Circular Economy as an Environmental Strategy Post COVID-19 in a Bus Manufacturing Industry in the State of Mexico

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Abstract

This research focuses on a bus industry in the State of Mexico, sustainability is essential to preserve our planet; a Circular economy is a transformative economy proposal that conserves and improves natural capital, optimizes the use of resources, and minimizes the risks of the system by managing a finite amount of existence and renewable flows. Currently, the population is suffering the aftermath of COVID-19, such as lung scars, chronic inflammatory processes, and a decrease in the level of oxygen saturation in the blood until; now it continues to evolve in different strains. The objective of this research is to develop a post-COVID-19 environmental strategy based on the circular economy considering sustainable plastic manufacturing in the auto parts sector to include bioplastics as raw material in the bus industry in the State of Mexico. To achieve this objective, it was carried out in 2 phases: situational analysis and determination-deployment of the strategy. The method used in research is deductive and applicative research. The main finding is identifying sustainable plastic materials such as bio-based PET (Polyethylene Terephthalate), soy foams, natural fibers such as rice husks, and coconut reinforcement used for molding plastic parts. In conclusion, the strategy presents the value that sustainability has for the market and customers, the environmental benefits of bioplastics, and a potential decrease in the cost of manufacturing auto parts, granting a greater appreciation of the brand image and the industry's environmental responsibility.

Key Words:
Circular Economy, Environmental Strategy; Sustainable Auto Parts; Bioplastics; Bus Industry.

1. Introduction
The automotive industry involves companies and activities in the design, development, manufacture, marketing and commercialization of motor vehicles; it is one of the most critical sectors in the world due to the economic income it generates (Mortimore and Barron 2005); the primary producers are China, the United States and Japan; Mexico is in seventh place (Organization for the Automotive Industry 2021).

In Mexico, the automotive industry has been strengthened as a strategic sector for economic growth; it has a presence within the economic activities with the highest contribution to the Gross Domestic Product (GDP) (Instituto Nacional de Estadística y Geografía 2016). According to the Secretaría de Economía (2014), in Mexico, the automotive industry comprises two sectors: terminal and auto parts. The terminal sector is made up of light vehicles (passenger cars and light commercial vehicles), heavy vehicles (heavy trucks) and buses. The auto parts sector is organized into "Tier 1. Direct suppliers and Tier 2. Companies that supply Tier 1" (Secretaría de Economía 2012). In manufacturing auto parts, these materials are mainly used: metallic, fibreglass, rubber, glass and plastic. Plastic auto parts are mainly used to manufacture automotive parts and vehicles (Plastics Technologies México 2017).

Global plastic production reached almost 360 million tons in 2018; plastic packaging contributed to 57% of plastic waste and covered a significant fraction of urban waste (Plasctics Europe 2019; Lebreton and Andrady 2019). In this sense, sustainable manufacturing helps organizations to achieve better operational and environmental performance, supporting the sustainability efforts of companies (Badurdeen and Jawahir 2017; Monge et al. 2013), taking in consideration the stages of the cycle of complete product life in its manufacture (Ghadimi and Heavey 2014). The development of sustainable plastic manufacturing technology transforms materials without the emission of GHG, the use of non-renewable or toxic materials, and the generation of waste (Allwood and Cullen 2015); adopting changes in manufacturing processes, green image approach and bio-based and biodegradable raw material (Goel et al. 2019; Kumar and Czekanski 2018).

Verma et al. (2016) mention that since plastic is not biodegradable and uncontrolled incineration produces toxic gases, these options are not environmentally friendly, which is why interest in bioplastics has been generated. *Plastic* is defined as bioplastic if it is considered biologically based, biodegradable or both, which is derived from biomass such as corn, sugar cane, trees, and algae (European Bioplastics 2017); it is considered biodegradable when it implies that organisms that are present in the environment can convert the material into natural substances: water, carbon dioxide or compost; without polluting the environment (Centre for Economics and Business Research 2015).

Consequently, Shrestha et al. (2020) affirmed that bioplastics reduce the carbon footprint, offer better waste management options and reduce dependence on fossil fuels, which can help to reduce GHG emissions. Cinar et al. (2020) conclude that the participation of bioplastics in the market is increasing; the main areas of application are in the packaging industry, followed by the textile industry, the construction industry and the automotive industry in this sense, Jõgi and Bhat (2020) argue that by increasing the market share of bioplastics, a crucial role can be played in reducing dependence on fossil resources, the transition towards a bio-based society and achieving a circular economy.

