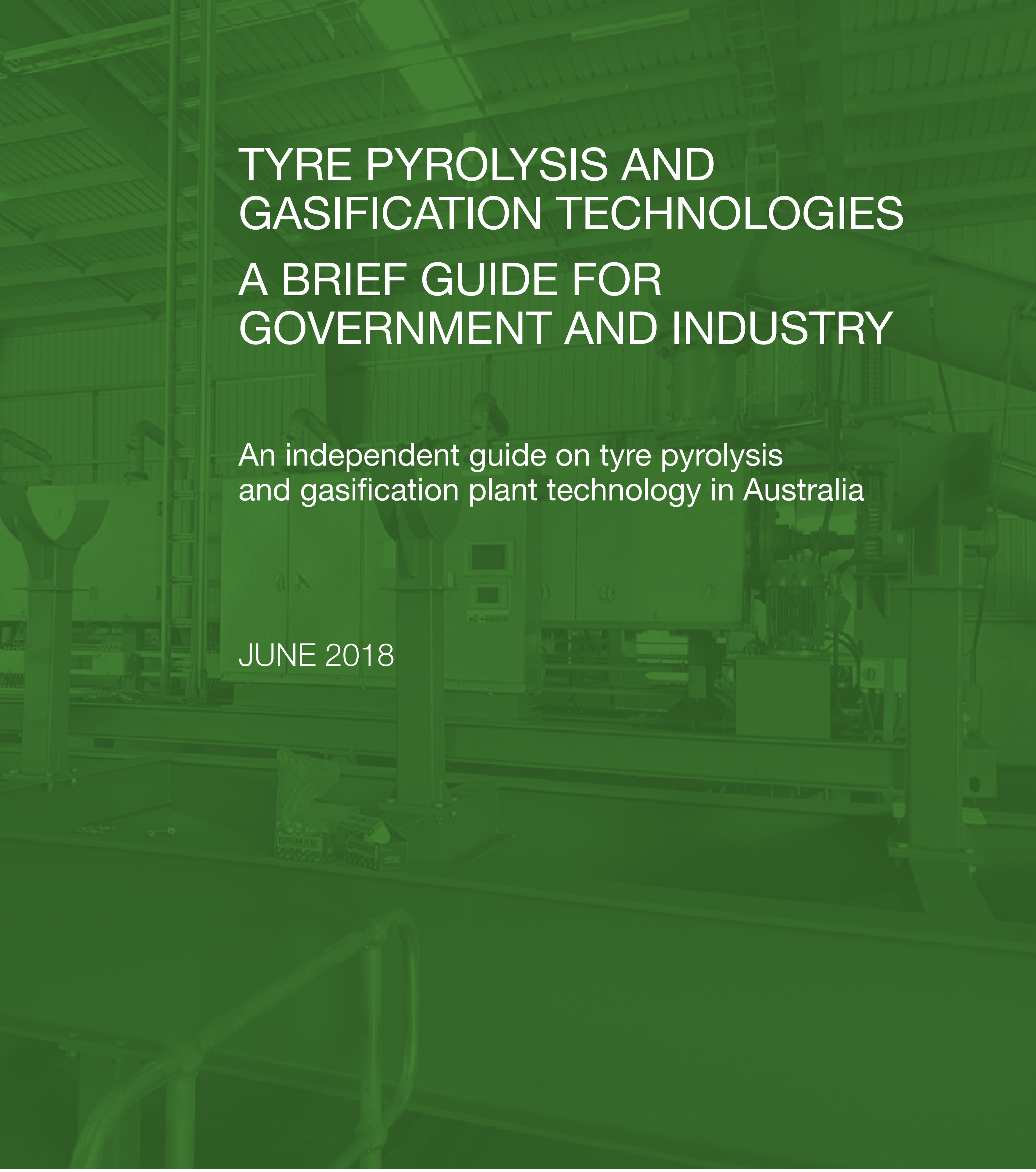

TYRE PYROLYSIS AND GASIFICATION TECHNOLOGIES

A BRIEF GUIDE FOR GOVERNMENT AND INDUSTRY

An independent guide on tyre pyrolysis and gasification plant technology in Australia

JUNE 2018

TyreStewardship AUSTRALIA

Tyre Pyrolysis and Gasification technologies: A Brief Guide for Government and Industry.

Guide developed by ARUP and Rawtec.

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This Guide should be attributed to Tyre Stewardship Australia.

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OVERVIEW

Introduction

Australians discard approximately 56 million equivalent passenger units (i.e. tyres) each year. This equates to an average of more than two passenger tyres per person, or 450,000 tonnes per annum[1]. This annual volume is increasing. The majority of used tyres are sent to landfill, stockpiled or illegally dumped[2]. Therefore, it is a matter of priority to find viable productive applications to appropriately use these tyre resources.

Despite the high proportion of non-recycled used tyres in Australia, there are currently a number of markets for end-of-life tyres and tyre derived products, including road surfacing, playground surfacing, conveyor belts, brake pads, explosives and fuel for energy recovery. A less-common or well-known method for processing used tyres is through tyre pyrolysis and gasification (henceforth referred to as tyre pyrolysis unless referring to the two technologies separately). Although this technology has been around for some time, there is limited independent information on tyre pyrolysis. Much of the available information on the technology is provided by, or associated with, the proponents of the technology. Therefore, to better inform relevant decision making, there is a demand from government, industry and associated agencies to access more impartial information.

Purpose of this Guide

This Guide has been developed to explain what tyre pyrolysis is and its current position in the Australian tyre processing market. It is intended to inform Government, the tyre industry, those considering funding the technology, and potential pyrolysis proponents.

