health and financial toll of road accidents.

According to Infrastructure Partnerships Australia,[25] around half of Australia's $15.8 billion aggregated public roads budget or $7.9 billion (in 2011 prices) is spent on maintenance and renewal.

In terms of accidents, BITRE estimated the social costs of road crashes in Australia to equal $17.85 billion in 2006.

The benefits assessed in this section estimate the potential reduction in the cost of maintenance and social cost of road crashes through the use of Pearl's products in asphalt. The assessment is based on Pearl Global's analysis of laboratory testing of asphalt mix containing rCB, published in research findings by the Australian Road Research Board (ARRB).[26] Based on the research, the economic analysis assumes a maintenance cost reduction of 15%. The testing found that asphalt with rCB had properties that increased the life of the asphalt and made it blacker, which results in a sharper contrast with lane markings.[27]

Due to the scale of maintenance and safety costs, any improvement has the potential to generate large economic benefits. For example, a 15% reduction in maintenance costs as estimated by Pearl Global, would lead to a benefit of **$1.6 billion (in 2022 prices)**.

Approach

RPS valued the safety and road maintenance benefits of using Pearl Global products in asphalt by using a welfare economics approach. In this case, the intention was not to run a full cost benefit analysis (CBA), but instead to use the approach to identify and establish values for the benefits of using recycled products associated with Pearl Global's operations.

Welfare economics is the most commonly used, and most comprehensive, of the economic evaluation techniques and requires a base case with which to compare options.

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[25] Dwyer, A., Road Maintenance: Options for Reform, 2011

[26] Malone, S. & Davcev, P., Recovered Carbon Char in Road Applications – Technical Report, 2022; Njogu, J., Simmons, D. & Gallage, C., Enhanced properties and performance of asphalt mixtures incorporating recovered carbon black from repurposed passenger vehicle tyres, Proceedings of Institute of Public Works Engineering Australasia (IPWEA) Conference, Toowoomba, 30-31 March 2022; The studies showed a 25-31% increase in the resilient modulus of lab prepared asphalt from reheated plant mix (Malone & Davcev, 2022, Table 2.9). The economic analysis in this report assumes a 15% reduction in maintenance costs as advised by Pearl Global, however based on the prior studies the benefits are likely to be higher.

[27] The research report noted that *"rCB addition to asphalt has the potential to improve both deformation resistance in the high temperature region and crack resistance in the low-temperature region,"* that *"rCB increased the resilient modulus, the tensile strength stripping potential (moisture sensitivity) of the dry and wet (freeze thaw) subsets, the stability of asphalt (Hamburg) and the fatigue life"*, and that *"rCB laboratory manufactured asphalt at the completion of stability of asphalt (Hamburg) testing was visually blacker when compared to the control asphalt"*.

Defining the base case

The base case, sometimes called the 'counterfactual', is the state of the world without the project being analysed. This Benefits Assessment defines the base case as the state of the world with no asphalt production making use of Pearl Global products.

Defining the project case

The project case, sometimes called the 'factual', is the state of the world where the project is implemented. This Benefits Assessment assumes that the project case is the state of the world where the full 130 kt per year of capacity is operating.

A wide range of studies identify recovered energy and materials from tyres as having a range of benefits.[28] [29] [30] [31] [32] [33]

Currently, Pearl Global uses its thermal desorption units (TDU) to extract these resources at its recycling facility in Stapylton, Queensland, processing around 20 kilo-tonnes (kt) of tyres a year.

When the low-carbon asphalt is used in new roads, the recovered carbon black (rCB) content improves **stopping distance**, through better grip with vehicle tyres, **visibility**, because it contrasts more sharply with lane markings, and durability by reducing the road's susceptibility to routine damage caused by road-use.[34]

With further investment, Pearl Global intends to grow by building and running four new, second-generation tyre recycling facilities in Brisbane, Sydney, Melbourne, and Adelaide. Each second-generation plant is anticipated to have a throughput capacity of 27.5 kilotons annually, which will result in a significant increase in Pearl Global's total capacity for tyre processing, from 20 kilotons to 130 kilotons of tyres processed annually.

Benefits for the project case are then measured as the incremental improvements in road safety and road maintenance provided by asphalt containing rCB produced from Pearl Global activities.

