Australian National Greenhouse Accounts and End-Of-Life Tyre Combustion Emission Factor

TYRE STEWARDSHIP AUSTRALIA

Final Report - July 2021

Prepared for Tyre Stewardship Australia by
Brian McGrath, OLM Technical Service Pty Ltd

TyreStewardship AUSTRALIA

Australian Government Accredited Product Stewardship Scheme

Contents

Summary

The case is made that the treatment of combusted end-of-life tyres in the National Greenhouse Accounts Factors [1] wherein end-of-life tyres are lumped in with industrial materials as a single category and assigned a common designated emission factor misrepresents the greenhouse impact of combusted end-of-life tyres. End-of-life tyres comprise sources of biogenic carbon, largely relating to their natural rubber content, which the current designated emission factor does not take into account.

It is argued that end-of-life tyres should be a standalone fuel within the Method 1 list of solid fuels in the National Greenhouse Accounts Factors and should be assigned a designated emission factor that better recognises, incentivises, and facilitates the reuse of end-of-life tyres as a fossil fuel replacement.

The current designated emission factor for end-of-life tyres is 81.6 kgCO2/GJ. End-of-life tyres fall into three categories, passenger car, truck and off-the-road. The outcome of this investigation is that a more representative designated emission factor that considers the biomass content of end-of-life tyres would be in the range of 59.0 kgCO2/GJ to 64.2 kgCO2/GJ for passenger car tyres and 42.4kgCO2/GJ to 56.4kgCO2/GJ for truck and off-the road-tyres.

Three jurisdictions were identified that accounted for the biomass content in their determination of a designated emission factor for end-of-life tyres. The designated values are 50.4 kgCO2/GJ, 53.6 kgCO2/GJ and 61.83 kgCO2/GJ.

The emission factor relates to carbon dioxide emissions only and does not consider emissions related to methane and nitrous oxides which are of the order of 0.03 kgCO2-e/GJ and 0.2 kgCO2-e/GJ respectively.

The case for a designated emission factor for end-of-life tyres under Method 1

The argument in favour of a standalone Method 1 solid fuel category for end-of-life tyres follows three principles, recognition, incentivisation and facilitation, defined by three corresponding assertions:

A. **Recognition** - The quantity of end-of-life tyres generated in Australia is sufficient to warrant its classification as a standalone fuel with a Method 1 designated emission factor.

B. **Opportunity** - The Council of Australian Governments' decision to ban the export of whole tyres from December 2021 will require expansion of existing markets and creation of new markets for end-of-life-tyres reuse to avoid landfilling and illegal dumping. There are a range of reuse opportunities available for end-of-life tyres (see Table 1). The energy reuse opportunity is currently not taken up in Australia. To properly consider the energy reuse opportunity, the greenhouse gas advantage of using end-of-life tyres as a substitute for fuels such as coal needs to be made explicit by means of a Method 1 designated emission factor.

C. **Facilitation** - The use of Method 2 and Method 3 to determine emission factors as an alternative to Method 1 requires sampling and testing protocols which are an unnecessary and onerous impost given there is sufficient data available to determine a Method 1 designated emission factor.

There are four prescribed methods for estimating emissions of greenhouse gases from the combustion of fuels.

Method 1 relies upon a designated emission factor for a fuel as listed in the National Greenhouse Accounts.

Methods 2 and 3 require sampling and testing of the fuel to determine an emission factor. The difference between Methods 2 and 3 is that the sampling under Method 2 is conducted to an industry standard and under Method 3 the sampling is conducted to an Australian or International standard.

Method 4 does not rely upon inputs and fuel composition but requires direct monitoring of the products of combustion of the fuel.

