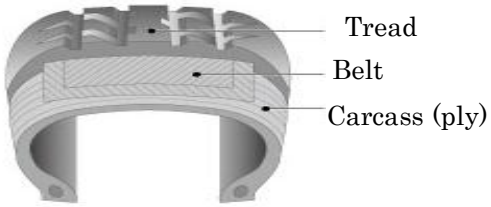
ICCA-WBCSD Avoided Emissions Guidance Case Study

Materials for Fuel Efficient Tires, Japan Chemical Industry Association (JCIA)

1. **Purpose of Study** LCA practitioner :JCIA, LCA commissioner: JCIA

Fuel efficient tires enable the fuel consumption of automobiles to be reduced by making their rolling resistance lower, and they contribute greatly to CO_2 emissions reduction. The goal of the study is to compare fuel efficient tires with conventional tires. Fuel efficient tires reduce the fuel consumption of automobiles by reducing their rolling resistance, and they contribute greatly to CO_2 emissions reduction in the transportation sector.

With regard to improvements in fuel consumption, the tread portion that comes directly into contact with the ground makes a great contribution to the improvements, whereas at the same time the tread portion is required to have gripping performance (braking performance). Chemical products play a great role in meeting the contradictory requirements for performance in which fuel consumption is improved and gripping performance is maintained. The tread portion uses rubber compounds that contain rubber chemicals such as natural rubber and synthetic rubber such as SBR (styrene-butadiene rubber), fillers such as carbon black and silica, silane coupling agents, etc. SBR transforms the physical properties by controlling the primary construction of polymers. It has the function of reducing the loss of energy caused by tire friction while an automobile moves, and this function contributes to the improvements in fuel consumption. Also, the addition of silica has become an important point in making reduced rolling resistance compatible with maintaining grip.



2. **Level in the value chain**

This study focuses on automobiles with fuel efficient tires and conventional tires.Thus, the level in the value chain is the end-use level according to the Guidance Document.

3. **Solution to compare**

The study compares two alternatives for automobiles in Japan - ones with fuel efficient tires and ones with conventional tires. It is assumed that the conventional tire is the implemented technoglogy mix. The differences between the two alternatives are considered in this analysis i.e. the production of the automobile, the CO_2 emissions during the use of the automobile and the disposal/recycling of the automobile at the end of its defined service life. Emissions from identical processes/materials for all alternatives such as the production phase of automobiles and disposal/recycling of automobiles are balanced out in calculating the difference between emissions in each phase, using a simplified calculation method. The market share for fuel efficient tires in 2010 was 19%, and the expected market share in 2020 will be 86%.

4. Functional Unit

4-1 Description of the Function and the Function unit

●Function

Passenger cars carry　passengers.

Trucks/buses carry　passengers or freight.

●Functional unit

Service life of tires was defined below as driving distance.

- Service life of tire for passenger cars (PCR): 30,000km
- Service life of tire for trucks/ buses (TBR): 120,000km

4-2 Quality Requirement

Two alternatives considered in this study to fulfil the same function and meet the minimum requirements concerning mechanical, safety properties.

4.3 Time and geographic reference

Data of the year 2012 in Japan is　considered. Moreover, avoided emissions in 2020 are estimated using the 2012 data and an assumed 16% growth rate.

5. Calculation Methodology

a. System boundaries

The entire life cycle of automobiles is considered, namely from the phases of the procurement to disposal.

An assessment was made on each of the fuel efficient tires and conventional tires. Note that regarding the use phase of the automobile, the amount of fuel consumed (fuel economy) by　the automobile has been calculated.