Discount Rates

Discounting is used to express future benefits and costs in present value (PV) terms. Discounting is consistent with the notion that people prefer immediate benefits over future benefits (social time preference) and it also reflects the opportunity cost of capital. For this project, a real discount rate of 7% has been applied. This complies with recommendations set by the Office of Best Practice Regulation (OBPR) and Infrastructure Australia at the Federal Government level.

The benefits valuation includes benefits over a 30-year timeframe reflecting the expected asset life of asphalt roads.

Summary of assumptions

Core assumptions used for this assessment are outlined in Table 5.

[28] Verma et al., Diesel engine performance and emissions with fuels derived from waste tyres, 2017

[29] Akbas & Yuhana, Recycling of Rubber Wastes as Fuel and Its Additives

[30] Buttlar & Punyaslokrath, State of Knowledge Report on Rubber Modified Asphalt, 2021

[31] Laboy-Nieves, Energy Recovery from Scrap Tires: A Sustinable Option for Small Islands like Puero Rico, 2014

[32] Zhao et al., Recycled Asphalt Pavement Materials in Transport Pavement Infrastructure: Sustainability Analysis and Metrics, 2021

[33] Ruwona et al., A Review on Material and Energy Recovery from Waste Tyres, 2019

[34] Malone, S. & Davcev, P., Recovered Carbon Char in Road Applications – Technical Report, 2022

Table 5 Benefit valuation assumptions

Assumption	Value	Unit	Source
First Generation Plant Throughput (kilotons)	20.0	kilotons	Pearl Global
Second Generation Plant Throughput (kilotons)	27.5	kilotons	Pearl Global
Total Available Market	449.0	kilotons	National Waste Report[35]
Carbon char recovery rate from tyres	42%	per cent	Pearl Global[36]
Carbon char content of asphalt	2.0%	per cent	Pearl Global
Asphalt used per km	4,000	tonnes per km	Pearl Global
VKT per km per year	234,000	VKT per km per year	Statista[37] & QLD Govt[38]
Maintenance cost per VKT	0.05	$/vkt	TfNSW[39]
Maintenance cost reduction (with char)	15%	%	(Malone & Davcev 2022; Njogu et al 2002; Pearl Global)[40]
Stopping Distance Reduction Assumption	4	metres	Queensland Government[41]
Crash risk reduction factor	1.74	Coefficient	Queensland Government
Baseline fatal crashes per VKT	0.45	Crashes per million VKT	BITRE[42]
Period of analysis	30	Years	OBPR
Discount rate	7%	%	OBPR
Value of statistical life	$5,860,000	$ AUD	TfNSW

Monetisation was based on standard economic parameter values recommended in Australian transport agency economic assessment guidelines.[43]

Fatal accident reduction benefits were estimated on the assumption that stopping distance could be improved by 4 metres. Queensland Transport advice suggests that crash risk is exponentially proportional to stopping distance, to a factor where each 5 metre reduction corresponds to a halving of crash risk. The crash reduction factor was applied to the fatal crashes per vehicle-kilometres travelled (VKT) parameter provided by BITRE to give the incremental difference used to estimate the reduction in fatal crashes.

A maintenance benefit was estimated based on the maintenance cost parameter from TfNSW (5 cents per VKT) and the estimated maintenance cost reduction provided by Pearl Global.[44]

[35] Department of Agriculture, Water and the Environment, National Waste Report, 2020

[36] Advice from Pearl Global

[37] Statista, Total Length of Roads in Australia, 2018

[38] Queensland Government, Vehicle Kilometres Travelled, 2021

[39] Transport for New South Wales, Economic Parameter Values, 2020

[40] Malone, S. & Davcev, P., Recovered Carbon Char in Road Applications – Technical Report, 2022; Njogu, J., Simmons, D. & Gallage, C., Enhanced properties and performance of asphalt mixtures incorporating recovered carbon black from repurposed passenger vehicle tyres, Proceedings of Institute of Public Works Engineering Australasia (IPWEA) Conference, Toowoomba, 20-31 March 2022; Pearl Global analysis of study results

[41] Stopping distances: speed and braking, Queensland Government, 2016

[42] BITRE, International Road Safety Comparisons, 2021

[43] Transport for New South Wales, Economic Parameter Values, 2020

[44] Pearl Global analysis of Malone, S. & Davcev, P., Recovered Carbon Char in Road Applications – Technical Report, 2022

Based on this approach, the use of Pearl Global's products in asphalt are estimated to deliver safety benefits from avoided road accidents and road maintenance benefits from more durable roads worth a total of **$320 million** in Present Value (PV) economic terms, or **$73.5 million per year** by 2054.

