Environmental Management Practices in the Automotive Industry and Plastics Circular Economy: A Case Study in Spain

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This thesis symbolizes an indescribable chapter of my life, which brought me much enlightenment along the academic, professional, and personal path.

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“You can’t control a system unless you understand its structure. And you can’t change a system unless you change the mindset that created it.”

— Donella H. Meadows

Resumo

Este estudo explora o papel da gestão ambiental e das estratégias de economia circular na indústria automotiva, com foco no impacto dos resíduos plásticos e na integração de práticas sustentáveis no contexto de um estágio profissional. Por meio de um estudo de caso realizado em uma empresa automotiva líder, a autora analisou as implicações de diferentes cenários de utilização de plásticos, comparando plásticos virgens com níveis variados de conteúdo reciclado (30%, 50% e 100%). O estudo avalia os impactos ambientais e financeiros de cada cenário, destacando a relevância de marcos regulatórios europeus, como a Lei 7/2022 e a Estratégia da UE para os Plásticos. Além disso, a pesquisa examina atividades-chave de gestão ambiental dentro da empresa, incluindo auditorias de conformidade, treinamentos ambientais e relatórios de sustentabilidade. Os resultados indicam que o aumento da proporção de plásticos reciclados reduz consideravelmente as emissões de carbono e está alinhado com os princípios da economia circular, com reduções de até 24% nas emissões de CO2 nos cenários com 30% e 50% de conteúdo reciclado, e uma redução máxima de 63% no cenário com 100% de material reciclado. No entanto, desafios econômicos e operacionais precisam ser superados para viabilizar essa transição. O estudo conclui recomendando ações estratégicas para aprimorar a sustentabilidade no setor automotivo, integrando os princípios da economia circular à gestão ambiental corporativa.

Palavras-chave: gestão ambiental, economia circular, indústria automotiva, plásticos reciclados.

Abstract

This study explores the role of environmental management and circular economy strategies in the automotive industry, focusing on the impact of plastic waste and the integration of sustainable practices in the context of a professional internship. Through a case study conducted in a leading automotive company, the author analyzed the implications of different plastic utilization scenarios, comparing virgin plastics with varying levels of recycled content (30%, 50%, and 100%). The study assesses each scenario's environmental and financial outcomes, emphasizing the relevance of European regulatory frameworks such as Law 7/2022 and the EU Plastics Strategy. Additionally, the research evaluates key environmental management activities within the company, including compliance audits, environmental training, and sustainability reporting. The findings indicate that increasing the proportion of recycled plastics considerably reduces carbon emissions and aligns with circular economy principles, with reductions of up to 24% in CO_2 emissions in scenarios with 30% and 50% recycled content, and a maximum reduction of 63% in the 100% recycled scenario. However, economic and operational challenges must be addressed to facilitate this transition. The study concludes by recommending strategic actions to enhance sustainability in the automotive sector, integrating circular economy principles with corporate environmental management.

Keywords: environmental management, circular economy, automotive industry, recycled plastics.

List of Abbreviations and Acronyms

BG	Business Group
CE	Circular Economy
EMS	Environmental Management System
EU	European Union
GF	Green Fundamentals
GHG	Greenhouse Gases
HSE	Health, Safety and Environment
KPI	Key Performance Indicator
LDPE	Low-Density Polyethylene
LE	Linear Economy
LLS	Lessons Learned
MR	Months Rolling
R&D	Research and Development
SDG	Sustainable Development Goals
SSED	Seating System Europe Division
UN	United Nations

Summary

1. Introduction

The transition to a circular economy, a global priority, is particularly pronounced within the European Union (EU). The EU's ambitious policies, notably the European Green Deal and the EU Plastics Strategy, drive concrete actions to reduce environmental impacts. These policies are especially significant for industries like the automotive sector, which faces the key challenge of high consumption of non-recycled plastics, leading to substantial environmental and economic concerns. Addressing this issue necessitates the integration of sustainable practices and compliance with evolving regulatory frameworks.

This dissertation focuses on two interconnected themes: the environmental management activities conducted during the author's professional internship and a case study on plastics management in the circular economy context within the automotive industry. The internship in the seat manufacturing sector of a French automotive company in Portugal provided a unique opportunity to integrate practical environmental management practices with academic research. The insights gained from this experience are a key motivation for this study, particularly considering the implementation of Spanish Law 7/2022, which imposes a tax on non-recycled plastics, aligning with the EU's broader circular economy objectives.

The environmental management activities during the internship included environmental performance monitoring, compliance audits, and training and awareness initiatives. These activities are interconnected with the case study, which evaluates plastics management strategies' environmental and financial impacts within circular economy principles. The research aims to provide insights into how sustainable practices can contribute to cost reduction, regulatory compliance, and environmental impact mitigation. Additionally, it examines how legislative frameworks such as Law 7/2022 can influence industrial sustainability practices and drive the adoption of circular economy principles.

Additionally, this study aims to analyze and report on the environmental management activities performed during the professional internship, explicitly focusing on plastics management within the circular economy framework and EU policies. The objectives are structured as follows: 1.1, the general objective, and 1.2, the specific objectives, which are designed to achieve the purpose of this dissertation.

1.1. General Objective

To report and analyze the environmental management activities carried out during the professional internship in a seat manufacturing business of the automotive industry, focusing on Environmental Performance Indicators, Training, Awareness initiatives, and Compliance Audits while conducting a case study on the plastics circular economy within the context of EU policies and Spanish legislation.

1.2. Specific Objectives

- Describe the main environmental management activities performed during the internship, focusing on Environmental Performance Indicators, Training, Awareness initiatives, and Compliance Audits.
- Conduct a case study on plastics circular economy in seat manufacturing industrial sites in Spain by:
    - Analyzing existing European Union strategies and plastic-related policies within the Circular Economy framework.
    - Evaluating the legal and sustainability implications of Spanish legislation on plastics within the automotive sector.

- Mapping the consumption of non-recycled packaging plastics in Spanish industrial sites, identifying key suppliers and tax costs associated with the legislation.
- Assessing scenarios' environmental and financial impacts with different percentages of recycled packaging plastics.
- Identifying key findings from the case study and existing circular practices related to plastics within the automotive industry value chain.

The first part of the dissertation presents the literature review, which covers fundamental concepts related to sustainability, environmental management, circular economy, plastics in the automotive industry, EU strategies and policies on plastics, and the legal and sustainability implications of these topics. The following chapter on the company characterization describes the organization where the internship was conducted, including its organizational structure and sustainability goals, providing the context needed to understand the activities carried out.

The Methodology chapter outlines the approaches used, including the literature review, the environmental management activities performed, and the case study methodology. The Environmental Management Activities chapter highlights the tasks undertaken during the internship, such as performance monitoring, awareness initiatives, and compliance audits, demonstrating how these activities contribute to advancing the company's sustainability and circular economy objectives.

The Case Study on Plastics Management and Circular Economy analyzes the implications of Spanish legislation on non-recycled plastics within the automotive industry. It evaluates different scenarios for increasing the use of recycled plastics and the strategies adopted by the company.

The final sections present the Conclusions and Recommendations, summarizing the key findings and their implications for the company and the broader industry. Practical recommendations for future sustainability practices and directions for further research are also provided. Finally, the Final Considerations discuss the significance of this professional internship experience, emphasizing its contribution to understanding real-world environmental challenges and integrating sustainability into corporate decision-making.

2. Literature Review

This dissertation's literature review chapter covers sustainability and environmental management. It focuses on plastics' circular economy, existing European strategies and related policies, and its legal and sustainability implications in the automotive industry.

2.1. Sustainability and Environmental Management

The United Nations Brundtland Commission 1987 defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations, 2024). Strategies for better health and education services, economic growth, dealing with climate change, and preserving natural ecosystems are recognized as part of the aim to minimize social inequalities, guarantee human rights, and impact less on the environment (UNDP, 2024).

At global scope regarding sustainability, 2015 was a landmark year for multilateralism and international policy shaping, with the adoption of several major agreements, such as the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change.

United Nations Member States adopted the 2030 Agenda for Sustainable Development by creating the 17 Sustainable Development Goals (SDGs). The Global Goals, according to the United Nations Development Program (2024), “were adopted as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people will enjoy peace and prosperity”.

The 17 SDGs (figure 1) are intimately attached, reuniting social issues with themes like water, energy, climate, oceans, urbanization, transport, science, and technology. This implies that each goal can be affected by the actions of the other goals and demonstrates the multiplicity of sustainable development in seeking social, economic, and environmental sustainability (UNDP, 2024).

Figure 1. 17 Sustainable Development Goals of UN 2030 Agenda

Source: the UN official website (2024).

Sustainable Development Goals are a collective responsibility that requires the active participation of all actors. This includes civil society, the private sector (e.g., industries), the public sector, and all stakeholders involved in the value chain. Each actor has a role in driving global change and achieving the SDGs.