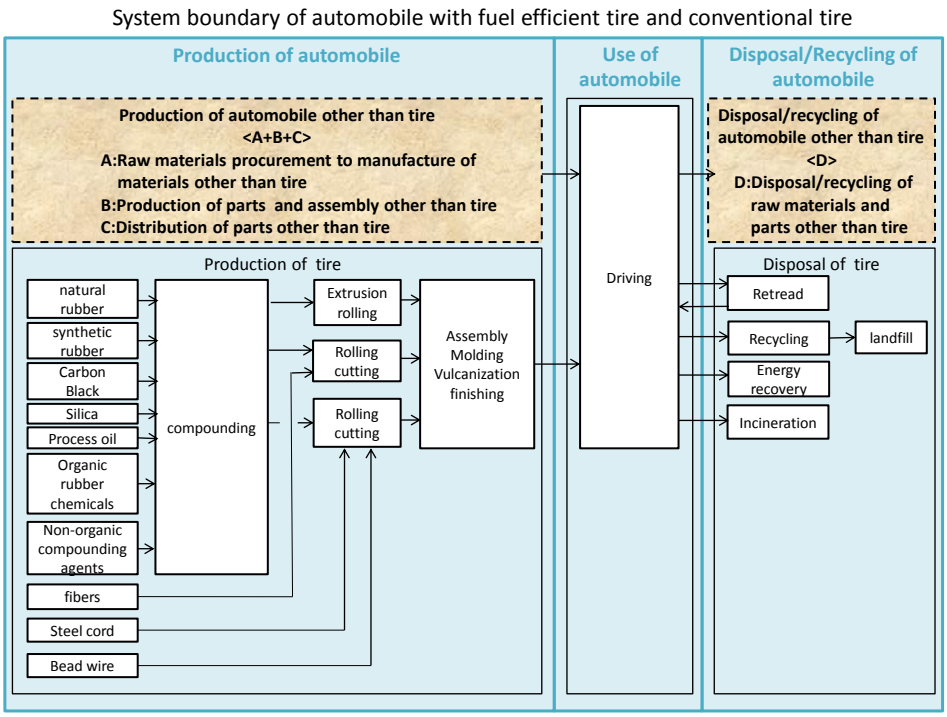


Fig.1. System boundary of automobile with fuel efficient tires and conventional tires

Legend

This process/material is considered in this analysis.

This process/material is identical for all altenatives in this analysis.

b.Preconditions[1]

Preconditions of automobile in the use phase and end of life scenario for tires are shown as follows. Table 1[1] shows the avoided CO_2e emissions per automobile at the use phase.

[1] "LCCO$_2$ Calculation Guidelines for tires, Ver. 2.0" of the Japan Automobile Tire Manufacturers Association, Inc. (general incorporated association).

Table 1. Avoided CO_{2e} emissions per automobile in the use phase

Item	PCR		TBR	
	Conventional tire	fuel efficient tire	Conventional tire	fuel efficient tire
Fuel consumption while driving (l/km)*	0.1	0.0975	0.25	0.2375
Number of tires fitted	4		10	
Service life of tire (km)	30,000		120,000	
Amount of fuel used (l)	3,000	2,925	30,000	28,500
CO_{2e} emissions coefficient for fuel (kg-CO_2e/l)	Volatile oil (gasoline); 2.81		Diesel; 2.89	
CO_{2e} emissions per automobile during the usage phase (kg-CO_2e/unit)	8,430	8,219	86,700	82,365
Avoided CO_{2e} emissions (kg-CO_2e/unit)		▲211		▲4,335
Avoided CO_{2e} emissions per tire (kg-CO_2e/tire) GWP (100 years time horizon) in IPCC 2007 is used.		▲52.75		▲433.5

LCI data are taken from $LCCO_2$ Calculation Guidelines for tires, Ver. 2.0" of the Japan Automobile Tire Manufacturers Association, Inc. (general incorporated association).

*Although the fuel economy in actual driving varies with the car model and driving conditions, these numerical values are typical values based on experiments/literature.

Figure 2. shows the disposal/ recycling ratio of used tires for PCR and TBR.
75% of used tires are utilized as heat and 25% of these are incinerated for the PCR.
For TBR,in addition to utilization of heat and incineration,retread and material recycling are conducted.

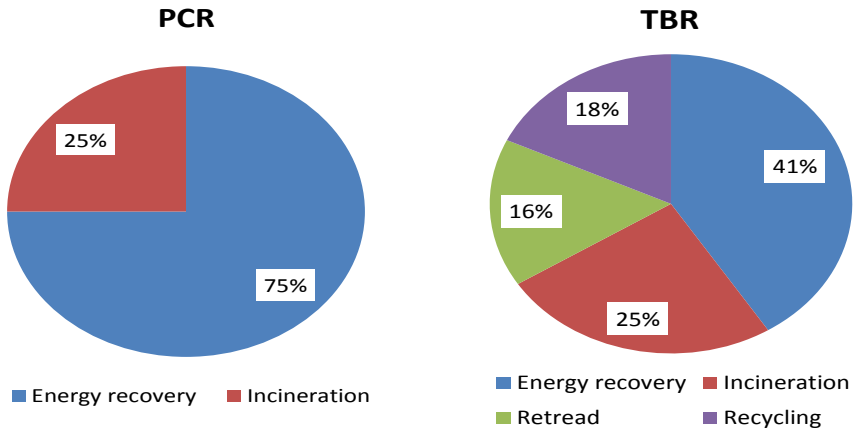


Fig.2. End of life scenario

Data sources and quality

The Life Cycle Inventory (LCI) data are taken from the database of "LCCO$_2$ Calculation Guidelines for tires, Ver. 2.0" of the Japan Automobile Tire Manufacturers Association, Inc. (general incorporated association).