Information provided in this Guide is general only and is not intended to argue the case for or against the construction of tyre pyrolysis plants. This Guide is focussed on increasing knowledge and identifying potential issues prior to approval, funding or the building of a plant in Australia. It is also not intended to be used as a sole decision-making tool, rather to assist in informing decision makers and other interested parties.

The information in this Guide is based on research together with industry and government consultations. It reflects a point in time only, and it is recommended that further research be undertaken by readers to verify data relevant for their circumstance. Further information on tyre pyrolysis and gasification is available in the report Independent review of Tyre Pyrloysis and Gasification Technology through contacting TSA.

1 www.tyrestewardship.org.au/this assumes 1 equivalent passenger unit = 8kg

2 Australian Government Department of the Environment (2014) Factsheet – Product Stewardship for end-of-life tyres. Accessed via http://www.environment.gov.au/system/files/resources/c9bd576e-d8d0-4e12-9351-f1ee8ba27ce0/files/35159-fs-tps.pdf

Glossary of terms/list of acronyms used in this Guide

Table 1: Glossary of terms/list of acronyms used in this Guide

TERM/ACRONYM	DESCRIPTION/DETAIL OF ACRONYM
DA	Development approval
End of life tyres (EOLTs)	A tyre that is deemed no longer capable of performing the function for which it was originally made. Often referred to as used tyres or waste tyres.
EfW	Energy from Waste
EPL	Environmental Protection License
ERA	Environmentally Relevant Activity
FTEs	Full Time Equivalent. An FTE is the equivalent of one person employed full time. For example, 0.5 FTEs is the equivalent of one person working 2.5 days per week and 2 FTEs is the equivalent staff of two people working full time.
R&D	Research and development
rCB	Recovered carbon black
Syngas	Synthetic gas
TPA	Tonnes per annum
Tyre derived fuel (TDF)	Shredded tyres prepared to a specification for use in energy recovery.
Tyre derived product (TDP)	Any product produced from rubber, steel, textiles or other material recovered from the recovery of EOLTs
Tyre Stewardship Australia (TSA)	The not-for-profit company established to deliver the National Tyre Product Stewardship Scheme.

WHAT IS PYROLYSIS AND GASIFICATION OF WASTE TYRES?

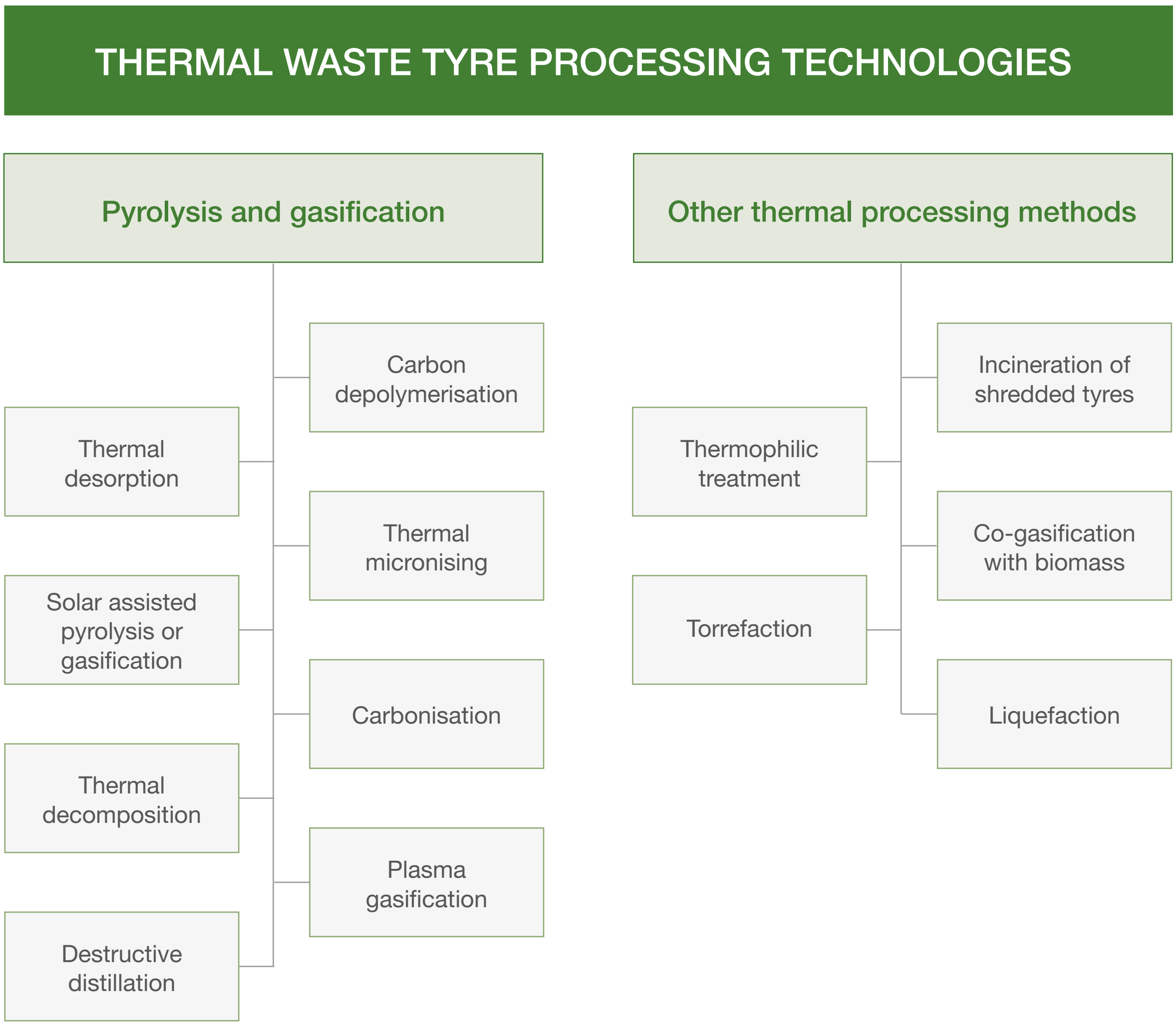
Pyrolysis and gasification refers to two similar thermal/heating processes.