This research is focused on a Bus Industry located in the State of Mexico; it is a business unit belonging to a multinational company that employs 1500 persons. Within the product portfolio are short-long distance foreign and urban buses; its production rate is three to four units daily. Based on the above, the research focuses on sustainable plastic manufacturing using bioplastics in buses' auto parts.

1 Objectives

The objective is to develop a post-COVID-19 environmental strategy based on the circular economy considering sustainable plastic manufacturing in the auto parts sector to include bioplastics as a raw material in the bus industry in the State of Mexico. To achieve this objective, 2 phases are carried out.

1. Preparation of the internal and external situational analysis of the industry, in this phase, a questionnaire was used to collect information that was applied to employees, suppliers and customers; subsequently, the information matrix was elaborated to proceed to carry out the situational analysis, to elaborate the Matrix of Strengths, Weaknesses, Opportunities, and Threats (SWOT) where the strategies were identified.
2. Determination and deployment of strategy in this phase, the strategies, sub-strategies, objectives and goals in the medium and long term were determined; finally, the deployment of strategies by the action group is carried out to develop the post-COVID-19 environmental strategy.

2. Literature Review

Sustainability owns excellent importance to preserve our planet, Geissdoerfer et al.(2017) mention that environmental problems such as the loss of biodiversity, pollution of water, air, and soil, as well as the depletion of resources endanger the sustenance of life on earth (Banerjee and Duflo 2011). On the other hand, Busu and Trica (2019) argue that population growth cannot be sustained worldwide at the same rate as finite natural resources and that industrial development and its impact on climate change bring environmental pollution that affects the ecosystem. Pieroni et al.

(2019) mention that Sustainability and the Circular Economy (CE) are of great and growing interest to governments, investors, companies and civil society, so greater sustainability or circularity requires changes in how companies create value, understand and do business.

Akanbi et al. (2018) sustain that the CE concept is a sustainable development strategy that, through a regenerative model, improves the efficiency of the use of materials and energy and reduces waste and emissions; in the same way, they affirm that the concept of CE has deep-rooted origins and a specific date and a single author is not recognized, however, at the end of the 1970s some practical examples applied to economic processes and industrial processes were implemented. Blomsma & Brennan (2017) establish that the CE emerged as a general concept in the 2010s and foresees achieving a more effective and efficient economic system regarding resources through reducing, decelerating and intentionally closing the flows of materials and energy. Nevertheless, Somoza-Tornos et al. (2021) mention that the concept of CE is broader by definition, and the literature shows its application in very diverse fields, which difficult a systematic analysis of its implementation in process engineering. Kravchenko et al. (2019) argue that CE is defined as a business and economic model and an industrial system aiming to promote economic prosperity and growth while preserving and regenerating environmental quality.

According to Sani et al. (2021), the main objective of the CE is to keep products and materials in circulation for as long as possible; increase the use of waste and reduce the use of primary or raw resources and when a product reaches the end of its life, its reuse is motivated to create more value in the economy with fewer levels of extraction of natural resources. However, Lakatos et al. (2021) establish that CE aims at the controlled integration of degenerative activities (active, extensive by definition) and regenerative (reactive, intensive by definition) in order to preserve the natural balance and, within the society, with a view to sustainable development. Guarnieri et al. (2020) mention that the CE is recognized worldwide as a new way of doing business based on managing the entire supply chain, considering the direct and inverse flows that allow the reduction of resource use and the negative impact on the environment. On the other hand, Torbey et al. (2021), establish that CE is considered a new business model where no waste is recovered, envisions a future in which nothing is wasted, a future in which "waste" becomes an asset, a future in which all products at the end of their primary use are recovered either reused, remanufactured or recycled by several generations (Bradley et al. 2016).