A. Recognition

The quantity of end-of-life tyres generated in Australia in 2018-2019 was 466,000 tonnes [2]. Approximately 55% of these tyres are exported and 45% are managed onshore via civil engineering applications, production of crumb, buffings and granules, pyrolysis, reuse as second-hand tyres, landfilling, onsite disposal, and illegal dumping. There is currently no onshore reuse application in energy recovery. A cement plant located near Geelong in Victoria did utilise up to 15,000 tpa of end-of-life tyres from 1994 up until its closure in 2014. A full breakdown of the fate of end-of-life tyres generated in Australia is given in table 1 [2]

Table 1 – Fate of Australian end-of-life tyres 2018-2019

End use	Volume (tonnes)
Energy	0
Casings and seconds	26,400
Civil Engineering	3,100
Crumb, granules and buffings	32,900
Pyrolysis	1,300
Stockpiling*	5,600
Landfills*	34,900
Onsite disposal (mining, other off the road)*	94,900
Dispersed dumping*	7,400
Export shred*	131,000
Export whole passenger tyres*	47,500
Export truck tyres	69,000
Export off the road tyres	11,500
Total	**465,400**

*End-of-life tyres that could be reused for energy recovery

There is currently a significant quantity of end-of-life tyres available within Australia for reuse following the energy recovery route, approximately 273,800 tonnes. The ban on the export of whole tyres from December 2021 would provide an additional 47,500 tonnes for waste to energy giving a total availability of 369,200 tonnes.

It is noted that within the Method 1 National Greenhouse Account Factors that Biodiesel and Ethanol enjoy the status of standalone fuels with designated emission factors. The quantities of these fuels produced in Australia 2019 were 25,000 tonnes and 197,000 tonnes, respectively. [3]

It is proposed that end-of-life tyres fall into the same category as biodiesel and ethanol ie emergent fuels and should be afforded that same status as them within the National Greenhouse Accounts.

B. Opportunity

The decision by the Council of Australian Governments to ban end-of-life whole tyre exports from December 2021 was predicated upon furthering two objectives:

- making a contribution to stamping out the highly polluting practice of diesel production from end-of-life tyres in the receiving countries
- taking responsibility for the management of Australia's waste and encouraging innovation and new end markets onshore.

The use of end-of-life tyres as an energy source has been proven as a non-polluting energy source internationally, and indeed within Australia. The encouragement of new end use opportunities is a corollary of the export ban. Introducing the ban is the first step. Encouraging reuse opportunities is the next logical step.

The current National Greenhouse Accounts factors do not recognise end-of-life tyres as a stand-alone fuel. Consequently, the accounts fail to highlight one of the major incentives for end-of-life tyre reuse, namely as a means by which an energy intensive business, such as cement production, can reduce its greenhouse gas emission. For example, where end-of life tyres are substituted for coal, the greenhouse gas emissions would be reduced by around 30% on a substituted energy basis. A further case in point, highlighted in Table 1, is the current management solution for end-of-life tyres in the mining industry - onsite pit burial. Mining tyres represent a resource of approximately 95,000 tpa of end-of-life tyres equivalent to an aggregate 40 megawatts of electrical power generating capacity which goes unrecognised as a potential energy source. Giving end-of-life tyres stand-alone fuel status would encourage reuse opportunities in this industry.

It is proposed that one of the means by which the intent of the export ban can be enacted is by making the greenhouse gas benefit of end-of-life tyres, when reused as energy, explicit by use of a Method 1 designated emission factor.

C. Facilitation

End-of-life tyres are unique amongst fuels in that the tyre manufacturing process requires raw materials that contain both biogenic and anthropogenic sources of carbon. The biogenic component arises from the natural rubber and textile components of the tyre. This situation is not reflected in the default emission factor assigned to end-of life tyres in the National Greenhouse Accounts.

The National Greenhouse Accounts does provide a mechanism for the situation where the Method 1 designated emission factor or default factor does not properly represent the emissions intensity of a particular fuel. Whereas Method 2 and Method 3 call for an ongoing sampling and testing regime to establish the emissions intensity of a fuel. It is argued that there is sufficient data available to assign a realistic default emission factor to tyres without the need to impose the burden of a Method 2 or Method 3 approach. Several jurisdictions around the world have adopted this approach.

A search of available data sources was conducted and used to establish tyre emissions intensity factors for comparison with emission intensity factors approved by various jurisdictions. The outcome is an expected range within which a realistic emission factor for end-of-life tyres may fall.