Pyrolysis refers to the heating of tyres in the absence of any reactive gases such as air or oxygen.

Gasification involves heating the tyres with the presence of low levels of oxygen.

Both heating processes are used to decompose and separate various organic components from waste tyres or tyre derived products (i.e. shredded or chipped tyres, sometimes named tyre derived fuel or TDF). After the pre-treated tyres are heated, end products include char, oil, syngas and steel (see overleaf). There are many different names used to describe this process. Figure 1 below displays terms that fall under what can be defined as 'pyrolysis and gasification', as well as some other tyre thermal processing methods that do not fall under both general terms.

Figure 1: Thermal waste tyre processing technologies



A step by step overview of the tyre pyrolysis process

The following steps broadly describe the tyre pyrolysis process:

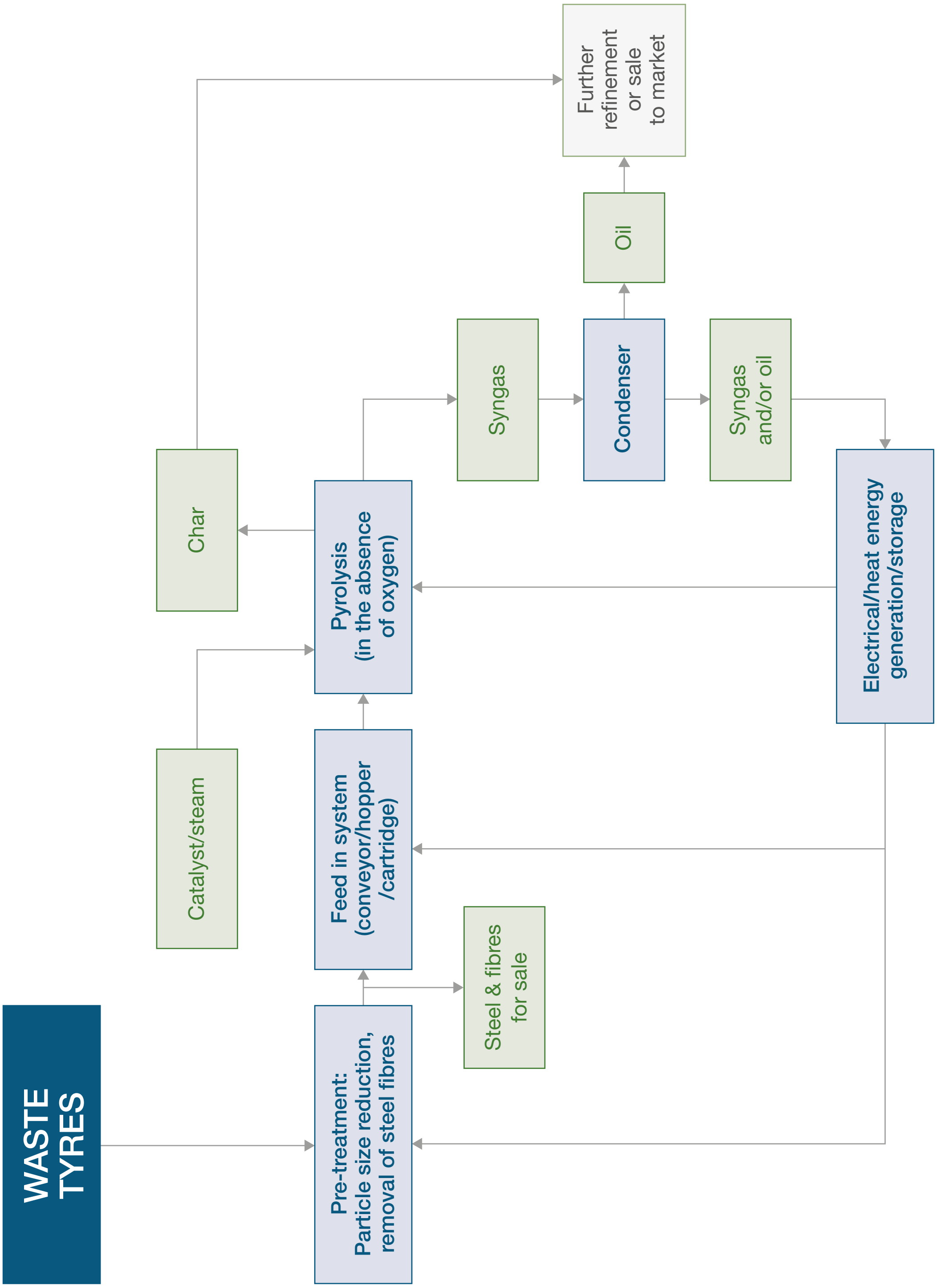
1. **Pre-treatment**: Pre-treatment usually involves extracting the steel and fibre reinforcement of the tyre before, or during, shredding, chipping or cutting the tyre into smaller pieces. This may involve a two or three step process. For example, first extracting the steel/fibre from the tyre rim, cutting the tyres into relatively large pieces and then, as a second stage cutting the tyres into smaller pieces to a size generally between 20 and 50mm.
2. **Feed in system:** The pre-treated tyres are loaded into a hopper, belt screw conveyor or cartridge system where they are fed into the reactor.
3. **Heating the tyres in the reactor**: After the tyres are fed into the reactor, they are heated (or 'cooked') in the absence of, or with limited, oxygen. Each pyrolysis plant will follow its own heating process. At lower temperatures more liquid products are produced and at higher temperatures more gaseous products are produced.
4. **This produces four products**: The end products are a char, oil, syngas and scrap steel.