Table 6 Monetised benefits ($m 2022 prices, Present Value)

Benefits	Value (PV)	Value (annual, 2054)
Avoided fatal accidents benefits ($m, Present Value)	192.1	44.1
Maintenance benefits ($m, Present Value)	128.4	29.4
Total monetised benefits	**320.5**	**73.5**

3.4 Quantified environmental benefits

Pearl Global's products can be used as a diesel substitute and carbon char can be used in low-carbon asphalt production, providing additional quantifiable environmental benefits that directly align with National, State and Industry policy

These benefits include the potential to exceed the **Resource Recovery Rate Target** of 80% set out in the National Waste Action Plan and significantly reduce embodied carbon since the embodied emission content of asphalt pavement infused with carbon char is less than asphalt using virgin material.

Resource recovery rate contribution

The National Waste Report estimates that there is a total market size of 449 kilotons of end-of-life tyres in Australia per year and estimates that the current resource recovery rate is approximately 70%, corresponding to 314 kilotons, albeit the pathways included in that 70% are likely to include sub-optimal endpoints from a circular economy perspective.

Pearl Global expects that under the investment case, they would have capacity to recycle an additional 110 kilotons of end-of-life tyres per year. This would boost the resource recovery rate of tyres significantly in Australia, with an uplift of 24.5 percentage points, resulting in an estimated resource recovery rate of 94.5%. This would position Pearl Global as a critical contributor to the tyre recycling market and exceed National Waste Action Plan targets.

Table 7 Pearl Global's contribution to achieving National Waste Policy targets

	Kilotons	%
Market size (kilotons)[45]	449	100%
Resource recovery rate target[46]	359	80%
Current tyre resource recovery rate[47]	314	70%
Current Pearl Global contribution	20	4.5%
Potential Pearl Global contribution	130	29.0%
Resource recovery rate uplift	110	24.5%
Tyre resource recovery rate with Pearl investment	**424**	**94.5%**

[45] National Waste Report, 2020

[46] National Waste Action Plan, 2019

[47] National Waste Report, 2020

Qualitative benefits

Pearl Global's activities also deliver a range of sustainability benefits, which have not been monetised or quantified in this report including:

- Enhance worker safety and visibility for drivers
- Utilise the partial biomass content of tyres to recover energy and aid in the generation of sustainable energy.
- Avoiding environmentally and socially damaging tyre disposal methods like burning tyres abroad or burying them in the ground, which releases hazardous emissions into the atmosphere.

4 ECONOMIC IMPACT ASSESSMENT

4.1 Purpose

The purpose of this section is to provide a summary of the economic impacts for this project, including:

- Opportunities for local businesses to participate in, and support construction and development activities (e.g. sub-contractors, suppliers, tradespeople); and
- The flow-on production and consumption impacts from construction and development.

4.2 Methodology

The economic impacts of the Pearl Global expansion were estimated using Input–Output (IO) modelling.

IO tables are part of the national accounts by the ABS[48] (2019/20 financial year) and provide detailed information about the supply and use of products in the Australian economy and the structure of and inter–relationships between Australian industries.

IO tables are converted into a series of economic multipliers which represent the relationship between the direct activity (expenditure or production) associated with a project and the wider economy.

The results of an EIA are generally presented as both direct effects (effects from the direct activity of the project or event) and indirect effects (additional effects from further rounds of spending in the supply chain). Consumption effects, resulting from rounds of consumer spending generated by the additional income in the region can also be calculated.

There are two broad levels of multipliers that can be utilised for impact assessments:

- **Simple multipliers** – including the direct or initial effect, first round and industry supply chain effects
- **Total multipliers** – including the simple multipliers and subsequent induced production and household consumptions effects.

