Circular Economy in Thai Rubber Industry for Motorcycle Tires Productions

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***Abstract*—This paper demonstrates the greenhouse gas reduction potential of the rubber industry producing motorcycle tires. By studying the potential of greenhouse gas reduction from the feasibility of circular economy measures. It was found that the motorcycle tire manufacturing industry could follow the concept of the circular economy for 2 models. Model 1: Circular Supplies Chain is the use of reclaimed rubber as a raw material to replace the use of some new rubber. The partial use of recycled carbon powder as raw material for tire production. This model has the potential to reduce greenhouse gas emissions in the factory by 825 tCO_2e. Model 2: Resource Recovery is the use of scrap rubber taken from the external rubber production process. The canvas attached to the rubber is sold to the recycling factory to add value or expand into other products such as pickup truck rubber. Using off-specification ex-ternal rubber and off-specification inner rubber to burn for energy which has the potential to reduce greenhouse gas emissions in the factory by 361 tCO_2e. All greenhouse gas reduction obtained from the circular economy measures is 1,186 tCO_2e. This implemented circular economy models can be applied and expanded to other factories.**

***Index Terms*—Circular economy, rubber industry, circular supplies, resource recovery, greenhouse gas emission**

I. Introduction

Thailand announced its determination to reach the national target of lowering net carbon dioxide emissions to zero or toward carbon neutrality by 2050 as it participated in the 26th session of the Conference of the Parties (COP 26) to the United Nations Framework Convention on Climate Change (UNFCCC). Government policy focuses on industrial development under the concept of Bio-Circular-Green (BCG) Economy. Therefore, it is regarded as one of the mechanisms to propel the country's economic development instead of Thailand's traditional economic system which is a linear economy that requires a large amount of resources to pro-duce goods and services to be passed on to consumers use and dispose of as garbage after use without reusing. This results in the increase in more greenhouse gas emissions including environmental problems. The circular economy focused on the reuse of raw materials and by-products, so that waste from production processes can be recycled or reused to use natural resources for maximum benefit. For the global rubber industry, Thailand is the second most important production and export base after China. From the data of the Office of Industrial Economics in 2021, the 3rd quarter (July-September), Thailand produced 498,874 tons of processed rubber, which increased from the second quarter of 2021 in 22.15% and increased 7.40% compared to 2020 during same time. Vehicle tire production in 2021, 3rd quarter (July-September), Thailand produced 40,340 million vehicle tires, a decrease of 12.80 percent from the second quarter of 2021, but an increase of 20.56 percent com-pared to the year 2020 in the same period as shown in Table I.

TABLE I: Volume of Rubber Products in Thailand, 2020–2021

Rubber Product (thousand pieces)	Year 2020	Year 2021		
	Q4	Q1	Q2	Q3
1. Bicycle external tire	6,067	6,852	6,656	5,883
2. Motorcycle external tires	7,026	7,273	6,776	5,437
3. Truck external tire	1,705	1,739	1,728	1,749
4. Passenger car external tires	10,835	11,116	10,866	10,360
5. Other external tires	351	407	423	324
6. Bicycle inner tire	7,020	7,096	7,759	6,705
7. Motorcycle inner tires	12,070	11,633	11,475	9,337
8. Truck inner tire	357	429	312	304
9. Rubber pad	298	305	266	241
Total	45,730	46,851	46,262	40,340

From Table I, it was found that Thailand has a wide variety of rubber products and a large quantity. The production of rubber products consists of raw materials such as synthetic rubber, natural rubber, carbon black, zinc oxide, sulfur, extender oil and additives. In the production of rubber products, waste is generated during the production process. Disposal of waste generated during the production process of rubber products which making it a wasteful use of natural resources It is important to reuse waste in the production process which can reduce the use of natural resources, reduce greenhouse gas emissions and costs. So, the implementation of the circular economy concept in the rubber industry is important and can be a model in other industries.

II. Data and Method

The goals and guidelines of the circular economy are to maximize the value of resources while minimizing the use of new resources by creating a series of circular approaches ranging from re-process, re-design, added value, innovation, collaboration with business and non-business related and reuse. The model is building better values and a more sustainable environment, community, society, and business.