The process for both pyrolysis and gasification is summarised and compared in Table 2 below.

Table 2: Comparison of pyrolysis and gasification

STAGE/COMPONENT	PYROLYSIS	GASIFICATION
Pre-treatment	Both processes generally involve extracting steel and fibre through shredding/cutting tyres	
Feed in system	Both processes may use a feed hopper, a form of belt or screw conveyor or a 'cartridge' system	
Reactor types	Fixed bed, screw kiln, rotary kiln, vacuum and fluidized-bed	Fixed bed and fluidized-bed
Oxygen present/absent	Absent	Present (low levels)
Temperature of reactor during process	400 – 1200°C	700 – 1,400°C
End products (predominant products)	• (Carbon black/char), • (Oil), • Syngas, • Steel and fibres, generally from pre-treatment phase	• (Syngas), • Ash/char, • Oil, • Steel and fibres, generally from pre-treatment phase

Figure 2: High level process schematic for pyrolysis of waste tyres[3]
The below diagram displays the process schematic for tyre pyrolysis. This is very similar to the process schematic for gasification.



3 Note that although the majority of tyre pyrolysis plants shred tyres in the pre-treatment stage, or procure pre-shredded tyres, some units are configured to process whole tyres. Some units also extract steel after the thermal treatment stage using magnetic separation.

An example plant to demonstrate the process

Figures 3 and 4 below show a tyre pyrolysis facility in Queensland[4]. The image shows the three production lines. Shredded tyres are fed into the hopper (1) and then the screw conveyor (2) feeds the tyres into the reactor (3). The shredded tyres are heated over 1 hour. After heating, at the back end of the reactor, the char is cooled on a water-cooled conveyor, steel is extracted using a magnetic separator and the resulting oil is captured in barrels.

Figure 4 includes a closer view of the reactor (3) in to which the tyres are fed and heated, in the absence of oxygen.

Figure 3: Example pyrolysis plant in Queensland, Australia

Figure 4: The pyrolysis chamber/reactor the site

4 Pearl Global has provided permission to include the above images to help demonstrate the pyrolysis process. Note: This is included as a demonstration only and the authors do not sponsor, endorse or necessarily approve of any material or equipment at this site, or on the company's website.

SUPPLY AND END MARKET CONSIDERATIONS

Supply considerations

It is critical to consider tyre supply input factors when setting up a tyre pyrolysis plant. There are important cost and production process considerations necessary to achieve the optimal form of tyre input into the pyrolysis process. Those considerations are discussed below.

Cost

In Australia, the recipients of disposed tyres generally receive a gate rate (i.e. money to receive tyres) for the whole tyres they take. However, what is often overlooked is the cost associated with the further processing of end-of-life tyres (EOLTs) to achieve the optimal size required for effective pyrolysis and ensure the tyre can be efficiently fed into the reactor.

Production process

The type and state of the tyre input will depend on the desired outputs. To meet end-product requirements (see End Market Considerations overleaf), proponents must spend time and resource researching the impact specific tyre inputs (e.g. size and type) have on the quality of the outputs. This R&D phase can take considerable time. Some European plants have devoted 10 – 15 years to this process. Research will help determine the type of tyres (and other products – if any) to feed into the reactor as well as acceptable levels and forms of contamination. Such research will also determine the overall quality of inputs, parameters of consistency, volumes and the particle size of the feed tyres required to arrive at end products suitable for market.

Implications

The cost and quality of the tyre feedstock has a large bearing on the potential success of a pyrolysis plant. It is essential to interrogate such factors when trying to ascertain the likely success of any pyrolysis related proposal.

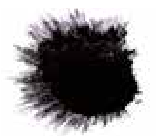
Supply of tyres via stockpiles

Many proponents claim to be able to use pyrolysis to clear tyre stockpiles. The authors found no evidence of this working in practice. Achieving such an outcome can be very challenging for multiple reasons, including the lack of gate rate, the cost setting up a plant at the stockpile location, contamination in the stockpile, inconsistent types and size of tyres (leading to lack of control over the feedstock and reducing the quality of the outputs) and the lack of EOLTs nearby after the stockpile is removed. Consideration of tyres types required and from where future volumes will be sourced must be factored in when evaluating the option of a facility that takes 'active' EOL tyres compared with a temporary facility that is only focused on removing a tyre stockpile.

End market considerations

Tyre pyrolysis produces four main products (tyre derived products or TDPs). The breakdown of each is provided in Table 3 below. It is worthy of note that the proportion of outputs can change depending on factors such as the temperature of the pyrolysis chamber. Other information included in Table 3 includes potential end markets for resulting products and the associated approximate value per tonne. The value depends on numerous factors, including the end product quality, product demand and the price for the raw material substituted by the TDP.

Table 3: Tyre derived products from pyrolysis and the potential end markets and value of each product

TDP	APPROX. PROPORTION OF OUTPUTS	POTENTIAL END MARKETS	ESTIMATED VALUE PER TONNE
 **Char** is refined into recovered carbon black (rCB)	30%	Ideally, proponents look to sell this as/to use this in: • Rubber strengthening and new tyre production[5] • Coke in the steel industry • A pigment • UV protection • An activated carbon • Lithium battery production • Plastic applications • Fuel cells	Consultations indicated that the price per tonne for rCB can vary depending on the quality and location, from AUD$200 per tonne to approx. AUD $3,000 per tonne. It is likely that if the proponent appropriately refines the product to near virgin material standards, they would aim to sell it for approximately $900 – $1,000 per tonne (if selling overseas), noting that this price has not been achieved in Australia, and prices for rCB are affected by crude oil prices.
Scrap steel 	15%	Scrap steel markets	The price for scrap steel in Australia varies from state to state – indicative prices range from AUD$150 to AUD$450 per tonne.