The automotive industry is an essential part that significantly influences the worldwide economy (Bhatia and Kumar, 2020, as cited in Abatan et al., 2024) and relates mainly to the SDGs of industry, innovation, infrastructure, responsible consumption and production, and climate action. Hristov, I., and Chirico, A. (2019) dictate that the environment is central to sustainability and signifies the capacity to protect the regeneration of natural resources and maintain their essential functions over time. It includes the critical importance of minimizing the use of nonrenewable resources and the degradation of nature and natural processes. Therefore, it is essential to establish environmental objectives that must be met in line with the SDGs.

Health, Safety, and Environmental (HSE) practices are crucial for maintaining the sustainability and responsible functioning of automotive manufacturing processes. HSE practices encompass environmental safeguarding actions, workplace health and safety guidelines, and adherence to laws and standards. Incorporating HSE into automotive production methods is crucial for reducing environmental footprint, safeguarding worker safety, and complying with legal regulations (Hussain, 2022, as cited in Abatan et al., 2024).

Abatan et al. (2024) state that strategies involve proactively incorporating HSE practices in manufacturing processes and addressing environmental issues such as lowering energy use, decreasing waste production, and incorporating environmentally friendly technologies like electric vehicles and renewable energy options. Tackling the environmental impact of car production necessitates collective action from industry participants, regulatory bodies, and the public to adopt sustainable methods, utilize cleaner technologies, and foster environmental responsibility across the automotive supply network (Staniszewska, 2020, as cited in Abatan et al., 2024).

Global standards and guidelines offer further direction and optimal practices for automotive producers to guarantee adherence to regulatory demands and enhance environmental and occupational health outcomes. Several pertinent standards encompass the ISO 14001 standard, which outlines criteria for establishing an environmental management system (EMS) (Secinaro et al., 2020, as cited in Abatan et al., 2024). An EMS enables organizations to comprehensively recognize, manage, oversee, and regulate their environmental challenges. It assists organizations in enhancing their environmental performance by utilizing resources more efficiently and minimizing waste, thereby gaining a competitive edge and the confidence of stakeholders. ISO 14001 applies to organizations of any type and size, including private, not-for-profit, or governmental organizations. An organization must consider various pertinent environmental concerns, including air quality, water and sewage challenges, waste disposal, soil pollution, climate change adaptation and mitigation, and resource utilization and efficiency (ISO, 2024).

Regarding monitoring environmental performance, the relevance of environmental Key Performance Indicators (KPIs) in implementing a sustainable strategy is highly emphasized in the academy. According to the reviewed papers, the key environmental KPIs affecting value creation are linked to these strategic areas: (1) gas emissions, (2) renewable resources, (3) resource consumption, and (4) waste (Hristov, I. & Chirico, A., 2019). The same authors dissert that:

> Maintaining strategic coherence between the elements is of fundamental importance in defining goals and the consequent set of indicators. The strategic objectives of the three aspects of sustainability exert a reciprocal influence: for example, obtaining a good employee satisfaction level and respect for company regulations leads to improved production processes, and this will allow the achievement of objectives connected to the economic dimension (reducing costs linked to failure to comply with laws, improving structures and production processes, increasing customer satisfaction).
>
> Simultaneously, achieving the environmental goals (such as reducing emissions about production volume, increasing the ratio between energy from renewable sources and energy used for production, reducing resource consumption, and reducing the environmental impact of the supply chain) is strategically linked to the economic dimension. For example, reducing emissions minimizes the risk of penalties imposed by breaking regulations, and reducing resource consumption leads to a general reduction in costs, including those related to waste. This strategic alignment underscores the financial benefits of sustainability.

Hakim, W., and Yunus, A. (2017) highlight that environmental audits are intrinsically linked to the EMS, as mentioned in the International Standard Organization (ISO) 14000. This is crucial for enhancing the company's performance in the environmental sector. The International Chamber of Commerce (ICC) defines environmental audits as:

> A management tool comprising a systematic, documented, periodic, and objective evaluation of how well environmental organization, management, and equipment are performing to help safeguard the environment by (i) facilitating management control of environmental practices, (ii) assessing compliance with company policies, which would include meeting regulatory requirements.

Close relations with suppliers and stakeholders enhance HSE effectiveness across the supply chain and foster collective accountability for environmental sustainability. Effective strategies involve involving suppliers in HSE efforts, performing supplier evaluations, and setting HSE contractual obligations to encourage transparency, responsibility, and adherence to environmental regulations. Engaging in industry organizations, alliances, and cooperative efforts facilitates the exchange of knowledge, benchmarking, and joint action on HSE concerns, fostering ongoing enhancement and innovation throughout the automotive industry (Dahlman and Roehrich, 2019, as cited in Abatan et al., 2024).

Furthermore, employees' role in promoting a culture of safety, environmental stewardship, and ongoing enhancement is crucial. Optimal practices involve offering employees training regarding HSE policies, procedures, and safe work methods, increasing hazard awareness, and encouraging adherence to regulations. This ensures the safety and well-being of the workforce and makes them feel valued and integral to the industry's sustainability efforts (Salguero-Caparrós, 2020, as cited in Abatan et al., 2024).

Ultimately, Abatan et al. (2024) emphasize that collaboration with local communities, NGOs, and government bodies promotes dialogue, nurtures trust, and tackles community issues regarding environmental and health effects, aiding in the acquisition of social license to operate and sustainable development.

2.2. Circular Economy and Plastics in the Automotive Industry

The conventional economic model is linear and relies on a produce–use–dispose method, which is the typical consumption behavior (Martins, 2021, as cited in Moita, 2024). Moita (2024) states the unsustainability and failure of the automotive sector's linear business model. To meet the Paris Agreement's objectives, which aim to restrict global warming to 1.5ºC above pre-industrial levels, the industry would necessitate a 50% decrease in carbon dioxide emissions generated from 2020 to 2030. However, only recently have major automobile manufacturers begun to focus on more circular production methods. This was more influenced by the updated EU Circular Economy Action Plan (CEAP) in 2020, setting forth initiatives and laws related to circularity in specific production sectors for the coming years (Moita, 2024).

On the other hand, the circular economy model tackles the problems of the current economic system due to the finite resources present on Earth (EMF, 2013, as cited in Moita, 2024). According to the Ellen MacArthur Foundation (2024), "a circular economy is a system in which materials never become waste and are regenerated in nature." This framework seeks to reduce plastic waste generation and environmental contamination, covering all value chain phases from design to end-of-life (European Commission, 2018).

In a circular economy, products and materials are circulated through maintenance, reuse, refurbishment, remanufacture, recycling, and composting. By decoupling economic activity from the consumption of finite resources, the circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution (Ellen MacArthur Foundation, 2024). The automotive industry shifted from a linear to a circular economy model following SDG focused on reducing environmental pollution and resource depletion through intentional product redesign (Habib et al., 2015; Arun, 2020; Adee et al., 2020, as cited in Osasona 2024).

Considering the product redesign and closed-loop scenarios, the circular economy relies on three design-driven principles: eliminate waste and pollution, circulate products and materials (at their highest value), and restore nature. Along with that, there is the transition to renewable energy and materials. Figure 2 shows the circular economy system diagram, known as the butterfly diagram, which illustrates the continuous flow of materials in a circular economy. There are two primary cycles: the technical cycle and the biological cycle. In the technical cycle, products and materials are circulated through reusing, repairing, remanufacturing, and recycling. In the biological cycle, the nutrients from biodegradable materials are returned to the Earth to restore nature (Ellen Macarthur Foundation, 2024).