Three pathways were used to calculate end-of-life tyre emission factors, determined by the form of the data sets discovered in the search. Each pathway relies upon a carbon foundation value to determine emission factor that is then adjusted and corrected to comply with the Australian National Greenhouse Accounts reporting basis.

Pathway 1 – Literature sourced, total carbon content of end-of-life tyres (%) including biomass converted to carbon dioxide emission corrected for biomass content and reported on an energy basis.

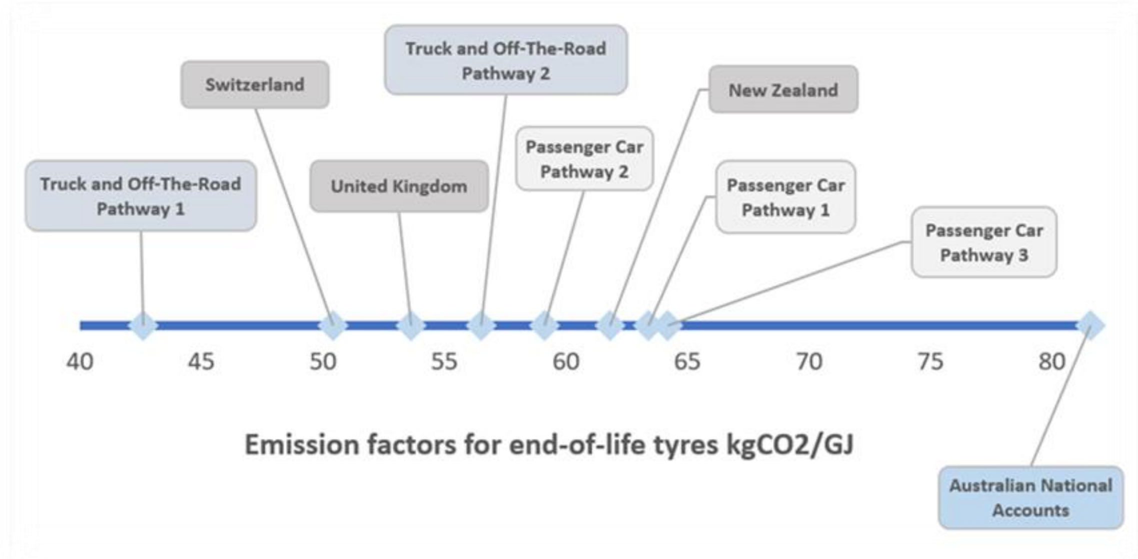
This pathway is the most comprehensive in that 17 data sets were searched to arrive at a representative value.

Pathway 2 – Literature sourced, carbon dioxide emission of end-of-life tyres excluding biomass (t/t or kg/kg) and reported on an energy basis. The representative value is based upon 2 data sets.

Pathway 3 – National accounts sourced, total emission factor for end-of-life tyres including biomass on an energy basis (kg CO2/GJ) corrected for biomass content. The representative value is based upon 6 data sets.

The pathway calculation results and published national accounts emission factors excluding biomass are presented for comparison with the Australian National Accounts factor in Figure 1.

Figure 1 – Summary of pathway emission factors and national accounts emission factors excluding biomass



Data sets and methodologies used in pathway calculations

The pathway calculations rely upon gathering representative values for each of the inputs classified as foundation, correction, or adjustment.

- Carbon values for end-of-life tyres (foundation)
- Biomass content of end-of-life tyres (correction)
- Calorific value of end-of-life tyres (correction)
- Hydrogen content of end-of-life tyres (adjustment)
- Steel content of end-of-life tyres (adjustment)
- Ash content of end-of-life tyres (adjustment)

The need for a foundation carbon value and the corrections for biomass content and calorific value are self-evident. The hydrogen adjustment is required to convert data expressed as Net Calorific Value (NCV) to be converted to Gross Calorific Value (GCV) as it is the reporting basis for the Australian National Accounts. The steel content and ash content are required to adjust reported carbon analyses of passenger car tyres to a whole-of-tyre basis.