5 Note that there are still significant challenges associated with selling recycled carbon black to tyre manufacturers.

TDP	APPROX. PROPORTION OF OUTPUTS	POTENTIAL END MARKETS	ESTIMATED VALUE PER TONNE
Oil 	45%	Used as liquid fuels for: • Industrial furnaces • power plants • boilers Or if refinement is not possible, it may be used in the marine industry as a bunker oil.	The oil is generally low grade and follows the terminal gate price for diesel. The price per tonne received for pyrolysis oil varies from AUD$140 (no refinement) to AUD$1200 (after refinement).
Gas 	10%	Syngas is usually best suited as fuel for electrical energy generation on site for operations.	Syngas is difficult to sell on the natural gas market as most companies will not want to risk degrading the quality of their supply therefore, syngas typically requires further refining. Hence it is best suited to fuel the pyrolysis plant or an auxiliary plant on-site.

OTHER CONSIDERATIONS

Financial

There are key financial considerations that must be factored into any successful pyrolysis initiative. These relate to gate fees, product output and demand, capital/plant investment and operational costs.

Gate fees

One of the income streams for a pyrolysis plant is from the gate rate for receiving whole tyres. However, due to market fluctuations, this fee can reduce to $0 per tyre or per tonne. It can even become a cost to the plant due to costs for transport and appropriately preparing the tyres for the kiln (e.g. shredding to the appropriate size).

Capital, plant and set-up costs

There are several costs to consider before building a tyre pyrolysis plant. Key costs include:

- Capital investment for the plant and equipment. This can be anywhere between AUD $1.5M and $40M depending on the size of the plant, the number of reactors and the proposed input tonnes.
- Research and development costs. R&D can take over 10 years before creating a product, competitive with virgin product, that has a viable end market.
- Planning and environmental compliance costs.
- Tyre transport costs.
- Tyre preparation costs to ensure appropriate size to be fed into the kiln (this is often overlooked by proponents).
- Transport costs to send the end products to their respective markets.

Operational costs (repair and maintenance, staff, energy etc.)

It is estimated that a typical plant would require between 10 and 20 full time equivalents (FTEs) for every 10,000 tonnes of tyres received per annum. In addition to the salary costs of employees, annual repair and maintenance costs should be factored at around 10% of the capital investment. This is in addition to power and other necessary operational costs.

Sale of products

Principal income is generated from the sale of the end products (see Table 3).

In summary, there are many financial challenges associated with building and operating a plant. Even though some plants claim to be financially viable, due to sales of recovered carbon black (particularly in Europe), the authors are aware of no long term (i.e. more than five years in operation) financially viable plants, anywhere in the world.

The Australian landscape

The challenges associated with building and operating a tyre pyrolysis plant in Australia include:

- The high costs to build a plant while ensuring development and environmental compliance
- Distributed supply feedstock with low collection volumes in many areas
- Lack of consolidated markets to support economies of scale required to underpin large scale investment and production
- Limited successful plants to base the process on
- R&D is still in the early stages (in most cases less than five years)
- Distance from supply and end-markets
- Pyrolysis is still an emerging and untested technology in Australian context
- Australia remains five to 10 years behind Europe. Even in the European examples, where plants have been working with stable supply and end-markets allowing for the refinement of inputs and outputs from pyrolysis over many years, there are still ongoing and significant challenges for operating companies
- Australia has less prevalent extended producer responsibility schemes compared to overseas (for example in Europe). This can make the business case for building a commercially viable plant in Australia even more challenging.

Environmental considerations

Environmental considerations for pyrolysis facilities primarily relate to negative impacts associated with potential air and liquid emissions that may exceed health and safety standards.

Elements of a good system

Better environmental performing pyrolysis plants will tend to:

- **Control air pollution**: One way of controlling air pollution is through the use of a thermal oxidiser (sometimes referred to as an afterburner). This is a high temperature process (in excess of 600 degrees Celsius) similar to a flare that decomposes gaseous air pollutants through chemical oxidation; sometimes with the aid of precious metal catalysts to increase the rate of oxidation. There are other air emission control systems available, for example desulphurisation scrubbers to remove hydrogen sulphide via conversion into elemental sulphur.
- **Prevent liquid emissions**: To help prevent liquid emissions, consideration should be given to secondary containment systems (e.g. bunding) for all storage tanks, and emergency measures and procedures such as spill kits should be easily available on-site.

If properly managed, the pyrolysis process has the potential to produce fewer pollutants than incineration (due to that process being undertaken at lower temperatures).

Considerations when writing or reviewing a proposal to build a tyre pyrolysis plant

Ensuring that appropriate controls are in place to capture both gas and liquid emissions is paramount. It is important to understand that if such emissions are not properly captured pyrolysis plants can be harmful to human health. For example, sulphur dioxide, which is a harmful gas to both humans and the environment, can be produced, as well as particulate matter, nitrogen oxides, dioxins and furans, hydrocarbon gases, volatile organic compounds, heavy metals, carbon dioxide and carbon monoxide. It is essential to ensure that regular monitoring is scheduled for both when the plant is in pilot phase and in full-scale operation.

Note: At least one tyre pyrolysis proponent in Australia has been able to demonstrate meeting applicable state regulatory air emissions standards through use of a thermal oxidiser to treat syngas.

Regulatory considerations

There is no national policy or regulation that directly outlines the requirements for construction and operation of tyre pyrolysis plants in Australia. Building and operating this type of facility fits under the laws and guidelines of each state or territory, and each state or territory has its own method and guidelines for responding to development and environmental applications for such plants. Local planning requirements also apply. In most cases, pyrolysis of tyres is considered thermal treatment of waste tyres, which falls under EfW (energy from waste) policy and guidelines (see Table 4 overleaf). It is also important for proponents to consider local land use planning and any additional relevant local government requirements.