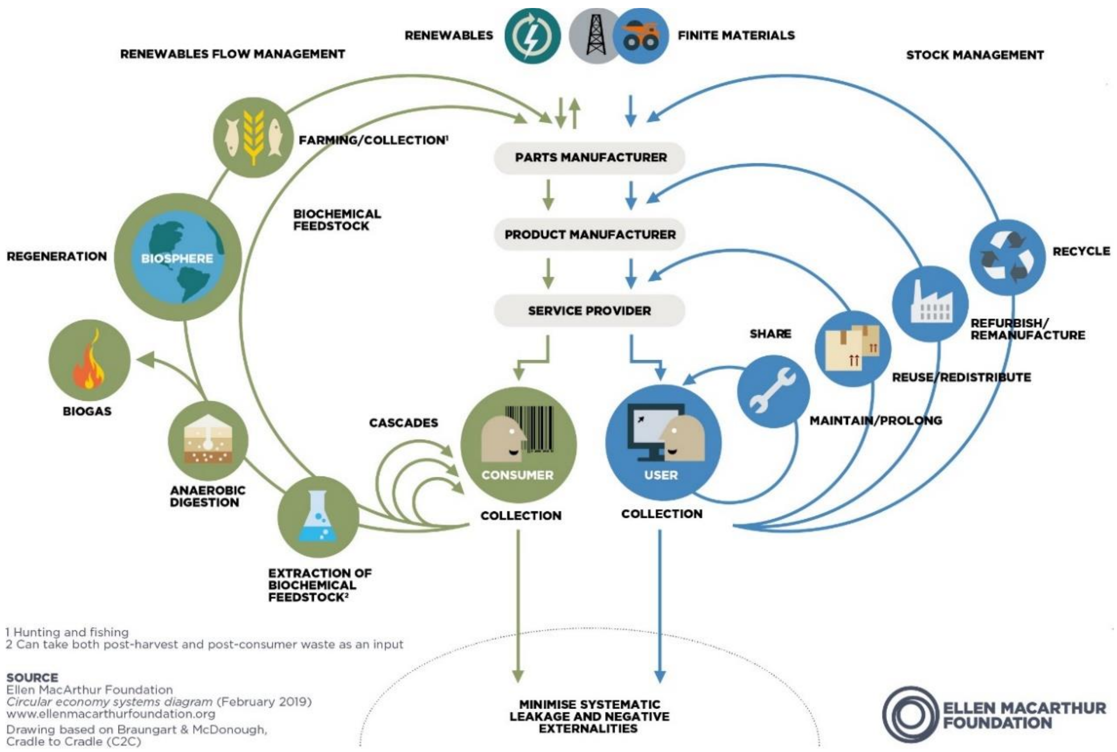

Figure 2. Circular Economy Systems Diagram

Source: Ellen MacArthur Foundation (2019).

A study on the present condition of the circular economy in the automotive industry (Prochatzki, 2023) indicates that a product is deemed circular if a specific percentage of material can be repurposed in a new product. Nonetheless, Prochatzki (2023) noted that the challenges in executing CE strategies from an industrial viewpoint include quality issues, complicated technical execution, inadequate databases, expenses, and limited customer interaction. The primary difficulties identified include quality issues, an altered product engineering process, and insufficient regulations. Legislation has a significant impact on the execution of CE strategies.

Considering the summary of definitions and trends from linear to circular economy, this dissertation examined plastics in the automotive industry. It is well-known that plastic is a vital and widespread material in our economy and everyday life. Its definition applies to a substance that includes a crucial component, an organic polymer, which can be formed at specific points during its processing into final products, such as through flow, extrusion, or molding. Conversely, recycled plastics are entirely or partially made from waste through a recycling process. They originate from post-consumer or pre-consumer waste and can serve as raw materials to create plastic products and components (Plastics Europe, 2024).

Plastics ushered in a new age in contemporary society. Their contributions lay in advancing microelectronics, food and water security, achievements in transportation, and diverse industrial applications, greatly enhancing health care and public safety. Plastics are adaptable and serve as adequate substitutes regarding weight ratio, durability, and cost efficiency. Consequently, the primary use of plastics is for packaging products (Klemeš et al., 2021). However, too often, plastics are produced, used, and discarded through a linear economy (European Commission, 2018).

Thus, considering plastics' economic relevance, tracking their numbers and environmental implications is important. World plastics production reached 400,3 Mt in 2022 (Plastics Europe, 2024). In Figure 3, the global plastics production comparison between Europe, North America, and China as the significant contributors provides an overview between 2006 and 2022. Over the years, both North America and Europe experienced a decrease while China experienced an increase.

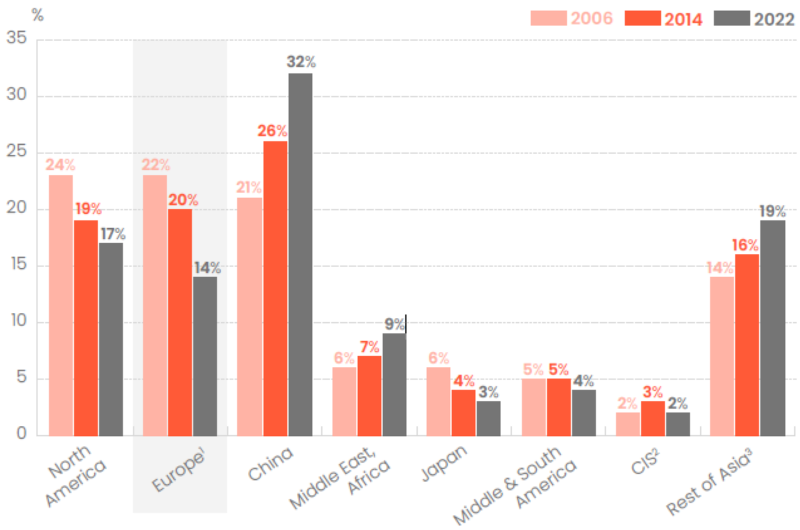

Figure 3. Europe in Global Plastics Production

Source: Plastics Europe (2024).

Figure 4 shows the number of plastics consumed in Europe: 53.3 Mt. The packaging, building, construction, and automotive sectors were the main contributors, with consumptions of 18.5 Mt (34.71%), 12.5 Mt (23.45%), and 4.7 Mt (8.82%), respectively.

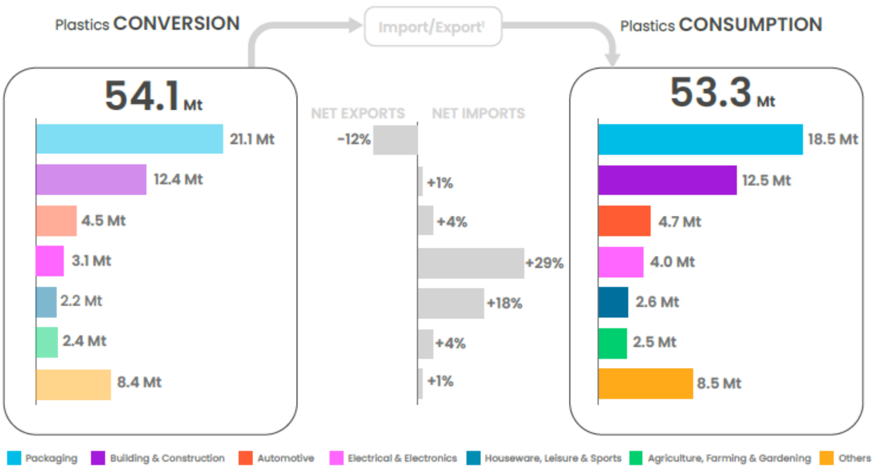

Figure 4. Plastic Consumption in Europe 2022

Source: Plastics Europe (2024).

Considering Plastics Europe's data (2024), it is possible to confirm that the European transition towards higher circularity has increased significantly. Since 2018, the use of post-consumer recycled plastics has increased by more than 70%, reaching 6.8 Mt. Circular plastics content in new products (conversion process) was 13.5% in 2022 (7.3 Mt) of all plastic resins converted into new products and components in Europe. The plastic sector is halfway towards realizing the roadmap ambition of 25% circular plastics by 2030.

For the first time, more plastic waste is being recycled than going to landfills, with the recycling rate reaching 26.9% in 2022. Europe’s share of global plastics production dropped from 22% in 2006 to 14% in 2022 (a decrease of 6% in 16 years). Nevertheless, almost 25% of plastic waste is still sent to landfills, and incineration has increased by more than 15% since 2018 (16 Mt in 2022). Circular plastics production in Europe continues to grow, representing 14.3% of European plastics production in 2022. This term includes recycled plastics, plastics from bio-based feedstock, and plastics delivered from carbon capture (Plastics Europe, 2024).

Considering recycled plastics, plastics production via mechanical recycling has increased by more than 57% since 2018 (7.7 Mt in 2022). According to Plastics Europe (2024), although chemical recycling is a complementary recycling solution and a key building block of the circular plastics economy, it currently accounts for only 0.1% of European plastics production (~0.1 Mt).

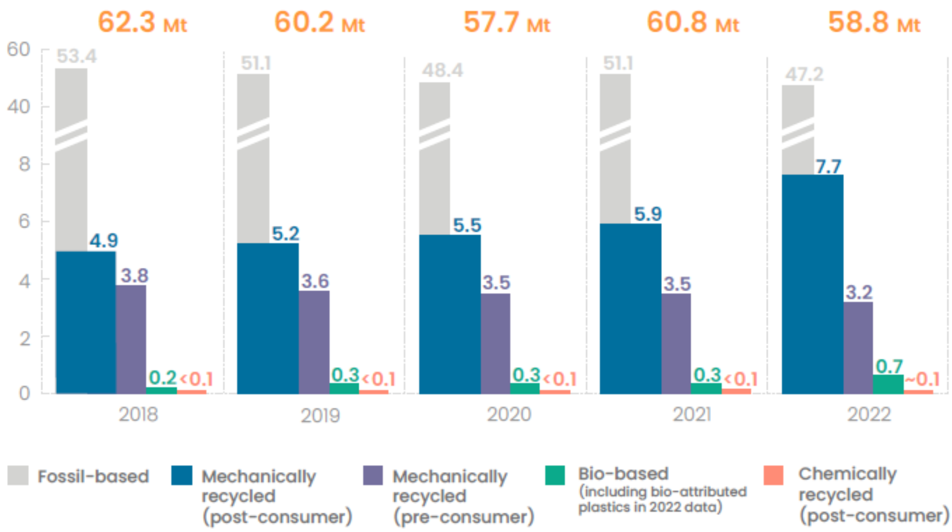

Figure 5. European Plastics Production Evolution 2018 – 2022

Source: Plastics Europe (2024).