A. Circular Economy Models

For circular economy system, there are two main cycles,

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the technical cycle and the biological cycle. In the technical cycle, products and materials are kept in circulation through processes such as reuse, repair, remanufacture and recycling. In the biological cycle, the nutrients from biodegradable materials are returned to the Earth to regenerate nature such as extraction of biochemical feedstock, anaerobic digestion, biogas, farming and biochemical feedstock. A concept that encourages the best use of existing things or resources. It is planned that the items we use can be restored to their original condition or ready to be reused including designing a form of use. There are five type of business models were used for driving towards the circular economy concept that shown in Fig. 1 and, details as follows:

- **Circular Supplies Chain** uses recycled Bio-based materials and recyclable materials serve as input to reduce the use resources and reduce waste, and use renewable energy in the process.
- **Resource Recovery** "Take-Back system" was designed to bring leftover raw material or disposal goods into to new process for reducing waste as much as possible.
- **Circular Design** focuses on designing long-life products or components.
- **Sharing Platform** focus on using and sharing resources for product optimization.
- **Product as a Service** is a business model providing rental services or "pay-for-use" instead of purchasing the whole product which is not only reduce cost of the service user but also reduce environmental impacts.

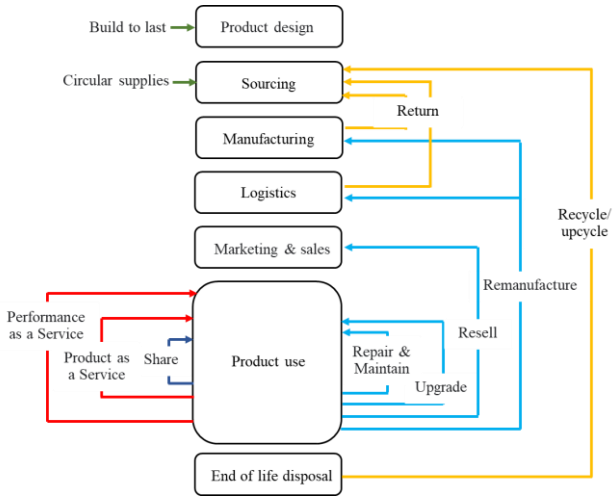

Fig. 1. Circular value chain, models, and sub-models.

B. Methodology

Assessment of greenhouse gas reduction from circular economy operations is shown in Eq. (1). Circular supplies chain model operates by shifting from virgin material to circular raw material. A baseline case of Greenhouse Gas (GHG) reduction potential assessment is shown in Fig. 2. A circular economy of circular supplies chain model covering industrial waste and others is presented in Fig. 3.

$$\text{Net GHG reduction} = \text{GHG from base case} - \text{GHG from CE scenario} \quad (1)$$

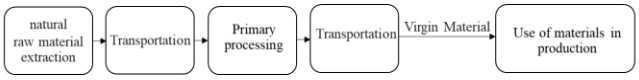

Fig. 2. Base case of circular supplies chain model.

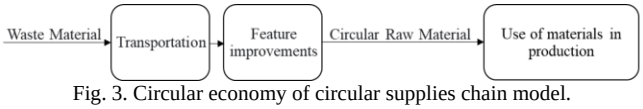

Fig. 3. Circular economy of circular supplies chain model.

Resource recovery model which is reduction of waste disposal from the pro-duction process and recovery of resource materials. The baseline case of GHG reduction potential assessment is shown in Fig. 4. A circular economy scenario of remanufacturing or reuse is also presented in Fig. 5. A circular economy of resource recovery model is shown in Fig. 6.

Fig. 4. Base case of resource recovery model.

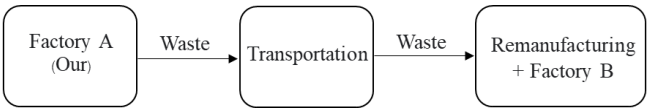

Fig. 5. Circular economy of resource recovery model (Remanufacturing / Reuse).

Fig. 6. Circular economy of resource recovery model (Recycle).