The data collected has been collated into 13 tables which present the data and calculations in both raw and consolidated form.

Notes on data sets and methodologies:

- The vast bulk of the data gathered related to passenger car tyres.
- Where the type of tyre used to acquire the data is not stated the assumption has been made that it relates to passenger car tyres.
- During the search, it was noted that end-of-life truck tyres have a significant compositional difference compared to passenger car tyres. No specific data was found for off-the-road tyres, but it was noted that off-the-road tyres can be expected to have a composition similar to truck tyres.
- In treating the data sets, the expedient of taking an average as the representative value of each data set has been used.
- Where data sourced is on an energy basis and the reporting as NCV or GCV has not been stated the assumption has been made that NCV is the reporting basis.
- It has been assumed the oxidation factor, which is a measure of the fraction of the carbon that is oxidized when combustion occurs is 1.
- Original source data has been accessed wherever possible to avoid repetition and cannibalisation of the data.

Table 2 – Summary of pathway emission factors for passenger car tyres

	Foundation carbon value	Emission factor kg CO2/GJ $_{gross}$ excluding biomass	Commentary
Pathway 1	Literature, total carbon content (%)	63.4	Averaged total carbon content for passenger car tyres 71.9%. (table 5) Conversion to kg CO2/GJ $_{gross}$ 71.9 ÷ 100 × (44/12) × (100 – 23.1) ÷ 100 ÷ 32.0 ×1000
Pathway 2	Literature, total CO2 emission excluding biomass (kg CO2/t tyres)	59.0	Averaged total CO2 emission 1.890 kg CO2/kg (table 6) Conversion to kg CO2/GJ $_{gross}$ 1.890 ÷ 32 × 1000
Pathway 3	National Accounts, Total CO2 emission factor including biomass (kg CO2/GJ)	64.2	Averaged total CO2 emission 83.5 kgCO2/GJ $_{gross}$ (table 7) Conversion to kg CO2/GJ $_{gross}$ 83.5 × (100 – 23.1) ÷ 100

Table 3 – Summary of pathway emission factors for truck (and off-the-road tyres)

	Foundation carbon value	Emission factor kg CO_2/GJ_{gross} excluding biomass	Commentary
Pathway 1	Literature, total carbon content (%)	56.5	Averaged total carbon content for truck tyres 61%. (table 5) Conversion to kg CO_2/GJ_{gross} $61 \div 100 \times (44/12) \times (100 - 31.5) \div 100 \div 27.1 \times 1000$
Pathway 2	Literature, total CO2 emission excluding biomass (kg CO2/t tyres)	42.6	Averaged total CO2 emission 1.155 kg CO2/kg (table 6) Conversion to kg CO_2/GJ_{gross} $1.155 \div 27.1 \times 1000$

Table 4 – Summary of published national accounts emission factors excluding biomass

Data Source	Emission factor kg CO_2/GJ_{gross} excluding biomass	Comments
National Accounts Switzerland [4]	50.4	Published figure 1.568 kg CO2/t. *CO2 emission factor for tyres and rubber used in the cement industry.* The published value has been converted to kgCO2/GJ_{gross} using the conversion 31.1 kg CO2/GJ
National Accounts New Zealand [13]	61.83	Published value 61.13 kgCO2/GJ_{net}. The published figure has been expressed as kg CO2/GJ_{gross} using the adjustment GCV = NCV +0.212H% where H% = 3.4
National Accounts United Kingdom [4]	53.6	Published value 1.669kt CO2/Mt. *CO2 emission factor for scrap tyres used in the cement industry.* The published value has been converted to kgCO2/GJ_{gross} using the conversion 31.1kg CO2/GJ