Figure 5 shows the numbers of European plastics production in 2022 per its source: 47.2 Mt of fossil-based plastic; mechanical recycling (7.7 Mt of post-consumer and 3.2 Mt of pre-consumer); 0.7 Mt of bio-based, and 0.1 Mt of chemical recycling (post-consumer). Future increases in plastics production via mechanical and chemical recycling require policy measures that stimulate demand for recycled plastics content and significant investments in waste management infrastructure and all recycling technologies.

In the context of European plastic production by polymer (figure 6), in 2022, polypropylene (PP) and polyethylene (PE), fossil-based plastics commonly used as packaging, represented a significant share of production, 37%, compared to other polymers.

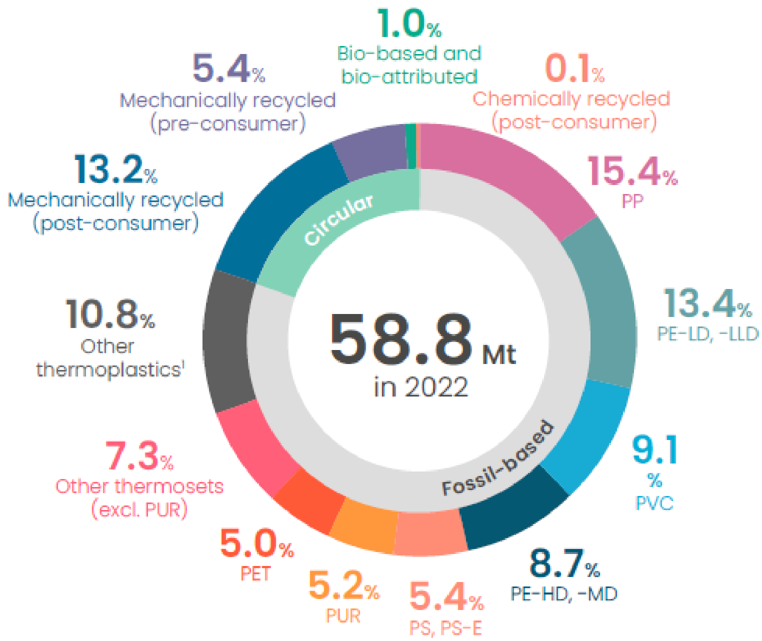

Figure 6. European plastics production by polymer 2022

Source: Plastics Europe (2024).

The recycling rate for plastic packaging waste reached 37.8% in 2022 (7 Mt). This rate must be improved to meet the 2018 Packaging and Packaging Waste Directive (European Parliament & Council, 2018) targets of 50% by 2025 and 55% by 2030 (Plastics Europe, 2024).

Plastics Europe (2024) yet set that in the conversion of European plastics, the process of turning resins into plastic products, packaging (39%), and building and construction (22,9%) applications is represented by the largest end-use markets for plastics in the EU27+3. The third biggest was the automotive sector, with an 8.3% share.

It is estimated that 32.3 Mt of post-consumer plastic waste was collected in 2022. For the first time, the share of plastic waste collected separately is slightly higher than that of mixed collection streams (16.4 Mt compared to 15.9 Mt). Plastic waste recycling rates are 13 times higher when collected separately than mixed collection streams. Spain was the second-best country in terms of recycling waste treatment (38%, behind Belgium's 38%) but remains with a share of 23% for incineration with energy recovery and 39% of landfill share. The automotive sector represented 18.8% of recycling, 43.7% of incineration, and 37.5% of landfill destinations (Plastics Europe, 2024).

In the report “Reshaping Plastics: Pathways to a Circular, Climate-Neutral System in Europe” (Systemiq, 2022), the study's scope covers 75% of total European plastic demand and 83% of known post-consumer waste generation. Five main findings regarding this subject were discussed. First, Systemiq (2022) stated that the European plastics system is an adaptation in the context of climate change mitigation and circularity but not yet fast enough to align with the goals of the Circular Plastics Alliance, European Green Deal, or the Paris and Glasgow climate agreements in achieving a circular economy and net zero GHG emissions by 2050.

Concerning circular economy strategies within the value chain, integrating upstream and downstream solutions can lead to considerable decreases in GHG emissions and waste management in the upcoming decade, as they complement each other. Furthermore, besides these methods, several less established avenues exist to create and implement groundbreaking technologies and strategies that further reduce emissions and separate plastic from fossil fuel resources (Systemiq, 2022).

Systemiq (2022) estimated that by 2050, the Plastics system could achieve 78% circularity (marked by reduction, substitution, mechanical recycling, and plastics-to-plastics chemical recycling methods), with 30% of waste avoided through reduction and substitution and 48% recycled, leaving 9% in landfills and incinerators, as seen in Figure 7.

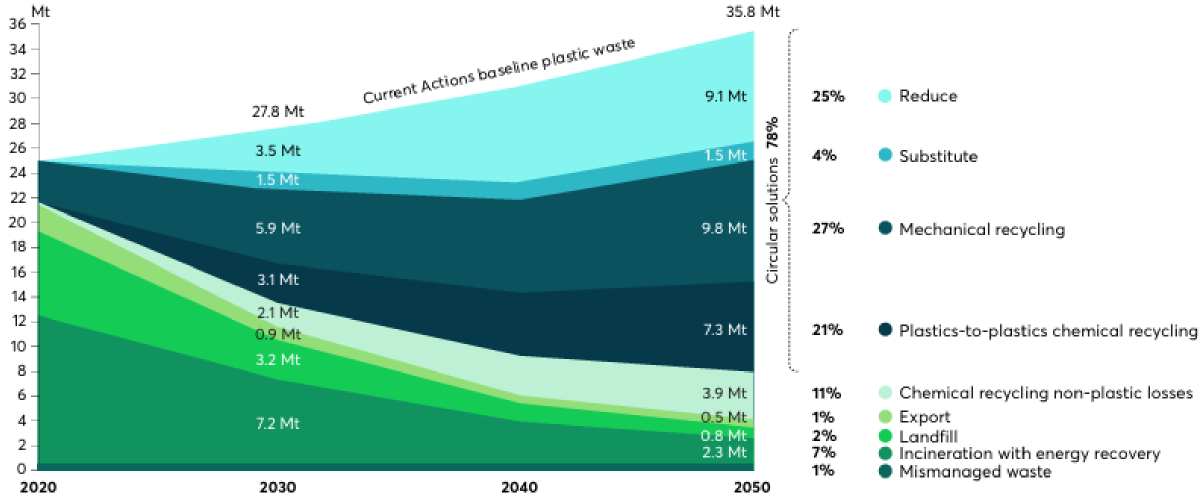

Figure 7. The physical fate of plastic waste from packaging, household goods, automotive, and construction 2020-2050 (Mt)

Source: Systemiq (2022).

The circularity scenario reduces 80% of end-of-life plastic disposal and 65% of CO_2 emissions by 2050, compared to 2022, throughout the following 8 phases (Figure 8): 1. Eliminate unnecessary packaging directly at source or through product re-design; 2. Reduce 1/3 of plastic packaging through reuse and new delivery models; 3. Reduce the overall vehicle stock and corresponding automotive plastics demand; 4. Substitute plastic packaging with paper and compostable alternatives; 5. design for recycling; 6. Expand collection for recycling; 7. Increase mechanical recycling capacity; and, finally, 8. Scale up chemical recycling (Systemiq, 2022).

Figure 8. Circularity Scenario: 8 Complementary System Intervention levers in the plastics value chain

Source: Systemiq (2022).

Still according to Systemiq Report (2022), by applying circularity levers, scaling mechanical and chemical recycling, and improving the levels of reuse and refurbishment in automotive industries, it is feasible to increase circularity to 66% by 2050, up from 9% today (Figure 9).