C. Scope

The circular economy framework will follow framework for implementing the principles of the circular economy in organizations—Guide. (BS 8001:2017) The circular economy framework consists of 8 steps: Framing, Scoping, Idea generation, Feasibility, Business Case, Piloting and prototyping, Delivery and implementation and Monitor, review and report. This study will proceed to the feasibility stage. After that, analysis of the amount of greenhouse gas emissions according to the Carbon Footprint for Organization (CFO) will be assessed. Greenhouse gas reduction potential from circular economy measures of the rubber industry will be analyzed. Conducting a CFO to consolidate its GHG emissions and removals into its inventory within its operational boundary. These GHG emissions and removals can be categorized into 3 scopes as the following:

- **Scope 1,** Direct GHG emissions/ removal include GHG emissions/removal from sources owned or controlled by the organization such as stationary combustion, mobile combustion, fugitive emissions and others
- **Scope 2,** Energy indirect GHG emissions are GHG emissions from the generation of purchased electricity, heat or steam consumed by the organization
- **Scope 3,** Other indirect GHG emissions are GHG emissions other than energy indirect emissions resulting from an organization's activities, but arising from sources that are owned or controlled by other organizations.

D. Material Flow Analysis

From the concept of circular economy in methodology topic, can be applied with production of rubber. The production of rubber consists of external tire and inner tire with raw materials such as natural rubber, synthetic rubber, reclaimed rubber, compound B, chemical, filter and other raw materials. Figs. 7 and 8 show the production of external tire

and inner tire, respectively.

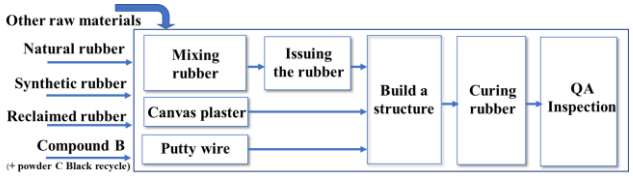

Fig. 7. Production of external tire of rubber industry.

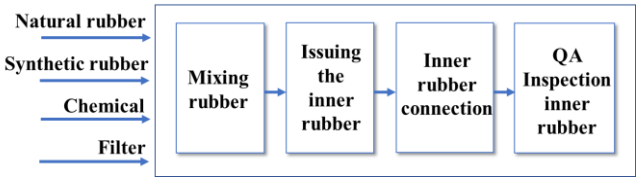

Fig. 8. Production of inner tire of rubber industry.

It was found that the rubber industry already used reclaimed rubber or recycled carbon powder as raw materials. This was a circular economy measure in the form of the circular supply chain model. The canvas scraps or scraps of canvas attached with rubber leftover from production would be disposed by sending them to the recycle factories. The off-specification tire was used to produce energy. Material flow analysis of external tire and inner tire are shown in the Figs. 9 and 10, respectively.

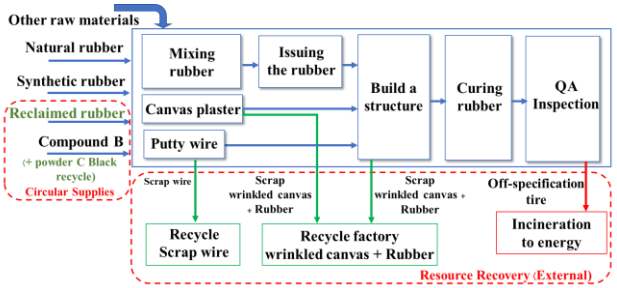

Fig. 9. Material flow analysis of external tire of rubber industry.

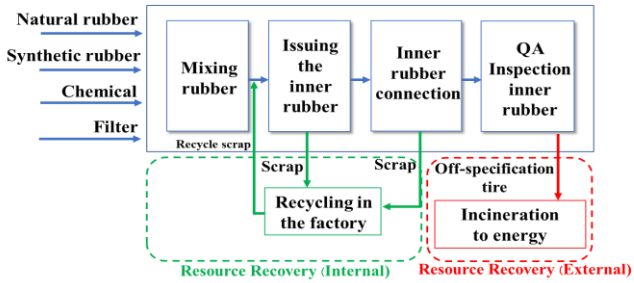

Fig. 10. Material flow analysis of inner tire of rubber industry.