Impact assessments can assess:

- **Output** - the actual dollar amount spent on the project in the region
- **Income** - the amount of wages and salaries paid to labour
- **Employment** - the full time equivalent per annum employment generated by the project
- **Value Added** - the value added to materials and labour expended on the project.

RPS has undertaken an Impact Assessment for the national economy focused solely on **simple multipliers** based on the national accounts[49]. This includes:

- Transaction tables developed from National IO tables for the national economy. The national transaction table was calculated by applying employment-based location quotients for the region, based on the results of the 2016 Census of Population and Housing. This has the effect of excluding spending on imports to the region since they generate no local economic activity
- Economic Multipliers generated for national economy across 119 industry categories defined by the ABS
- Construction and operation expenditure and production associated with the development were allocated across 119 industry categories
- Economic impacts associated with the project are calculated.

[48] Australian National Accounts: Input-Output Tables 2019-20 Financial Year, Australian Bureau of Statistics (2022)

[49] The data required to estimate simple multipliers is only available at the national level. Further disaggregation would require significant additional analysis of jobs and gross value added by industry at a state or regional level but is not expected to materially change the results.

Critique of impact assessments

Economic Impact Assessments based on IO-tables and economic multipliers have been critiqued by Government and academia. RPS recognises economic multipliers are based on limited assumptions that can result in multipliers being a biased estimator of the benefits or costs of a project.

Shortcomings and limitations of multipliers for Economic Impact Assessment include:

- **Lack of supply–side constraints**: The most significant limitation of economic impact analysis using multipliers is the implicit assumption that the economy has no supply–side constraints. That is, it is assumed that extra output can be produced in one area without taking resources away from other activities, thus overstating economic impacts. The actual impact is likely to be dependent on the extent to which the economy is operating at or if it is near capacity.
- **Fixed prices**: Constraints on the availability of inputs, such as skilled labour, require prices to act as a rationing device. In assessments using multipliers where factors of production are assumed to be limitless, this rationing response is assumed not to occur. Prices are assumed to be unaffected by policy and any crowding out effects are not captured.
- **Fixed ratios for intermediate inputs and production**: Economic Impact Assessment using multipliers implicitly assumes that there is a fixed input structure in each industry and fixed ratios for production. Impact analysis using multipliers can be seen to describe average effects, not marginal effects. For example, increased demand for a product is assumed to imply an equal increase in production for that product. In reality it may be more efficient to increase imports or divert some exports to local consumption rather than increasing local production by the full amount.
- **No allowance for purchasers' marginal responses to change**: Economic Impact Assessment using multipliers assumes that households consume goods and services in exact proportions to their initial budget shares. For example, the household budget share of some goods might increase as household income increases. This equally applies to industrial consumption of intermediate inputs and factors of production.
- **Absence of budget constraints**: Assessments of economic impacts using multipliers that consider consumption induced effects (type two multipliers) implicitly assume that household and government consumption is not subject to budget constraints.
- **Not applicable for small regions**: Multipliers that have been calculated from the national IO table are not appropriate for use in Economic Impact Assessment of projects in small regions. For small regions multipliers tend to be smaller than national multipliers since their inter-industry linkages are normally relatively shallow as they usually do not have the capacity to produce the wide range of goods used for inputs and consumption. Instead, import large proportions of these goods from other regions.

Adjustments to improve EIA reliability

IO tables and economic multipliers remain popular due to their ease of use and communication of results. RPS has undertaken a number of steps and made appropriate adjustments to the EIA methodology to address and mitigate these concerns.

RPS has only used simple multipliers in the assessment. This has the effect of excluding household consumption impacts from the assessment. By doing so, only those industries with a first round or supply chain connection are considered. This has the effect of making the results of the EIA conservative.

4.3 Summary of results

The following tables provide a breakdown of the direct and indirect economic impacts of the expansion of four additional tyre processing facilities during construction.

To calculate construction impacts, RPS first established the construction spend based on data provided by Pearl Global. RPS allocated the costs (excluding price escalation) to their most relevant industry categories defined by the ABS.