6. Results

The results for passenger cars and trucks/buses fitted with fuel efficient tires and conventional tires are shown in Table 2. Note that the CO_2e emissions of tires in the phases from the collection of raw materials through production and distribution as well as use phase to disposal/recycling have been cited from the "LCCO$_2$ Calculation Guideline for tires, Ver. 2.0" of the Japan Automobile Tire Manufacturers Association, Inc. (general incorporated association).

Table2. Avoided CO_{2e} emissions per automobile (kg-CO_{2e}/unit)

phase	PCR			TBR		
	a. Fuel efficient tires	b. Conventional tires	Avoided CO_{2e} emission(b-a)	a. Fuel efficient tires	b. Conventional tires	Avoided CO_{2e} emission (b-a)
Manufacture*	95.6 + A	100 + A	4.4	1397 + A	1480 + A	83
Production	28.0 + B	31.2 + B	3.2	352 + B	356 + B	4
Distribution	6.0 + C	6.4 + C	0.4	101 + C	104 + C	3
Use	8,219	8,430	211	82,365	86,700	4,335
disposal/recycling	2.8 + D	11.6 + D	8.8	-309 + D	-311 + D	-2
Entire life cycle	8,351.4+A+B+C +D	8,579.2+A+B+C +D	**227.8**	83,906 +A+B+C+D	88,329 +A+B+C+D	**4,423**

**Manufacture :From raw material procurement to manufacture of material*

Note: A: CO_{2e} emissions during the phase of raw material procurement to the manufacture of materials other than tires that are used in automobiles, B: CO_{2e} emissions during the phase of the production of parts other than tires, C: CO_{2e} emissions during the phase of distribution of parts other than tires, D: CO_{2e} emissions during the phase of the disposal/recycling of raw materials and parts other than tires.

The avoided emissions are calculated as the difference between the emissions of automobiles fitted with fuel efficient tires and conventional tires. A,B,C,D are identical with each other, thus are balanced out in calculating the difference between emissions in each phase, based on the simplified calculation method.

7. Significance of contribution

The focus product of this study,namely rubber chemicals,fundamentally contributes to the GHG emissions avoidance effect of the solution since it is the key material in the tire, providing the function reducing the loss of energy caused by tire friction while an antomobile moves.

Nevertheless, avoided emissions calculated at the final solution level are attributed to the complete value chain,and not only to the chemical industry.

8. Review of results

This summary is cited from the booklet entitled "Life Cycle Analysis of Chemical Products in Japan and around the world". In October, 2012, the draft of the booklet was presented to a panel of four experts in the field of LCA and their opinions were solicited. The four experts in charge of the review did not cover all elements of an LCA peer review as described in ISO guidelines. While the review focused on methodology only, we believe the data and the results shown are representative and well supported. Opinions of panel of experts concerning the cLCA Report

ⅰ)With regard to CO_{2e} emissions during the stage of disposal/recycling of tires for passenger vehicles, emissions from fuel efficient tires and ones from conventional tires are given as follows.

conventional tires: 2.9 kg CO_{2e}/tire, fuel efficient tires: 0.7 kg CO_{2e}/tire.

What are the details of these figures?

ⅱ)Explanation of the settings of the market size of fuel efficient tires in 2020

It is desirable that the scenario should be described in an easy-to-understand way.

Response to the results of the review

ⅰ) CO_{2e} emissions during the stage of disposal/recycling -

The explanations have been done using the following table.

Table3. GHG emissions and the reduction in emissions during the stage of disposal/recycling (unit: kgCO_{2e}/4 tires)

		Conventional tyres	Fuel efficient tyres
Proportion of recycling	Thermal utilization	75%	75%

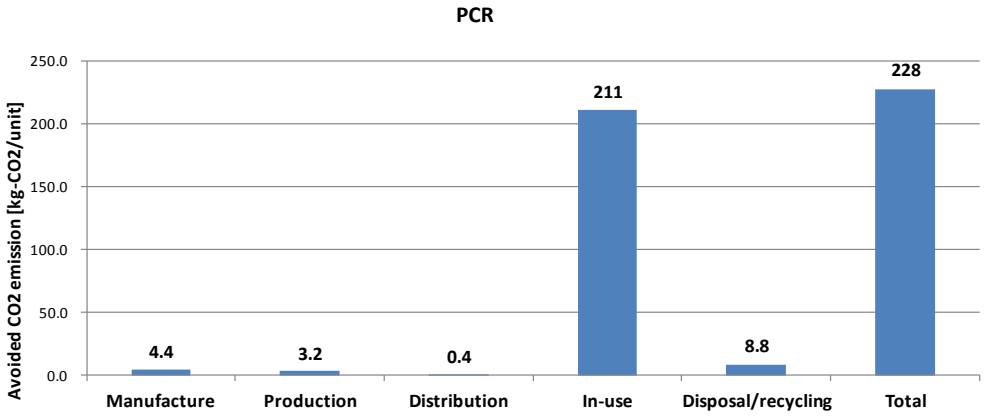
	Except recycling	25%	25%
GHG emissions	Transportation for procurement	1.6	1.6
	Thermal utilization)	46.8	38.4
	Simple incineration	15.6	12.8
	Total	**64.0**	**52.8**
Reduction in emissions	Thermal utilization[c)]	**-52.4**	**-50.0**
CO_2 emissions during disposal/recycling phase		**11.6**	**2.8**