The CE's vision is attractive and has sparked widespread awareness and willingness to act among governments and industries and supports the implementation of the Sustainable Development Goals (SDGs) (Haupt and Hellweg 2019). The European Commission proposed a circular economy strategy (Erupean Comission 2012). It recommends a list of objectives including adaptation to climate change, reduction of dependence on finite resources and its effects, food security and employment growth in rural areas. Nevertheless, Kirchherr et al. (2017) consider the CE as a business strategy that can be adapted to operate at a global, regional and municipal level (macro level), industrial park level (meso level) and company and product level (micro and nano levels). However, Kravchenko et al. (2019) establish that CE strategies are applicable in a manufacturing context as well as specific operational processes and products: supply chain, product design and business models for circularity as well as in the dimensions of sustainability: economic, social and environmental. Nußholz (2017) affirms that CE principles are sometimes called "Strategies", "Resource efficiency strategies", or "Reuse, recycling, recovery, remanufacturing strategies",; which imply reducing waste and the carbon footprint, as well as preventing CO2 emissions" (Winans et al. 2017). In this sense, it is vital to develop strategies that support the reduction of GHG emissions in the environment and more now that the population suffers the COVID-19 pandemic.

In January 2020, scientists from Fudan University, Shanghai, China, and their collaborators published on the Internet the genomic sequence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), responsible for the current COVID-19 pandemic (Rappuoli et al. 2021), an emerging coronavirus that was first recognized in Wuhan, China, in December 2019 (World Health Organization, 2021); in Mexico, the first case of COVID-19 that was detected was on February 27, 2020 (Suárez et al. 2020); The World Health Organization (WHO) declared COVID-19 as a pandemic on March 11th, 2020 (World Health Organization 2021).

Aytür et al. (2021) mention that while the majority of people with COVID-19 develop only a mild (40%) or moderate (40%) illness with symptoms of fever, joint pain and diarrhea, approximately 15% develop severe illness requiring oxygen support, and 5% have a critical illness with complications such as respiratory failure, acute respiratory distress syndrome, sepsis and shock, thromboembolism, and multi-organ failure, including acute kidney injury and cardiac injury. In this regard, anecdotal evidence suggests that some people experience severe levels of prolonged fatigue as they recover from this infection (Islam et al. 2020).

According to Xiao et al. (2020), many COVID-19 survivors experience symptoms of physical and mental distress such as dyspnea, Acute Respiratory Difficulty (ARDS), catims, altered consciousness, and traumatic medical treatments (e.g., Tracheostomy). On the other hand, Aytür et al. (2021) argue that the long-term sequelae of COVID-19 reveal that after recovery, patients with viral lung infections may suffer irreversible lung dysfunction and show residual images or functional abnormalities. However (Yuan et al. 2021), mention that previous studies have found that one of the sequels of COVID-19 that is occurring is long-term psychological distress as well as post-traumatic stress disorder that contribute to the reduction of quality of life, functional decline, frequent rehospitalizations and financial stress, and an increased risk of depression, insomnia, and anxiety.

In this sense, after a year and a half of the COVID-19 pandemic, federal and state governments have asked the population to rejoin their activities onsite, so it is necessary to move to workplaces and re-adapting to a new way of life: use a mask, healthy distance, constant sanitization, and the use of personal and public ways of motor transport that becomes adaptable to economic, environmental and social conditions is very necessary.

Based on the above ideas, this document presents the development of a post-COVID-19 circular economy environmental strategy for the bus industry. Two phases are considered: 1. Situational analysis and phase 2. Determination and deployment of the strategy.

3. Methods

This research is based on the deductive method. The research type is action research using two phases: the first for the preparation of the internal and external situational analysis of the industry, through the Matrix of Strengths, Weaknesses, Opportunities, and Threats (SWOT) where the strategies were identified and the second for the determination and deployment of strategy, through the identification of strategies, sub-strategies, objectives and goals in the medium and long term were determined; finally, the deployment of strategies by the action group is carried out to develop the post-COVID-19 environmental strategy.

4. Results

Phase 1. Situational analysis, table 1 shows the results of the information obtained on the knowledge and availability of the auto parts sector, including the use of bioplastics as raw material, where the indicators, dimensions, and results are presented. The target alignment gap percentage. Table 2 shows the strategy matrix SO, WO, ST and WT resulting from the SWOT matrix where nine strategies were identified.