Table 4: Key relevant Australian regulation, policy and resultant requirements/guidelines (tyre thermal treatment/EfW facilities)

STATE	KEY RELEVANT REGULATION AND POLICY	RELEVANT SECTIONS/REQUIREMENTS FOR PROPONENTS/GUIDELINES/FURTHER WORK
ACT	Environment Protection Regulation 2005	Process is an online application, proponent pays a fee and an environmental assessment is undertaken, then DA. Environmental authorisation is required for burning certain substances.
NSW	NSW EfW policy statement; Resource recovery orders and exemptions; Protection of the Environment Operations Act 1997	An Environmental Protection License (EPL) has a requirement for: • proof of performance trials relating to air emissions • air quality impact assessment • 25% thermal efficiency criteria and practicable recovery of heat.
NT	Waste Management and Pollution Control Act 2016	Environmental protection approval and/or license required under Schedule 2 of the WMPC Act. Application supported by environmental risk assessment.
QLD	Environmental Protection Act 1994; Environmental Protection regulation 2008; Planning Act 2016	An Environment Relevant Activity (ERA) approval is required, with ERA 61 most relevant to tyre thermal treatment.

STATE	KEY RELEVANT REGULATION AND POLICY	RELEVANT SECTIONS/REQUIREMENTS FOR PROPONENTS/GUIDELINES/FURTHER WORK
SA	Enhancing resource recovery and discussing the place of energy recovery EPA SA discussion paper; Environment Protection Act 1993; Environment Protection (Waste to Resources) Policy 2010	Emphasises importance of community consultation and stakeholder engagement for EfW projects. Development Approval must demonstrate compliance with the waste management hierarchy. Multiple prescribed activities of environmental significance likely to be triggered, resulting in requirement for one or more licenses that will require demonstration of the EP Act and various license conditions.
TAS	Environmental Management and Pollution Control Act 1994	Waste tyre storage depots are assessed and regulated by the Tasmanian EPA.
VIC	Energy from Waste Guideline; Environmental Protection Act 1970	These documents provide guidance on requirements for siting, design and construction of EfW facilities. The works approval is under section 19B, stating that EfW proposals are assessed against multiple criteria including suitability, waste acceptance, siting, emissions, application of best practice and demonstrating EfW is the best management option.
WA	Waste to energy position statement; Section 16e of the Environmental Protection Act 1986; Planning and Development Act 2005	Recommendations around siting, buffer zones and community consultation/stakeholder engagement. Tyre thermal treatment is likely to fall under 'incineration' under schedule 1 of prescribed activities that require licensing. Development Approval is required under the Planning and Development Act.

EXAMPLE PLANTS IN AUSTRALIA AND AROUND THE WORLD

Australia

As of June 2018, one company in Australia had received the relevant licenses for the thermal treatment of tyres through pyrolysis at a commercial scale. However, there were numerous pilot-phase plants, as well as plants that had been trialled, that are now defunct. Table 5 below summarises the known plants currently in operation in pilot phase, or are no longer in operation, by state. Note: The below is a point in time only and applicable at the time of publication.

Table 5: Known tyre pyrolysis facilities (incl. pilot plants) – Australia

STATE	NUMBER OF PLANTS	CURRENT SITUATION (AS OF APRIL 2018)
NSW	2	NSW EPA has issued no licences to operate a tyre pyrolysis facility. The two operating examples are a pilot proof-of-concept facility and a site undertaking research in conjunction with a University.
QLD	3	One Queensland plant is currently in operation (as of April 2018), processing approximately 16,000 tonnes of tyres per annum. The focus is on the oil and char outputs. The second site has been constructed and is in commissioning/small scale operational stage. The last site is a fuel testing facility and fuel lab located at a waste oil refining facility. In this case three pyrolysis technologies are being tested at pilot scale for waste tyres.
SA & NT	0	There are no current or previous tyre pyrolysis plants in SA or NT.
TAS	1	In 2015, a proponent lodged a development application for a site that would take 16,000 tonnes of EOL tyres per annum. This has not progressed further.

STATE	NUMBER OF PLANTS	CURRENT SITUATION (AS OF APRIL 2018)
VIC	2	The first of the two Victorian facilities received Research, Development and Demonstration approval for a small scale limited duration trial for used tyres (and mattresses and plastics). The second Victorian example received works approval to allow construction of pyrolysis infrastructure in 2015. However, this plant is not in operation.
WA	2	One WA plant is under construction and still in commissioning stage. The predicted capacity of this site is 5,000 tonnes of tyres per annum. A second facility is scheduled to be fully operational by end 2018. The operator's website states that it will recover carbon char, light oil and milled steel.

Example Australian Case Study – Pearl Global

The following case study is intended to provide an example of a tyre pyrolysis plant in operation in Australia. Note: The commercial viability of this plant is unknown, and it is provided as a demonstration only[6].

CASE STUDY – PEARL GLOBAL

Overview

Pearl Global Limited is an Australian company established in 2010. They operate a low temperature (>600 °C) anaerobic thermal desorption process, which takes place in a modular reactor known as a TDU (Thermal Desorption Unit). The process produces char, oil and steel from shredded tyre feedstock. No other additional pre-treatment of feedstock is required.

Gases from the process are condensed to produce oil, and any excess gas is flared through a thermal oxidiser. Oil is sold to third parties for blending into fuel oil or lubricant applications. The recovered steel is sold to recycling markets, and the char is used as a fuel in cement kilns (although it has the potential to be upgraded for activated carbon applications).

Since 2015 to the end of 2017, Pearl Global undertook testing, research and development of a TDU at a site in WA under an Environmental License. Since early 2018, they have transferred all operations to their Queensland site where they are currently finalising offtake and feedstock supply agreements and ramping up production of two TDUs to operational scale, with the potential to include a further two additional TDUs at a later stage. EPA approval has been granted for the Queensland site.