ii)Market size of fuel efficient tires in 2020 - Corrections have been made to the explanations concerning the quantity of fuel efficient tires expected to be sold annually in 2020.

9. Scenario Analysis :Evaluation of the impact of the A,B,C,D on the results of the analysis

Total emissions of identical parts ,A,B,C,D make up 20%[2] of the complete life emissions for PCR and 8%[3] of the complete life emissions for TBR.
Omitting emission of A,B,C,D does not change the overall conclusion of the study, due to the fact that these processes are identical for the two alternatives and the absolute emissions avoidance remains the same.

- PCR
  - Avoided CO_{2e} emissions per passenger cars: 227.8kg-CO_{2e}/4 tires
  - Avoided CO_{2e} emissions per tire: 57.0kg-CO_{2e}/tire



[2] Website of MAZDA MOTOR CORPORATION
http://www.mazda.co.jp/csr/environment/management/lca_measures.html

[3] Website of HINO Motors LTD.
http://www.hino-global.com/j/csr/environment/activity/lca.html

- TBR
  - Avoided CO_{2e} emissions per trucks/buses: 4,423 kg-CO_{2e}/10 tires
  - Avoided CO_{2e} emissions per tire：442.3 kg-CO_{2e}/tire

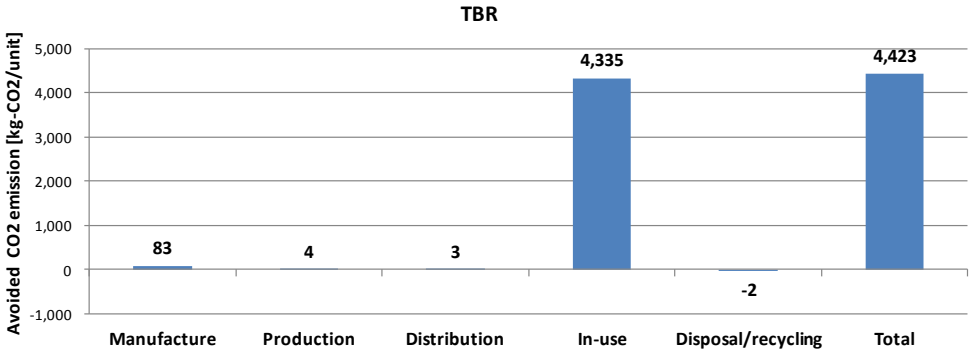


Fig.3 Avoided CO_{2e} emissions per the automobile with PCR and TBR

10. Extended estimates

Demand forecast for fuel efficient tires in Japan (2020): 78,000 thousand tires
The quantity of tires expected to be sold annually in 2020 has been specified as 78,000 thousand tires, assuming that annual growth is 2% in addition to the 70,000 thousand tires that is the quantity of fuel efficient tires expected to be sold annually in 2015 [4]

●Tires for passenger cars: 73,000 thousand tires
●Tires for trucks/buses: 5,000 thousand tires

Avoided CO_{2e} emissions by fuel efficient tires to be sold in 2020: 6.37 million t-CO_{2e}

- Tires for passenger vehicles
  57.0 kg-CO_{2e}/tire × 73,000 thousand tires = 4.16 million t-CO_{2e}
- Tires for trucks/buses
  442.3kg-CO_{2e}/tire × 5,000 thousand tires = 2.21 million t-CO_{2e}

11. Study Limitation and Future Recommendations

The results of this analysis are dominated by the use phase, i.e. fuel consumption while driving and service life of tire. Therefore, these results are sensitive to the car model and driving conditions. Thus the results of this study cannot be applied

unreservedly to unnatural conditions.

[4] " Current Situation Concerning Plastic Highly Functional Materials and Future Outlook in 2001" Fuji Chimera Research Institute,Inc.