Table 1. Results of the questionnaire for employees, suppliers and customers

Indicator	*Dimension*	*Survey Result*	*Objective*	*Alignment gap*	*Questions Qty*	*Answers Qty*
External diagnosis	Competitive forces	179	300	40.33%	4	15
External diagnosis	Economic forces	184	300	38.67%	4	15
External diagnosis	Political, governmental and legal forces	105	225	53.33%	3	15
External diagnosis	Social, cultural, demographic and environmental forces	93	120	22.50%	2	12
External diagnosis	Technological forces	145	180	19.44%	3	12
Internal diagnosis	Operating efficiency	78	90	13.33%	2	9
Internal diagnosis	Organizational structure	38	45	15.56%	1	9
Internal diagnosis	Research and development	63	75	16.00%	1	15
Internal diagnosis	Quality procedures	37	45	17.78%	1	9
Strategy	Convenience	205	300	31.67%	4	15
Strategy	Feasibility	177	300	41.00%	4	15
Objectives	Aligned to strategies	62	75	17.33%	1	15
Protecting and improving the environment	Resource allocation	20	30	33.33%	2	3
	Obligation	68	75	9.33%	1	15
	Responsibility	133	150	11.33%	2	15
Consumption needs satisfaction	Trend	140	375	62.67%	3	15
Rational use of natural resources	Resources safeguarding	68	75	9.33%	1	15

Source: own elaboration with the information obtained from the questionnaire

Table 2. Matrix of Strategies SO, WO, ST y WT

SO Strategies	*WO Strategies*
1. Technical assistance program for client adherence to programs like Clean Transportation (SEMARNAT) (S1, S4, O1, O5)	5. Citizens initiatives generation to give fiscal incentives to carrier lines for the operation of vehicles with sustainable (W1, W5, O2, 05)
2. Generation of Alliances with suppliers to encourage the exploration of the use of sustainable material (S2, O6, O7)	6. Joint research program with educational and / or research institutions that promotes sustainable materials development (W1, W2, O8)
3. Product launches with sustainable attributes (S3, S5, S6, O8)	7. Implement a design methodology with suppliers and research institutions to standardize materials specifications demanded by the market (W4,W7, O8)
4. Media campaigns that emphasize the sustainable products (S3, S6, O4)	2'. Generation of Alliances with suppliers to encourage the exploration of the use of sustainable material (D3, 07)
ST Strategies	*WT Strategies*
8. Concurrent design program for common platforms development involving suppliers (S1, S2, S6, T1, T3, T6)	9'. Implement a sustainable manufacturing methodology focusing on operating costs reduction (W2, T1, T3)
5. Citizens initiatives generation to give fiscal incentives to carrier lines for the operation of vehicles with sustainable characteristics (S1, S3, S4, T7, T8)	8´. Concurrent design program for common platforms development involving suppliers (W4, W5, T1, T3, T8)
9. Implement a sustainable manufacturing methodology focusing on operating costs reduction (S1, S3, T1, T4)	
4´. Media campaigns that emphasize the sustainable products (S3, S6, T2, T5)	

Source: own elaboration based on information extracted from the SWOT matrix.

In phase 2, the strategies are determined and deployed (table 3), where the sub strategies, objectives and goals are established, finally the post-COVID-19 environmental strategy is elaborated (table 4), in which three action groups are set: environmental legislation and regulations, supplier development, design and manufacture of sustainable products.