Key advice to thermal waste tyre processing proponents

Understand the regulatory and policy landscape for your site and seek advice early. It is important to appreciate the likely requirements for monitoring and compliance, in particular for air emissions.

Contact

For further information, contact Pearl Global on:
Phone: +61 (08) 9431 9830
Email: info@pearl-global.com.au

PEARL GLOBAL
CLEAN CONVERSION TECHNOLOGIES

Key facts

Location:
Stapylton, Queensland, Australia

Time in operation:
Currently in commissioning phase

Time in R&D:
5 years

Tonnes of tyres processed per annum:
10,000 current capacity, 20,000 anticipated capacity

Focus:
Oil and char

End markets:
Fuel oil, carbon char and steel recycling

Funding received to build plant:
Some Australian Research Council funding received.

6 Note this case study is included as a demonstration only and the authors do not sponsor, endorse or necessarily approve of any material or equipment at this site or on the company's website.

International

Outside of Australia there are a number of tyre pyrolysis plants currently in operation. Examples are provided in Table 6 below, along with brief information on these plants. Note: The below is used as a demonstration only and does not include all tyre pyrolysis plants in operation globally.

Table 6: Example international plants from across the globe

STATE/COUNTRY	PLANT OPERATOR	CURRENT SITUATION (AS OF APRIL 2018)
Netherlands	Black Bear Carbon	This is a commercial facility focused on producing high quality recovered carbon black. It takes approximately 15,000 tonnes per annum.
Åsensbruk, Sweden	Scandinavian Enviro Systems	According to its website, this facility, at full scale, processes approx. 27,000 tonnes of tyres per annum. The carbon black is used in rubber applications where it acts as a reinforcement filler, as well as a black pigment in plastics and UV protector, the oil is sold as fuel oil for industrial combustion, the steel sold as scrap and the gas is used to power the plant.
Stegelitz, Germany	Pyrolyx	Pyrolyx is a commercial facility in Germany and is currently building another facility in Indiana, USA to commence operation in 2019. According to its prospectus, the new plant will accept 40,000 tonnes of tyres per annum.
Dillingen, Germany	Pyrum innovations	A pilot unit was built in 2008–2009 and construction of the larger 5,000 tpa input industrial plant commenced in 2013. According to their website, feedstocks are tyres, plastics, oil shale and other products.
Malopolskie, Poland	Niersberger (tech) Operator/owner: Reoil	This is a commercially run facility built in 2014 that, according to its website, has a 10,000 tonne per annum (tpa) capacity.

STATE/COUNTRY	PLANT OPERATOR	CURRENT SITUATION (AS OF APRIL 2018)
Oregon, USA	Reklaim	This pyrolysis plant in the USA opened in 2008 but according to its website closed in 2016, due to excessive cost in transport of materials to markets.
South Africa	Milvinetix	Their website states that this facility currently processes approximately 2,000 tonnes of waste tyres per annum with the focus on creating an oil with a calorific value similar to unrefined Stage 6 diesel oil. The oil is sent to an organisation that purifies the oil and sells it to the market.
Vancouver – various	Klean Industries	Klean Industries has many facilities, including one in Vancouver which is claimed to be one of the largest facilities in operation globally. Limited plant data is publicly available.

Example case studies

The following case studies are intended to provide examples of two global tyre pyrolysis plants in operation, with one currently building another plant in the USA. Note: The commercial viability of these plants is unknown and that these are provided as demonstrations only[7].

CASE STUDY – BLACK BEAR CARBON

General information

Black Bear Carbon is a tyre pyrolysis facility in the Netherlands. The facility takes waste tyres and using pyrolysis, processes the tyres into carbon black, oil and gas. It is a closed loop process that produces no emissions, as all gases and outputs are captured and sold or used in the facility as an energy source.

Key advice to tyre pyrolysis proponents

For those looking to set up a plant, Black Bear Carbon believes that it is important to create partnerships with tyre collectors as well as the markets for the end products. This helps ensure consistent feedstock and that the products align with market requirements and specifications. It is also important to ensure that the pyrolysis equipment is high quality.

Key facts

Location:
Nederweert, Netherlands, Europe

Year the facility opened:
2015

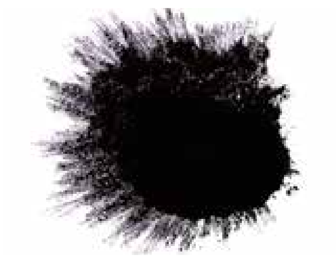
Time in R&D:
7 years

Tyres processed per annum (tonnes):
15,000

Product of focus:
Carbon black

End markets:
Tyres and other applications for carbon black (plastics, inks etc)

Funding received to build plant:
Yes – from the EU and Netherlands Government

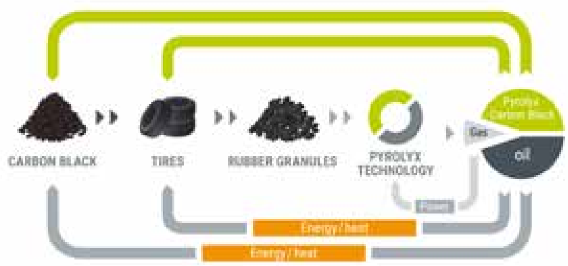

7 Note these are included as a demonstration only and the authors do not sponsor, endorse or necessarily approve of any material or equipment at these sites or on the companies' websites.