Table 5 – Pathway 1, Literature, Total carbon content of end-of-life tyres

Data Source	Carbon %	Comments
Juma et al [10]	68.6	Published value 81.24. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
L Rodrigues et al [10]	74.2	Published value 74.2.Includes steel and ash content
Jong Min Lee et al [10]	70.7	Published value 83.8.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Yu Ming Chang et al [10]	74.4	Published value 74.4.Includes steel and ash content
Gonzales et al [10]	73.2	Published value 86.7.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Chen et al [10]	68.5	Published value 81.16.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Berrueco et al [10]	74.7	Published value 88.5.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Arion et al [10]	73.8	Published value 73.8.Includes steel and ash content
Loresgoiti et al [10]	74.2	Published value 74.2.Includes steel and ash content
Orr et al [10]	68.6	Published value 81.3.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Williams and Botrelli [10]	72.4	Published value 85.8.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Lanoir et al [10]	69.7	Published value 82.63.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Senneca et al [10]	73.2	Published value 86.7.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Roy et al [10]	73.1	Published value 81.24.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Cunliffe and Williams [10]	72.9	Published value 86.4.Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Aliapur [9]	69	Published value 69. Passenger car tyres sourced from France. Samples of shredded passenger car tyres taken from 6 different locations in France
Aliapur [9]	61	Published value 61.Truck tyres sourced from France. Samples of shredded truck tyres taken from 2 different locations in France.
Passenger car tyre average = 71.9% Truck tyre single value = 61%		

Table 6 – Pathway 2 Literature, Total CO2 emission excluding biomass of end-of-life tyres

Data Source	Emission factor excluding biomass kg CO2/kg	Comments
Japan Automobile Tyre Manufacturers Association [12]	1.980	Published values for passenger car tyres are 2.127 kg CO2/kg for so called general tyres and 1.833 kg CO2/kg for so-called fuel-efficient tyres. The published values have been averaged
Japan Automobile Tyre Manufacturers Association [12]	1.210	Published values for truck tyres are 1.247 kg Co2/kg for so called general tyres and 1.173 kg CO2/kg for so-called fuel-efficient tyres. The published values have been averaged
Aliapur [9]	1.8	Published value for passenger car tyres 1.8 t CO2/t. *Samples of shredded passenger car tyres taken from 6 different locations in France.* 31.1kg CO2/GJ
Aliapur [9]	1.1	Published value for truck tyres 1.1 t/t. *Samples of shredded passenger car tyres taken from 6 different locations in France.* 31.1kg CO2/GJ
Passenger car tyre average = 1.890 kgCO2/kg Truck tyre average = 1.155 kgCO2/kg		

Table 7 – Pathway 3 National Accounts, Total CO2 emission factor including biomass of end-of-life tyres

Data Source	Emission factor including biomass kgCO2/GJ $_{gross}$	Comments
National Accounts Latvia [4]	80.5	Published value 79.4 tCO2/TJ $_{net}$. *CO2 emissions factor for used tyres in the cement industry.* The published figure has been expressed as kg/GJ $_{gross}$ using the adjustment GCV = NCV +0.212H% where H% = 3.4
National Accounts Spain [4]	82	Published value 82 tCO2/TJ $_{net}$. *CO2 emissions factor for used tyres in the cement industry.* The published figure has been expressed as kg/GJ $_{gross}$ using the adjustment GCV = NCV +0.212H% where H% = 3.4
National Accounts Mexico [4]	85.1	Published value 84442 kgCO2/TJ $_{net}$.*CO2 emission factor for waste tyre combustion.* The published figure has been expressed as kg/GJ $_{gross}$ using the adjustment GCV = NCV +0.212H% where H% = 3.4
National Accounts Germany [5]	89.1	Published value 88.4 tCO2/TJ $_{net}$. The published figure has been expressed as kg/GJ $_{gross}$ using the adjustment GCV = NCV +0.212H% where H% = 3.4

National Accounts United States [6]	82.6	Published value 85.97 kgCO2/mmBtu The published figure has been expressed as kg/GJ $_{gross}$ using the adjustment GCV = NCV +0.212H% where H% = 3.4 and the conversion factor 1.06GJ = 1mmBTU
National Accounts Australia [1]	81.6	Published value 81.6 kgCO2/GJ $_{gross}$ *Industrial materials and tyres that derived from fossil fuels, if recycled and combusted to produce heat and electricity*
Overall average = 83.5 kgCO2/GJ $_{gross}$		