Construction

Direct and indirect economic impacts of construction of the proposed investment to the economy are summarised in the table below assuming capital costs of $108 million. A total of 536 direct and indirect jobs are estimated, inclusive of, and stemming from construction. Given the nature of the investment and the anticipated timeframe of construction completion, all of this construction job creation will be realised over a period of two years. A projected $67.9m of income is expected to stem from the construction, with overall direct and indirect GVA projected to reach $125.4m (based on Simple economic multipliers).

Table 8: Construction Impacts ($m undiscounted), Pearl Global expansion, national, total

Economic Indicators (total – 2 years)	Direct Impacts	First Round Impacts	Industry Support Impacts	Total Impacts	Multiplier*
Output	$237.0	$68.8	$60.2	$366.0	3.4
Income	$41.2	$12.1	$14.6	$67.9	0.6
Jobs (FTEs)**	399	123	15	536	5.0
Gross Value Added	$75.5	$23.6	$26.2	$125.4	1.2

*Notes: * Multiplier is estimated based on total impacts divided by total capital costs. **Jobs are totals over the entire construction period and should there be interpreted as job-years.*

The expansion of the new facilities would be constructed over approximately 2 years, and so the table below also presents average annual results. This is particularly relevant to the job estimates, which could be interpreted as 536 jobs for 1 year each based on the total results above or 268 jobs for 2 years each based on average annual results (as well as any permutations within this range).

Table 9: Construction Impacts ($m undiscounted), Pearl Global expansion, national, average annual

Economic Indicators (avg. annual)	Direct Impacts	First Round Impacts	Industry Support Impacts	Total Impacts	Multiplier
Output	$118.5	$34.4	$30.1	$183.0	3.4
Income	$20.6	$6.0	$7.3	$33.9	0.6
Jobs (FTEs)	199	61	7	268	5.0
Gross Value Added	$37.8	$11.8	$13.1	$62.7	1.2

Operation

Direct and indirect economic impacts of ongoing operation and maintenance of the proposed investment to the economy are summarised in the table below assuming operating costs of $36 million per annum. A total of 234 direct and indirect jobs are estimated, inclusive of, and stemming from operation. A projected $26m of income is expected to stem from the operation of the additional plants, with overall direct and indirect GVA projected to reach $46.3m (based on simple economic multipliers).

Table 10: Annual impacts during operation ($m, undiscounted), Pearl Global expansion

Economic Indicators	Direct Impacts	First Round Impacts	Industry Support Impacts	Total Impacts	Multiplier*
Output	$55.6	$10.8	$8.8	$75.3	2.1
Income	$14.3	$9.6	$2.1	$26.0	0.7
Jobs (FTEs)**	136	96	2	234	6.5
Gross Value Added	$25.3	$16.9	$4.0	$46.3	1.3

*Notes: * Multiplier is estimated based on total impacts divided by total annual operational costs. **Jobs are on a per annum basis and should there be interpreted as job-years.*

5 CONCLUSION

Pearl Global's tyre recycling activities are expected to provide the following triple-bottom line benefits:

- Use of Pearl's products in asphalt production is estimated to GHG reduce emissions by ~23 kgCO_2-e per tonne of asphalt (a 24% reduction in the embodied emissions of the asphalt produced) or 61,777 tonnes of CO_2-e per year
- This same process is expected to deliver safety benefits from avoided road accidents and road maintenance benefits from more durable roads worth a total of $320 million in Present Value (PV) economic terms, or $73.5 million per year by 2054
- Expanding Pearl Global's capacity from 20 kt per year to 130 kt per year would increase Australia's tyre recycling recovery rate by 24.5 percentage points
- The expansion is expected to create 268 FTE jobs per year over 2 years of construction, and a further 234 FTE per year during operation.

In addition to these quantified benefits, the process:

- Allows for a lower mix temperature during the production of asphalt
- eliminates the need to use diesel from virgin fossil fuel sources, which has significantly higher embodied emissions
- Lowers the required amounts of bitumen and lime, both of which have large embodied emissions.
- Enhances worker safety and visibility for drivers
- Utilises the partial biomass content of tyres to recover energy and aid in the generation of sustainable energy
- Avoids environmentally and socially damaging tyre disposal methods like burning tyres abroad or burying them in the ground, which releases hazardous emissions into the atmosphere.

A review of key government and industry policies and strategies shows that these benefits align strongly with government and industry priorities.