CASE STUDY – PYROLYX

About Pyrolyx Group

The Pyrolyx rCB plant in Stegelitz, Germany has been in operation since 2012. The focus of the plant is recovered carbon black from end-of life tyres. By-products (oil, gas) that arise during production are reused either as energy in the manufacturing process or to make other products. Prior to opening the plant in Germany, Pyrolyx had a pilot facility in the Netherlands. Pyrolyx USA is now building the world largest rcB plant in Terre Haute, Indiana, USA, which is due for completion in 2019. Pictures can be seen below.

pyrolyx



Key facts

Location:
Stegelitz, Germany (production plant) and currently building a facility in Terre Haute, Indiana, USA

Facility opened:
2012 in Germany and 2019 in USA

Cost:
USA plant AUD $40 million

Time in R&D:
11 years

Tyres shreds processed per annum (tonnes):
Approx. 12,000 (German site) and 40,000 (USA site)

Focus Product:
Recovered Carbon black (rCB)

End markets:
Tyres and other applications for rCB (rubber, pigments etc)

Grant or government funding received to build plant: No

BUILDING A PLANT IN AUSTRALIA – KEY CONSIDERATIONS FOR STAKEHOLDERS

Government

There are several considerations for Government agencies (local, state and federal) if presented with an application to build a pyrolysis plant. These are highlighted in the table below.

Table 7: Key questions to consider for stakeholders considering pyrolysis proposals:

INFORMATION/QUESTIONS TO ASK
1. Has the proponent provided evidence of end markets that will purchase the end products?
2. Has the proponent considered the entire system, e.g: • the location where the tyres are disposed, • transportation of the tyres, • the gate fee, • the cost to prepare the tyres for the reactor, • stock accumulation and site requirements, • the price the proponent can sell the end products for (if at all), • the cost to transport the end products to a market?
3. Has the proponent considered the relevant environmental requirements, relating to your state or jurisdiction, to build and operate the plant? Key operational requirements include effectively capturing air and liquid emissions.
4. Is the gate rate below the current market rate for acceptance of tyres and has the proponent considered the transportation and tyre preparation costs?
5. Are there restrictions in place to avoid the proponent being paid a fee to take the tyres and accumulate them, but then not process them properly?
6. If there is a large stockpile that the proponent is proposing to remove through pyrolysis, have they considered quality and contamination issues (e.g. dirt)? Does their business model rely on receiving money for these tyres? If so, how will the facility operate when there is no stockpile?
7. Is the proponent is using a different name and description for the technology when the underlying processes are the same as tyre pyrolysis or gasification? If so, have they factored in the abovementioned considerations?

Potential funders of tyre pyrolysis plant

If faced with a grant application or the opportunity to fund a tyre pyrolysis plant, potential funders should consider the following information (Table 8):

Table 8: Key questions to consider for potential funders

CONSIDERATION/INTERNAL QUESTIONS TO ASK
1. Consider funding for R&D rather than full-scale operations or pyrolysis plants built to address tyre stockpile issues. Organisations looking to immediately remediate stockpiles to mitigate fire, health and associated risks to the community should consider more proven, conventional processing means.
2. Has the proponent considered the importance of inputs and the cooking process on the outputs? What controls are in place to ensure that pyrolysis process will create end products that will meet required quality levels?
3. Has the proponent considered all potential costs? E.g. tyre feedstock preparation, capital costs for plant construction, the time it takes to refine the product, costs to transport the material in and out of the facility etc.
4. What relationships does the proponent have with the end markets? Are the end markets willing to accept the product? What price will buyers pay for end products? What is the cost to transport the product to market?
5. It is important to note that return on investment for this technology can take time – it can take years of research and development before the quality of end products reaches a level appropriate for sale at a high enough price to achieve a commercial return.

Proponents/those considering building a plant

In addition to the many considerations outlined above, there are further considerations for proponents considering the building of a pyrolysis plant. They are highlighted in Table 9 below.

Table 9: Key questions to consider for tyre pyrolysis proponents

CONSIDERATION/INTERNAL QUESTIONS TO ASK
1. Do you have access to an ongoing supply of feedstock that are of appropriate quality and a competitive gate rate?
2. Have you worked with tyre collectors (and shredders if applicable) to ensure consistent supply of tyres?
3. Can you produce products that are an appropriate quality and specification for the end markets?
4. What price can you currently sell your end products per tonne? Is this likely to fluctuate?
5. Have you worked with the end markets to ensure you understand their requirements and the price they will pay for the end products?
6. Have you considered the cost to prepare the tyres for the pyrolysis process? (Although you may be able to receive a gate rate per tonne of tyres you receive, there is a cost to shred and prepare the tyres)
7. Have you considered the type of feedstock and the quality implications? For example, mining tyres may be more appropriate, due to the lesser content of silica than passenger tyres. However, transporting and preparing these products for the pyrolysis reactor may be challenging, and such tyres can often be contaminated with gravel and sand.

CONCLUDING REMARKS

In summary, tyre pyrolysis technology in Australia, as well as globally, is, largely, still in the development stage. There are yet to be long-term commercially successful enterprises, processing large volumes of tyres on an ongoing basis, in any jurisdictions that have regulatory and environmental requirements comparable to those in Australia. Pyrolysis can function from a technical and environmental perspective: tyres can be fed into a reactor and four key products can be created for sale, all whilst capturing or minimising emissions. However, input and operational costs, quality control and the relatively low price received for the end products make for a difficult business case to support in the current Australian economic climate. Claims that pyrolysis will solve large stockpile issues and that it is a well-established commercial practice are currently unjustified and should be met with caution.

European facilities demonstrate that pyrolysis technology has a potential role in meeting the end-of-life tyre management challenge. However, Australia is 5–10 years behind Europe in experience and fully understanding how to harness that potential. This Guide has highlighted some of the key limitations of pyrolysis, provided general information about the technology and outlined a list of questions and considerations for Government, industry, potential funders and tyre pyrolysis proponents looking support and/or introduce commercially viable Australian pyrolysis facilities.