Table 8 – Summary of corrections used in pathway calculations

Data set	Passenger Tyre	Truck Tyre	Reference
Biomass content (%)	23.1	31.5	Table 10
Calorific value (GJ/t)	32.0	27.1	Table 11

Table 9 – Summary of adjustments used in pathway calculations

Data set	Passenger Tyre	Truck tyre	Reference
Ash content (%)	3.4	-	Table 12
Steel content (%)	12.2	25.5	Table 13
Hydrogen content (%)	6.2	-	Table 14

Table 10 – Biomass content of end-of-life tyres

Data Source	Biomass %	Comments
World Business Council for Sustainable Development Cement Sustainability Initiative [7]	27	*"This value coincides with default values set in different European countries like Austria or Germany for the reporting within the European Emissions Trading Scheme."* Default value determined from the average of 44 data sources.
EU Commission Directorate [8]	20-30	The EU directive cites *"the typical values informally reported"*
L Rodriguez et al [11]	21.5-22.9	Passenger car tyres sourced from Spain. In the Spanish study one sample set consisted of 200 passenger car tyres (1.62 tonnes) taken as representative of the market as well as a further sample set of 190-210 (1.58 tonnes) passenger car tyres taken at random for testing. The reference includes the study outcomes from Aliapur. These results are excluded and reported separately
L Rodriguez et al [11]	33.7-34.1	Truck tyres sourced from Spain. In the Spanish study a sample set of 30 (1.67 tonnes) of truck and bus tyres were tested. The reference includes the study outcomes from Aliapur. These results are excluded and reported separately.
Aliapur [9]	18.3	Passenger car tyres sourced from France. Samples of shredded passenger car tyres taken from 6 different locations in France
Aliapur [9]	29.1	Truck tyres sourced from France. Samples of shredded truck tyres taken from 2 different locations in France.
Passenger car tyre average = 23.1% Truck tyre average = 31.5%		

Table 11 – Calorific value of end-of-life tyres

Data Source	Gross Calorific value GJ/t	Comments
World Business Council for Sustainable Development Cement Sustainability Initiative [7]	31.7	Value determined from the average of 44 data sources. The net calorific value, 31 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
EU Commission Directorate [8]	26-36	The EU directive cites *"the typical values informally reported "* The net calorific value, 25-35 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
Aliapur [9]	30.9	Passenger car tyres sourced from France. Samples of shredded passenger car tyres taken from 6 different locations in France The net calorific value, 30.2 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
Aliapur [9]	27.1	Truck tyres sourced from France. Samples of shredded truck tyres taken from 2 different locations in France. The net calorific value, 26.4 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
US EPA [6]	33	Passenger car tyre The net calorific value, 32.3 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
Japan Automobile Tyre Manufacturers Association [12]	33.9	Value appears to be based upon experience using tyres as an energy source in the pulp and paper industry in Japan The net calorific value, 33.2 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
I de Marco Rodriguez et al [15]	31.8	Reported as GCV
Brian McGrath, Blue Circle Southern Cement [16]	30.7	Experience on an operating cement kiln between 1994 and 2014 using passenger car tyres. The end-of-life tyre calorific value was back calculated from the quantity of natural gas replaced The net calorific value, 30 has been converted to gross calorific value using the formula GCV = NCV +0.212 H% where H% = 3.4
Passenger car tyre average = 32.0 GJ/t Truck tyre single value = 27.1 GJ/t		

Table 12 – Ash content of end-of-life tyres

Data Source	Ash %
Jong Min Lee et al [10]	3.7
Gonzales et al [10]	2.9
Chen et al [10]	7.44
Orr et al [10]	1.4
Williams and Botrelli [10]	2.4
Senneca et al [10]	3.3
Cunliffe and Williams [10]	2.4
I de Marco Rodriguez et al [15]	3.9
Passenger car tyre average = 3.4%	