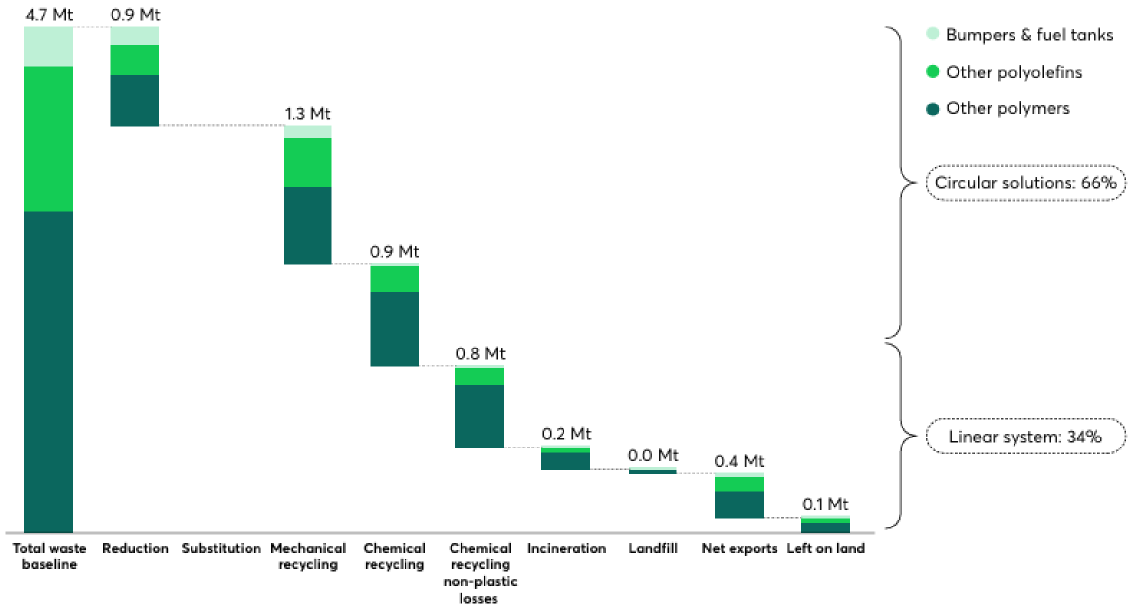

Figure 9. Physical fate of plastic waste from automotive in the Circularity Scenario in 2050 (Mt)

Source: Systemiq (2022).

The interventions depicted in the Circularity Scenario utilize existing technologies, which can be trusted more reliably to affect change. However, these existing technologies do not exclude the chance that additional advancements may occur in circularity technologies that could enhance circularity to even greater levels (Systemiq, 2022).

2.3. European Strategies and Policies on Plastics

European Strategies and policies regarding plastics in the circular economy pathway have emerged since 2015 when the European Commission adopted the first action plan (COM (2015) 614). In 2016, the Eco-design Working Plan 2016-2019 was adopted (European Commission, 2024).

A whole package related to the Circular Economy context was adopted in 2018 by the EU, composed of a monitoring framework for the circular economy, a report on critical raw materials and the circular economy, and a strategy on plastics in the circular economy (COM (2018) 28) along with the revision on waste legislative framework. Furthermore, in 2019, the Commission adopted the European Green Deal (the EU's roadmap for a sustainable economy aiming at Europe being neutral in 2050), the Directive on single-use plastics, the Ten Eco-design implementing rules, the report on implementing the circular economy action plan, and a staff working document on sustainable products in a circular economy. Given this greater legislative circular context, in 2021, a Global Alliance on Circular Economy and Resource Efficiency (GACERE) was launched to gather all stakeholders involved (European Commission, 2024).

In 2022, the EU implemented some of the proposed measures in the circular economy plan, like the Sustainable Products Initiative, including the Eco-design for Sustainable Products Regulation proposal and empowering consumers in the green transition. Additionally, the European Commission adopted more measures proposed in the action plan by revising EU rules on Packaging and Packaging Waste and communicating a policy framework for biobased, biodegradable, and compostable plastics. By 2023, the circular economy monitoring framework was revised to include topics on microplastics, such as the REACH restriction addressing intentionally added microplastics, a proposal for a regulation on preventing pellet losses to reduce microplastic pollution, and a brochure on EU action against microplastic pollution (European Commission, 2024).

Plastics strategies are critical to Europe´s transition towards a carbon-neutral and circular economy. According to the European Union (2018), it contributes to reaching the 2030 Sustainable Development Goals, the Paris Climate Agreement objectives, and the EU´s industrial policy objectives. Since this dissertation's case study focuses on plastics management within the circular economy framework, it was crucial to delve deeper into “A European Strategy for Plastics in a Circular Economy,” the strategy COM (2018) 28 established by the European Commission in 2018.

This approach seeks to safeguard the environment and decrease marine debris, greenhouse gas emissions, and reliance on imported fossil fuels (leading to increased backing for sustainable and safer consumption and production practices for plastics) while changing how plastic items are designed, manufactured, utilized, and recycled in the EU (European Commission, 2018). It is a component of the EU's circular economy action plan (COM (2015) 614) and enhances current initiatives to decrease plastic waste. The action plan recognized plastics as a crucial priority and pledged to “develop a strategy that tackles the challenges associated with plastics across the value chain while considering their complete life cycle.”

Clear actions at the EU level for some actors at different levels - the private sector, national and regional authorities, cities, and citizens, as well as international engagement to drive change outside Europe’s borders – are disposed of in the strategy, such as making recycling profitable for business, curbing plastic waste, driving innovation and investment, and spurring global change. Contextualized by the challenges regarding plastics, the EU proposes a circular economic strategy on plastics a vision (European Commission, 2018):

> A bright, innovative, and sustainable plastics industry, where design and production fully respect the reuse, repair, and recycling needs, brings growth and jobs to Europe

and helps reduce the EU's greenhouse gas emissions and dependence on imported fossil fuels.

According to the policy, making this vision a reality requires action from all players in the plastic value chain, from plastic producers and designers to brands and retailers to recyclers. The European Commission's ambitions are summarized: by 2030, the EU aims for all plastic packaging to be reusable or recyclable cost-effectively, with over half of plastic waste recycled. Enhanced sorting capacities will create jobs and reduce fossil fuel dependence while cutting CO_2 emissions. Market demand for recycled plastics is rising, promoting sustainability and creating growth opportunities in the industry.

EU strategy emphasizes measures, impact assessments, and critical actions (Annexes 1 and 2, European Commission, 2018). Improving plastics recycling economics and quality requires redesigning products, enhanced cooperation across the value chain, and better collection and sorting systems. Therefore, this strategy focuses on recyclability, the demand for recycled plastics, and reducing environmental plastic waste (European Commission, 2018).

Regarding the historical overview of policy initiatives targeting plastic pollution, Figure 10 illustrates the impact of this trend worldwide.

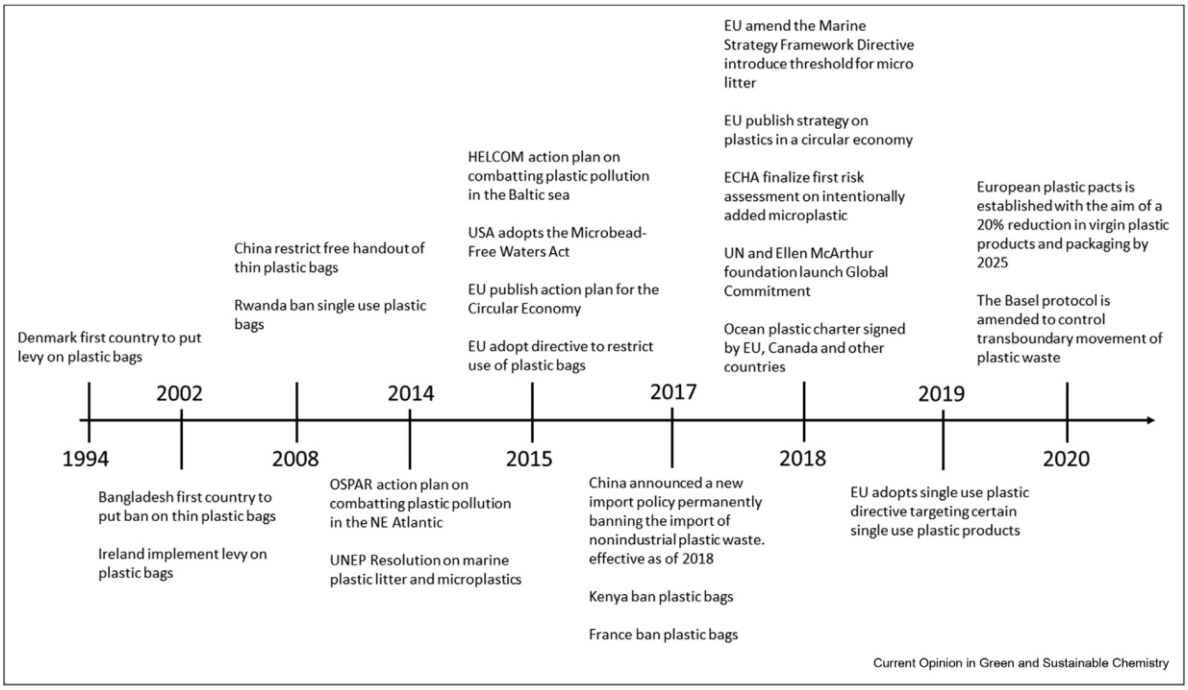

Figure 10. Historical overview of policy initiatives targeting plastic pollution

Source: Syberg et al. (2021).