Table 3. Strategies determination and deployment

Strategy	*Sub strategy*	*Objectives*	*Goals*
1. Technical assistance program for client adherence to government programs focused on environment care	1.1 Technical assistance program for client adherence to programs such as Clean Transportation (SEMARNAT)	Affiliate 95% of corporate clients to the Clean Transportation program	Participate as a collaborator in the SEMARNAT Clean Transportation Program (06 months)
			Launch the training program for adherence to the clean transportation program with a focus on corporate clients (1 year)
			Launch training program for adherence to clean transportation program focused on retail customers (1 year)
2. Generation of one or more alliances with suppliers to encourage the exploration of sustainable material use.	2.1. Potential supplier evaluation program	Establish that 100% of the supply base must execute a plan to incorporate bioplastics into its raw material options	Select a national supply base that qualifies with all the requirements of The Bus Factory (01 year)
6. Joint research program with educational and / or research institutions for sustainable materials development	2.2. Local supplier development program (triple helix: Government, Industry and academia)		Adherence and participation in local triple helix collaboration programs (02 years)
7. Implement a design methodology with suppliers and research institutions to standardize the specification of materials demanded by the market.			Develop a projects portfolio that ensures the redesign of specified components with bioplastics as raw material (03 to 04 years)
3. Product launches with sustainable attributes.	3.1. Product launches with sustainable attributes.	Annually launch at least one vehicle with sustainable attributes	Become a member of the Automotive Alliance for Environmental Sustainability (AASA) (01 year)
			Register in the National Registry of Scientific and Technological Institutions and Companies (RENIECYT) in the INNOVATEC modality (Technological Innovation for large companies) (01 year)
4. Media campaigns that emphasize the products sustainable attributes.	4.1. Advertising strategy based on ecological Marketing	100% advertising campaigns with an ecological approach	Evaluation and selection of an advertising agency for the launch of advertising with a sustainable theme (01 year)
5. Citizens initiatives generation to give fiscal incentives to carrier lines for the operation of vehicles with sustainable characteristics	5.1. Promotion of the laws formulation that incentivize the use of sustainable material	Issuance of regulations by SEMARNAT that promotes the use of sustainable material in the bus auto parts sector	Formulate and register the citizen initiative for granting fiscal incentives to manufacturing companies for production and to transport lines for the operation of vehicles with sustainable characteristics (01 year)
8. Concurrent design program for common platforms development involving suppliers	8.1 Concurrent Design	100% new parts designed with early supplier involvement	Realization of FMEAs of product design (01 year)
			Develop a portfolio of projects that ensures the redesign of specified components with bioplastics as raw material (03 to 04 years)
9. Implement a sustainable manufacturing methodology focusing on operating costs reduction	9.1 Processes designed under the sustainable manufacturing approach	100% of processes designed under the principles of sustainable manufacturing	Realization of FMEAs for assembly process (01 year)
			Process reengineering to align them to the sustainable manufacturing approach (02 to 03 years)

Source: self-made

Table 4. Post COVID-19 environmental strategy based on circular economy

	Action groups	*Strategies*
Post COVID-19 environmental strategy based on the circular economy considering sustainable plastic manufacturing in the auto parts sector to include the use of bioplastics as raw material, in a bus industry located at Mexico´s State	1. Legislation and regulations	1. Technical assistance program for clients to adhere to government programs focused on environment care. 2. Formulate and register the citizen initiative for granting fiscal incentives to manufacturing companies for production and to transport lines for the operation of vehicles with sustainable characteristics
	2. Suppliers Development	3. Generation of one or more alliances with suppliers to encourage the exploration of sustainable material use
	3. Design and manufacture of sustainable products (process reengineering)	4. Product launches with sustainable attributes. 5. Media campaigns that emphasize the products sustainable attribute. 6. Joint research program with educational and / or research institutions for sustainable materials development 7. Implement the design methodology with suppliers and research institutions to standardize the specification of materials demanded by the market. 8. Program for concurrent design of common platforms including suppliers. 9. Implement a sustainable manufacturing methodology focusing on operating costs reduction

Source: self-made

5. Conclusion

In this research, the research objective was achieved because a post-COVID-19 environmental strategy was developed based on the circular economy, considering the sustainable manufacturing of plastic, which presents sustainability's value for the market and customers. The environmental benefits of bioplastics and a potential decrease in the cost of manufacturing auto parts give a greater appreciation of the brand image and responsibility. Bioplastics are currently used for application in auto parts. A starting point in the bus industry is using sustainable plastic raw materials, such as bio-based PET (polyethene terephthalate), soy foams and natural fibers, such as rice husks and coconut reinforcement, for molded plastic parts.

On the other hand, it was possible to identify sustainable plastic materials that offer the same or better mechanical and appearance characteristics of the plastics currently in use but whose use represents less negative environmental impact and is economically feasible. The bioplastics currently in application in auto parts represent a starting point in sustainable plastic raw materials for the bus factory.

The directions for future research work are implementing strategic plans and designing strategies for using bioplastics in the industrial and service sectors to minimize the environmental impact and contribute to the Sustainable Development Goals of the 2030 Agenda.

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