Table 13 – Steel content of end-of-life tyres

Data Source	Steel %	Comments
Basel Convention Working Group [14]	16.5	Passenger car tyre
Basel Convention Working Group [14]	25	Truck tyre
L Rodriguez et al [11]	11-12	Passenger car tyre. Cited as Fe content
L Rodriguez et al [11]	25-27	Truck tyre. Cited as Fe content
I de Marco Rodriguez et al [15]	9.6	Passenger car tyre
US EPA [6]	11	Passenger car tyres
Passenger car tyre average = 12.2% Truck tyre average = 25.5%		

Table 14 – Hydrogen content of end-of-life tyres

Data Source	Hydrogen %	Comments
Juma et al [10]	6.21	Published value 7.36%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
L Rodriguez et al [10]	5.8	Published value 5.8%. Includes steel and ash content
Jong Min Lee et al [10]	6.4	Published value 7.6%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Yu Ming Chang et al [10]	5.88	Published value 6.96%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Gonzales et al [10]	6.8	Published value 8.1%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Chen et al [10]	6.10	Published value 7.22% Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Berrueco et al [10]	5.6	Published value 6.6%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Arion et al [10]	5.3	Published value 5.3%. Includes steel and ash content
Loresgoiti et al [10]	5.8	Published value 5.8%. Includes steel and ash content
Orr et al [10]	6.2	Published value 7.3%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Williams and Botrelli [10]	6.8	Published value 8.0%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Lanoir et al [10]	6.3	Published value 7.5%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Senneca et al [10]	5.8	Published value 6.9% Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Roy et al [10]	6.8	Published value 8.1%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
Cunliffe and Williams [10]	6.8	Published value 8.0%. Corrected for ash content assumed at 3.4% and steel content at 12.2% for a total correction of 15.6%
I de Marco Rodriguez et al [15]	5.8	Published value 5.8%. Includes steel and ash content
Passenger car tyre average = 6.2%		

Conclusions and Recommendations

The major finding of this investigation is that there is a case for end-of-life tyres to be listed in the National Greenhouse Accounts as a standalone fuel with a designated emission factor that recognises the biogenic nature of the raw materials used in their manufacture.

It was identified that the different categories of end-of-life tyres (passenger car, truck, off-the road) have compositional differences, principally the natural rubber content, that influence the carbon emission factor.

The emission factor for passenger car tyres is in the range 59.0 kgCO2/GJ to 64.2 kgCO2/GJ.

The emission factor for truck tyres is in the range 42.6 kgCO2/GJ to 56.5 kgCO2/GJ. The truck tyre emission factors are based upon very limited data compared to the passenger car tyre emission factors.

There is no data available from the literature for emission factors for off-the-road tyres. It is expected that due to their natural rubber content, off-the-road tyres would have an emission factor comparable to truck tyres. More research is required to establish a representative emission factor for off-the-road tyres.

Three jurisdictions were identified in the search as having adopted a designated emission factor for end-of-life tyres that considers their biogenic content. The values chosen by those jurisdictions were 50.4 kgCO2/GJ, 53.6 kgCO2/GJ and 61.83 kgCO2/GJ. The current emission factor for end-of life tyres in the Australian National Greenhouse Accounts is 81.6 kgCO2/GJ.

It is recommended that the Department of Industry, Science, Energy and Resources, the responsible authority for setting the emission factors, considers the evidence provided in this technical note with a view to revise the current value to one that better reflects the greenhouse gas impact of combusted end-of-life tyres.