From 1994 to 2020, policy initiatives related to plastics are described, the first being Denmark's levy on plastic bags. Bangladesh, Ireland, China, Rwanda, the USA, the EU region, Kenya, France, and Canada participated in plastics regulations. 2020 was highlighted by the established European Plastic Pacts, which aim to reduce virgin plastic products and packaging by 2025 by 20%.

During the EU's approach to plastics in a circular economy, it was recognized that plastic is a precious resource; maintaining its presence through recycling and reuse is advantageous for both the environment and the economy (European Commission, 2018). Recognizing that plastic pollution needs to be tackled across the value chain from product design to the end-of-life cycle (Ellen Macarthur Foundation, 2016), rather than only after plastic enters the environment, it became crucial to concentrate on enabling a shift toward a circular plastic economy (European Commission, 2018). Figure 11 summarizes the key examples of legislation implemented to address each plastics value chain step: 1. Product design, 2: Production, 3. Use, and 4. End-of-life.

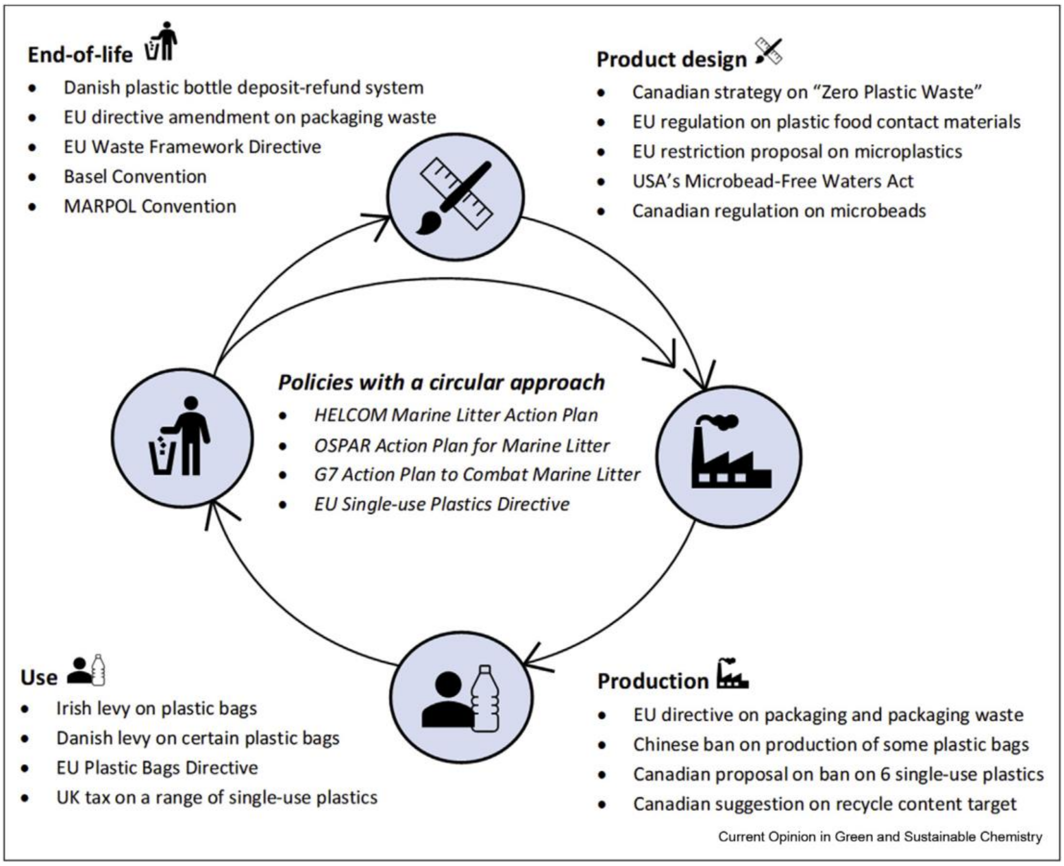

Figure 11. Overview of legislation targeting each step of the plastic value chain

Source: Syberg et al. (2021).

The presence of European Union policies is observed in all the phases of the value chain: in product design with the EU regulation on plastic food contact materials and EU restriction proposal on microplastics; in production with the EU Directive on packaging and packaging waste; in use with the EU Plastic Bags Directive; and at End-of-life with the EU Directive amendment on packaging waste and EU Waste Framework Directive.

Additionally, the EU has implemented policies with a circular strategy, including the EU Single-use Plastics Directive. This Directive seeks to manage plastic throughout various stages of its life cycle instead of concentrating solely on one phase, like the waste stage (Syberg et al., 2021). Regarding policy incentives, the most used measures implemented since 2018 in various vital global regulations are shown below.

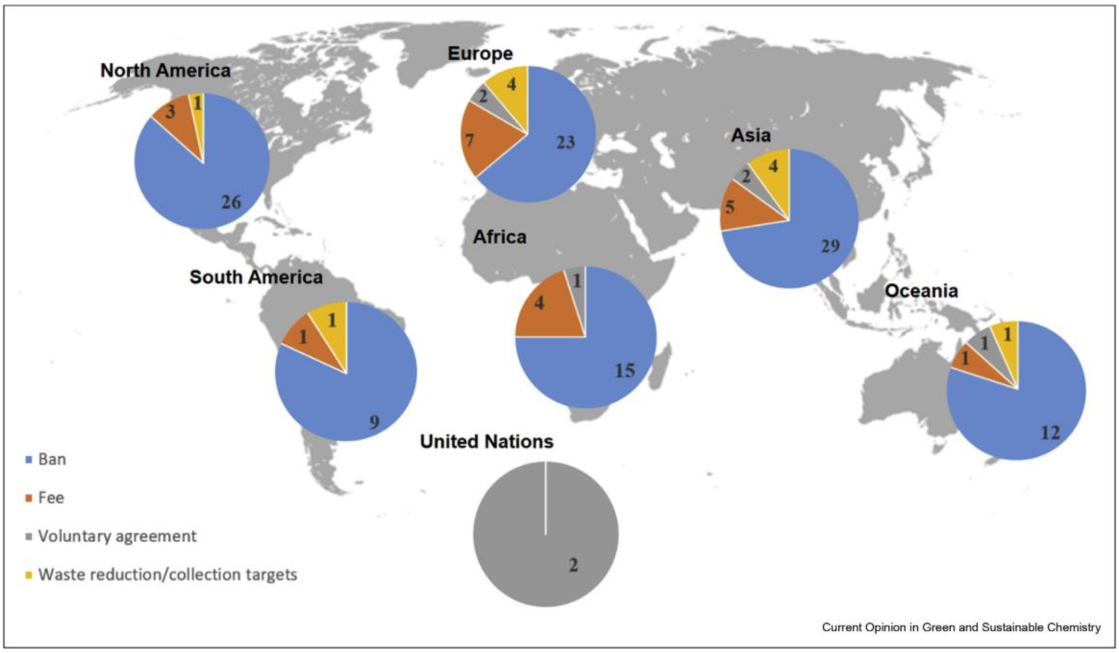

Figure 12. The most often used policy measures targeting plastic pollution have been implemented since 2018

Source: Syberg et al. (2021).

Figure 12 shows that banning single-use products (such as plastic bags) is the most frequently used policy measure. In this global overview, Europe is third in the number of implemented policy measures, behind Asia and North America. This exemplifies the worldwide trend related to this kind of strategy towards a circular economy.

Considering the historical background of Spanish legislation around plastics, Gatta Sánchez (2021) defines that it dates back, without prejudice to any isolated regulation, to the pre-constitutional period, specifically to the Law on Urban Solid Waste and Residues of 1975.

By existing Laws and the requirement to adhere to the 2015 European Directive regarding plastic bags, Spanish Royal Decree 293/2018 was enacted to decrease plastic bag usage. Although this policy has existed since 2018, some concepts and actions were already aligned with the circular economy principles in the earlier Royal Decree and the Plans and Programs. A formal Spanish Circular Economy Strategy was adopted in 2020. The Council of Ministers endorsed the "Spain Circular 2030" strategy, which adopts the circular economy's new production and consumption model in line with European policies on this issue (Gatta Sánchez, 2021).

According to Gatta Sánchez (2021), the new Spanish strategy addresses the “use-consume-throw away” linear growth model, which depletes natural resources and causes pollution and biodiversity loss. It aligns with international initiatives and Spanish legislation on the right to an adequate environment. Key strategies include eco-design, waste hierarchy, food waste reduction, sustainable consumption, and employment.

The objectives for 2030 include reducing material consumption (by 30%) and waste generation (by 15%), reducing food waste (by 20% in production), increasing the reuse of 10% of municipal waste, reducing gas emissions (to below 10 million tons of CO_2 equivalent), and improving water efficiency (by 10%) (Gatta Sánchez, 2021).