III. Result

There are two circular economy models, i.e., (i) circular supplies chain and (ii) resource recovery models, implemented in the rubber industry. In the circular supplies chain model, reclaimed rubber is used as a raw material to replace the use of some new rubbers which have the potential to reduce greenhouse gas emissions in the factories by 328 tCO_2e. The partial use of recycled carbon powder as raw material has the potential to reduce greenhouse gas emissions in industrial factories by 497 tCO_2e. In the Resource recovery model, the canvas attached to the scrap rubber from the external tire was sent to the recycling factory to add value or expand into other products such as pickup truck rubber. The potential to reduce greenhouse gas emissions of the economy is 180 tCO_2e. Using off-specification external tire and off-specification inner tire to incinerate as energy. It has the potential to reduce greenhouse gas emissions of the economy by 50 tCO_2e. However, if the off-specification external tire are recycled instead of be incinerated into energy and the off-specification inner tire are upcycled into other products instead of being burnt for energy, there will be a potential reduction of industrial green-house gas emissions by 67 $tonCO_2e$ or a reduction potential the greenhouse gas of the economy by 64 $tonCO_2e$ as shown in Table II.

TABLE II: The Greenhouse Gas Reruction Results from the Circular Economy Concept of Motorcycle Tires

Circular Economy Model	Circular Economy Measures /Concepts	GHG Reduction (tCO_2e)
1. Circular Supplies Chain	Use of reclaimed rubber as a raw material to replace the use of some new rubber	328
	The partial use of recycled carbon powder as raw material.	497
2. Resource Recovery	The canvas attached to the scrap rubber from the external tire was sent to the recycling factory to add value or expand into other products such as pickup truck rubber.	180
	Using off-specification external tire and off- specification inner tire to incinerate as energy.	50
	The off-specification external tire are recycled instead of incinerated into energy and the off- specification inner tire are upcycled into other products instead of incinerated into energy.	131
	Including net greenhouse gas reduction	1,186

In addition, greenhouse gas emissions from various resource of utilization activities can be analyzed. The amount of GHG emission from the rubber factory are shown in Table III. It was found that Scope 1 emitted the most greenhouse gas-es at the amount of 16,563 tCO_2e, followed by Scope 3 at the amount of 12,985 tCO_2e and Scope 2 at the amount of 3,685 tCO_2e, respectively. It was found that Scope 1 emitted greenhouse gases at 49.84%, followed by Scope 3 at 39.07% and Scope 2 at 11.09% respectively.

TABLE III: The Amount of GHG Emission

Scope	GHG emission (tCO_2e)	Proportions compared to Scope 1 and 2 (%)	Proportions compared to Scope 1, 2, and 3 (%)
Scope 1	16,563.00	81.80	49.84
Scope 2	3,685.00	18.20	11.09
Scope 3	12,985.00		39.07
Total Scope 1 & 2	20,248.00	100.00	
Total Scope 1 & 2 & 3	33,233.00		100.00

IV. Discussion

In 2021–2023, Thai rubber products was tended to recover. It is expected that demand will expand in line with the direction of related industries that tend to grow, such as the automotive industries. In this study, the result of the implementation of circular economy measures is only one

factory. Other factories in the rubber group can apply this circular economy concept for develop the GHG reduction potential of the factory itself. It also contributes to Thailand's target of lowering net carbon dioxide emissions to zero or toward carbon neutrality by 2050.

V. Conclusion

This study aimed to study the greenhouse gas reduction potential of motorcycle tires in the rubber industry according to circular economy measures. Overview of the circular economy measures of the rubber industry, that produces motorcycle tires has the potential to reduce greenhouse gases by 1,186 tCO_2e. In the Circular Sup-plies model, the potential to reduce greenhouse gas emissions of the economy is 825 tCO_2e. Resource recovery model, the potential to reduce greenhouse gas emissions of the economy is 361 tCO_2e. However, from the analysis of green-house gas emissions in Scopes 1, 2, and 3, it was found that the amount of green-house gas emissions was 33,233 tCO_2e. The circular economy models implemented in the factory have the potential to reduce the GHG emission of 1,186 tCO_2e accountable for 3.56% of the total GHG emission from the factory.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Wongkot Wongsapai conducted the research; Natanee Vorayos and Napat Jakrawatana analyzed the data; Chaiyasit Samrittivanicha supported the data; Det Damrongsak and Kanokwan Khiaolek wrote the paper; Nattaphon Kuensuwong, Tassawan Jaithiang, and Chaichan Ritkrerkkrai supported the paper; all authors had approved the final version.

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