References

1. Australian Government Department of Industry, Science, Energy and Resources, *National Greenhouse Accounts Factors*, June 2020 (https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2020)

2. Randell Environmental Consulting Pty Ltd, *Used Tyres Supply Chain and Fate Analysis* prepared for Tyre Stewardship Australia, June 2020 (https://www.tyrestewardship.org.au/wp-content/uploads/2020/06/Used-Tyres-Supply-Chain-and-Fate-Analysis-1.pdf)

3. USDA Foreign Agricultural Service Global Agricultural information *Network Australia Biofuels Annual,* November 2018, (https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_Canberra_Australia_11-7-2018.pdf)

4. Intergovernmental Panel on Climate Change *Emission Factor Data Base - Industrial Wastes* displayed records 1-31 (https://www.ipcc-nggip.iges.or.jp/EFDB/find_ef.php

5. Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2020 German Environment Agency *National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2018*- UNFCCC-Submission 15 April 2019, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-04-15-climate-change_23-2020_nir_2020_en_0.pdf

6. U.S. Environmental Protection Agency Office of Resource Conservation and Recovery *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)* Tires May 2019 (https://www.epa.gov/sites/production/files/2020-12/documents/warm_tires_v15_10-29-2020.pdf)

7. World Business Council for Sustainable Development Cement Sustainability Initiative *CO2 and Energy Accounting Standard for the Cement industry* May 2011 version 3 (http://docs.wbcsd.org/2011/05/CSI-CO2-Protocol.pdf)

8. EUROPEAN COMMISSION DIRECTORATE-GENERAL CLIMATE ACTION Directorate A – *Monitoring, Reporting, Verification Frequently Asked Questions Regarding Monitoring and Reporting in the EU*, International and Climate Strategy CLIMA.A.3 - ETS Version of 16 December 2013 (https://ec.europa.eu/clima/sites/default/files/ets/monitoring/docs/faq_mmr_en.pdf)

9. R&D ALIAPUR. A *Using used tyres as an alternative source of fuel* [Internet] 2009. https://www.aliapur.fr/sites/default/files/files/RetD/Extract_-_Used_tyres_

10. M. Juma, Z. Koreňová, J. Markoš, J. Annus, Ľ. Jelemenský Institute of Chemical and Environmental Engineering, Faculty of Chemical and Food Technology, Slovak University of Technology, *Pyrolysis and Combustion of Scrap Tire* (https://www.researchgate.net/publication/26499998_Pyrolysis_and_combustion_of_Scrap_tyre)

11. Leticia Saiz Rodríguez, José M. Bermejo Muñoz, Adrien Zambon and Jean P. Faure *Determination of the Biomass Content of End-of-Life Tyres* Biomass Volume Estimation and Valorization for Energy Jaya Shankar Tumuluru Books on Demand, 22 Feb 2017 - Technology & Engineering (https://www.intechopen.com/books/biomass-volume-estimation-and-valorization-for-energy/determination-of-the-biomass-content-of-end-of-life-tyres)

12. The Japan Automobile Tyre Manufacturers Association, Inc. *Tyre LCCO2 Calculation Guidelines Ver. 2.0* April 2012 (https://www.jatma.or.jp/english/tyrerecycling/pdf/lcco2guideline_en.pdf)

13. Impact Summary: NZ ETS regulation updates 2018 *The default emissions factor for combusting used tyres for energy.* (https://environment.govt.nz/assets/Publications/2018-NZ-ETS-regs-updates-used-tyre-DEF-impact-summary.doc)

14. Basel Convention *Technical Guidelines on the Identification and Management of Used Tyres* Basel Convention series/SBC No. 02/10First Published in October 2000 and reprinted in November 2002 (http://archive.basel.int/meetings/sbc/workdoc/old%20docs/tech-usedtyres.pdf)

15. Isabel de Marco Rodriguez), M.F. Laresgoiti, M.A. Cabrero,A. Torres, M.J. Chomo´n, B. Caballero *Pyrolysis of scrap tyres* Fuel Processing Technology 72 Ž2001 (https://www.researchgate.net/publication/26499998_Pyrolysis_and_combustion_of_Scrap_tyre)

16. Brian McGrath, Blue Circle Southern Cement *Personal experience of the author*

Australian National Greenhouse Accounts and End-Of-Life Tyre Combustion Emission Factor

Tyre Stewardship Australia

Author
Brian McGrath

Report Disclaimer

TyreStewardship AUSTRALIA

Australian Government Accredited Product Stewardship Scheme

2/59 Keele Street, Collingwood, VIC 3066

getonboard@tyrestewardship.org.au