To promote the circular economy throughout the country, in 2020, Spain's Council of Ministers adopted the Preliminary Draft Law on Waste and Contaminated Soils, revising the 2011 Law to align with the 2018 Circular Economy Package Directives and the 2019 Single-Use Plastics Directive. The updated law, “Law 7/2022,” was published in 2022 (Spain, 2022).

2.4. Legal and Sustainability Implications

The case study on plastics management and circular economy in the Spanish context concerns the national law 7/2022 on waste and contaminated soils for a circular economy (Spain, 2022). This law is a policy categorized as a governmental market-based instrument due to its mechanism of economic incentive (EI) through tax regarding plastic materials (UNIDO, 2024).

Law 7 of 2022 is enrolled with the objectives of reducing waste generation and the environmental impacts of resource use. Moreover, it seeks the European trend of a circular economy and fewer carbon emissions through sustainable and efficient products and materials. This policy specifically aims to prevent and reduce the impact of determined plastic products on human health and environmental marine issues. The waste hierarchy within waste policy principles suggests the priority flow from waste prevention, reuse, recycling, and other valorization methods (e.g., incineration with energy recovery) to, finally and least, waste disposal (Spain, 2022).

The main legal concerns for the present case study in the automotive industry include policy tools, waste prevention, extended responsibility of product producers, impact reduction of certain plastic products in the environment, and tax measures to encourage a circular economy.

Regarding the environmental impact reduction of certain single-use plastics, the law targets a 50% plastic reduction (in weight) until 2026 and a 70% plastic decrease by 2030. To achieve these goals, starting in 2023, a tax was imposed on plastics, which is included in the law's annex IV, part A (Spain, 2022).

Accordingly, considering the referred annex and the scope of the case study, the Spanish automotive industry applies the tax measure on the consumption of non-recycled packaging plastics. Articles 68, 69, and 71 explicitly explain the plastic categorization, the tax application within the Spanish territory, and the definitions of intracommunity plastic acquisition, importation, and others. Furthermore, articles 72, 77, and 78 show the demands for compliance (Spain, 2022) (Note: Authors translation):

Article 72. Taxable event.

The manufacture, ***importation, or intra-community acquisition of products*** *that form part of the tax objective scope shall be subject to the tax.*

The irregular introduction into the territory of application of the tax of the products that form part of the objective scope of the tax is also subject to the tax.

It will be understood that there has been an irregular introduction of such products into the territory of application of the tax if the person who possesses, markets, transports, or uses them does not prove that they have been manufactured, imported, or acquired within the Community, or when he does not justify that the products have been acquired in Spanish territory.

Article 77. Taxable income.

The taxable base shall be constituted by the amount of non-recycled plastic*,* ***expressed in kilograms, contained in the products that form part of the target scope of the tax.***

Suppose other plastic elements are incorporated into the products that form part of the objective scope of the tax, for which the tax has been previously accrued, in such a way that they form part of the product in which they are incorporated. In that case, the taxable base shall be constituted exclusively by the quantity of non-recycled plastic, expressed in kilograms, incorporated into said products.

[…]

Article 78. Tax rate.

The tax rate shall be ***0.45 euros per kilogram****.*

Thus, the primary legal and economic implications for Spanish industrial sites are the monthly payment of 0.45 euros per kilogram of non-recycled packaging plastics consumed (from imported and intracommunity sources) within the value chain. This significantly impacts the automotive industry beyond the risk of other countries needing to comply due to Europe's expanding trend of these policies.

In the context of the automotive industry, various environmental issues arise from the production processes due to high resource consumption, including air and water pollution, greenhouse gas emissions, energy use, waste generation, and ecosystem deterioration (Giampieri et al., 2020, as cited in Abatan, 2024).

Plastic waste from land and sea harms the environment and economy, with rising microplastic pollution threatening marine life and human health. Biodegradable plastics present new challenges, compounded by poor labeling and waste management practices (European Commission, 2018). Because of their widespread use, single-use plastics lead to environmental problems, even though some data indicate a rise in plastic waste recycling that has surpassed landfill levels. Nevertheless, this recycling rate is challenged by the waste export prohibition in various nations (such as developing countries) due to insufficient data on the proper recycling of this waste (Plastics Europe, 2018 Brooks et al., 2018, as cited in Klemeš et al., 2021). The missing pathway, environmental leakage, is emphasized in Figure 13 and is rarely considered (Klemeš et al., 2021).

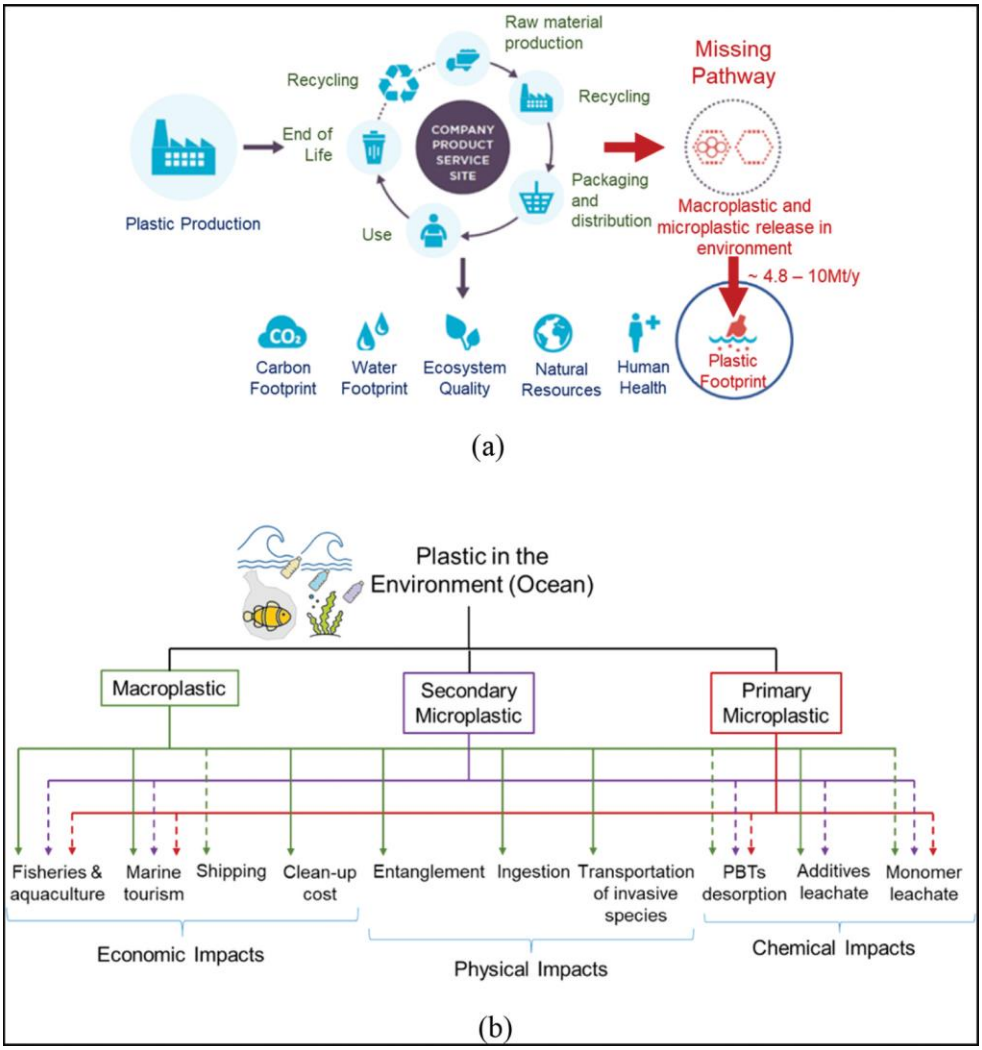

Figure 13. Plastics Impact pathways (a) and (b) the valuation model

Source: Klemeš et al (2021).

These missing pathways illustrate the effects of plastic—including macro, secondary, and primary microplastics—on the environment and marine ecosystems beyond the carbon and water footprint, ecosystem quality, natural resources, and human health.

The environmental impacts of plastic processes remain inadequately addressed, as unmanaged plastic waste contributes to ecological harm and enters the food chain. Predominantly derived from petrochemicals, over 90% of plastic is petroleum-based and non-biodegradable. Although bioplastics like polylactic acid are promoted as sustainable alternatives, their environmental implications are not fully understood. Plant-based plastics necessitate fertilizers, pesticides, and land. While bioplastics from food waste present a potentially lower impact, economic feasibility and indirect effects must be evaluated. Additionally, biodegradable plastics, despite being less harmful, may still result in pollution if improperly managed. Promoting a circular economy and enhancing awareness can improve management and reduce the impact of plastic. Key recycling barriers include public awareness, legislation, and infrastructure, with successful waste management requiring advanced technology and resources (Klemeš et al., 2021).

According to Klemeš et al. (2021), plastic can be divided into seven groups. The polymer with the highest demand in the EU is PP, followed by LDPE, HDPE, and PVC. Widely recycled plastic is PETE and HDPE. However, it should be noted that the recyclability of the plastic is also highly dependent on the degree of separation (contaminants) and the additives/pigments added. In most cases, plastic does not appear in its pure form (but as a mixture) and cannot be categorized into six groups. The wide variety of plastic types complexified the sorting and recycling processes. Low-density polyethylene (LDPE) is commonly used in plastic bags and food wrapping; it presents as lightweight, low-cost, and versatile but fails in recycling.

The tools and methodology to assess plastics' environmental impact are calculated robustly through all plastic life cycle components—Life Cycle Analysis (LCA) - or managerial tools identifying Greenhouse Gas emissions specific activities or processes, like the GHG Protocol. Integrating Life Cycle Assessment (LCA) into design decisions is essential. LCA aids in identifying significant trends rather than minor details, guiding product line development. Key indicators include conducting LCAs for primary products, evaluating improvements in environmental metrics, and comparing mobility concepts while assessing impacts like global warming potential and resource consumption (Gaudillat et al., 2018).

From a management perspective and carbon footprint measurements, industries also often use the GHG Protocol. It is a standardized framework established in 1988 by the World Resources Institute and the World Business Council for Sustainable Development for measuring and managing greenhouse gas emissions across various sectors. It facilitates companies' efforts toward emissions reduction and carbon neutrality through accessible standards and guidance for monitoring and reporting GHG emissions (Carbmee, 2025).

GHG Protocol categorizes emissions into three scopes: Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (indirect emissions from the value chain including upstream and downstream emissions). This dissertation focuses on Scope 3, which is related to plastic consumption (material use), specifically for LDPE (Carbmee, 2025).

The automotive industry is urged to improve circularity in vehicles and materials, particularly plastics. Systemiq (2022) presents four scenarios for plastic management: Current Actions, Reduction and Substitution, Recycling, and Circularity. Current Actions involve implementing existing regulations and strengthening waste trade regulations. Reduction and Substitution focuses on reducing plastic use through elimination, reuse models, and substitutions. Recycling aims for expansion of plastic collection and recycling, including mechanical and chemical recycling. Circularity involves a comprehensive approach, incorporating both upstream and downstream strategies, and encouraging consumers to change consumption and waste management behaviors.

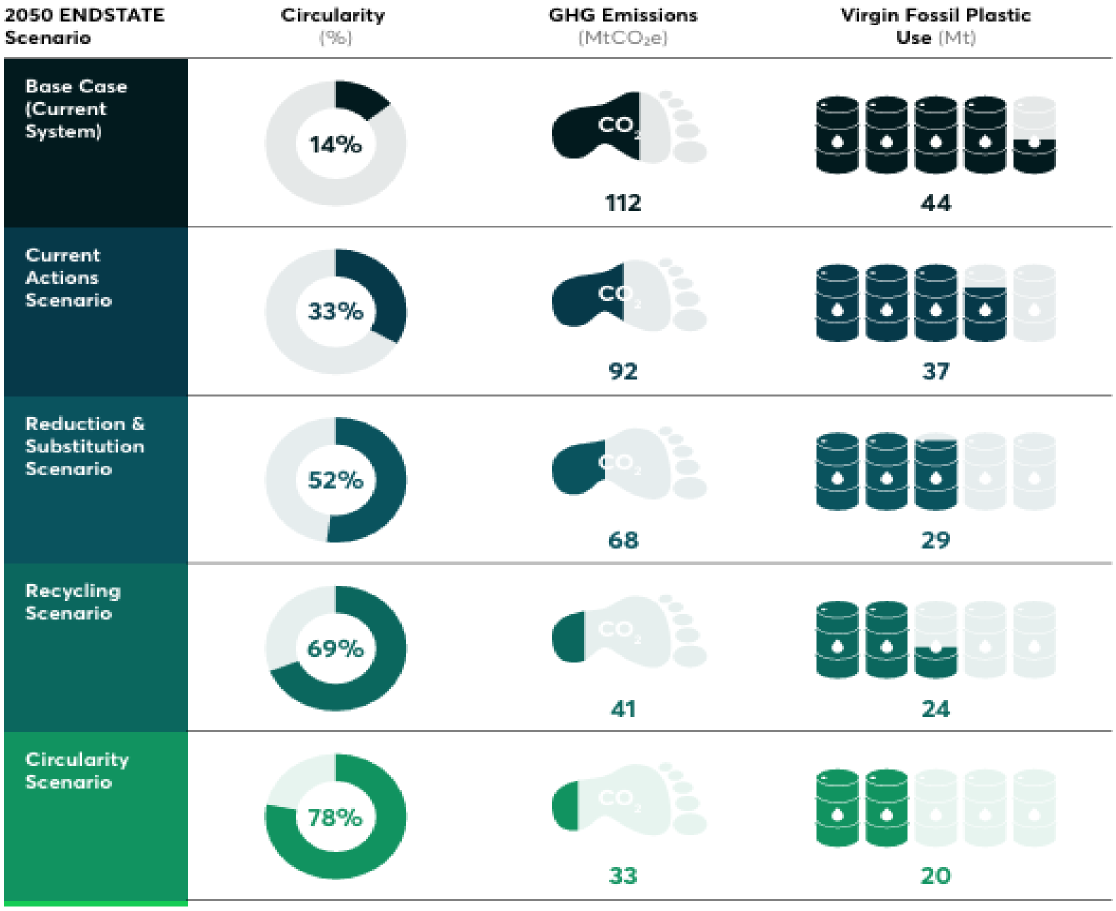

Figure 14. Scenarios of a Circular reality and Circularity (%), GHG Emissions ($MtCO_2eq$), and Virgin Fossil Plastic use (Mt) indicators

Source: Systemiq (2022).

According to Figure 14, in a circularity scenario, the percentage of circularity would be 78%, the GHG emissions would be 33 Mt CO_2eq, and 20 Mt of virgin fossil plastic would be used. Compared to the current scenario, it represents an increase of 64% in circularity and a decrease in the environmental impact numbers (minus 71% GHG emissions and 55% of non-recycled plastic use). Moreover, by committing to circularity and investing now, significant future savings and a resource-efficient sector can be achieved.

As new vehicle ownership models and mobility-as-a-service gain popularity, Original Equipment Manufacturers (OEMs) have opportunities to adopt innovative business strategies.

They can support car-sharing initiatives, optimize vehicle designs, and sell mobility services while retaining ownership. Additionally, leveraging digitization for vehicle traceability, partnering with recyclers, and investing in advanced recycling technologies will help ensure the efficient recovery of end-of-life vehicles and materials (Systemiq, 2022).

Its advantages are associated with the capacity to utilize recycled materials as an alternative to new materials, thus preventing the lifecycle effects connected to the extraction and processing of raw materials and primary production, which significantly impact the environment and lead to considerable greenhouse gas emissions. The optimal framework for plastic management and recovery promotes adequate resource circulation, minimizes energy and material consumption, lessens the effects of climate change, and is practical to execute based on the existing technology, end markets, and the actions of system participants (Suppliers Partnership for the Environment, 2024).

This dissertation will present some case study examples from the Science for Policy report by the Joint Research Centre (JRC) of the European Commission regarding existing environmental practices on the recycling of waste materials in the automotive sector (Gaudillat et al., 2018).

Toyota Valenciennes in France has adopted a closed-loop control system to optimize processes, reduce parts inventory, and minimize waste. This involves recycling plastic scraps by grinding and melting them for reuse in the injection process (Toyota, 2014, as cited in Gaudillat et al., 2018). General Motors utilizes cardboard from its Marion Stamping and Fort Wayne Assembly plants, turning it into sound-absorbing material for the Buick Lacrosse's headliner. At the same time, the Fort Wayne facility's plastic caps are repurposed as radiator shrouds for Chevrolet Silverado and GMC Sierra pickups (General Motors, n.d., as cited in Gaudillat et al., 2018).

Renault-Nissan mandates that suppliers comply with recycling designs, promoting recycled materials for new applications. Toyota also requires suppliers to minimize waste and ensure all packaging is recyclable (Toyota, 2010, as cited in Gaudillat et al., 2018). The BMW Group has notably increased the use of secondary raw materials, achieving up to 20% of thermoplastic materials in their vehicles from recycled sources (BMW Group, 2015, as cited in Gaudillat et al., 2018). Meanwhile, Ford emphasizes using sustainable materials in purchasing and selecting recycled-content materials for various components (Ford, 2012, as cited in Gaudillat et al., 2018). These initiatives highlight the auto industry's commitment to sustainability and the circular economy through resource optimization and waste reduction strategies.

Supplier development involves measures to boost awareness, compliance, and supplier relations. Tier 1 suppliers typically undergo self-assessments to evaluate their status and must communicate standards to their suppliers. Support and training are provided through face-to-face sessions or online. Recognizing supplier performance through environmental awards is also essential. Monitoring and enforcing supplier Environmental Management Systems (EMS) includes auditing for compliance with environmental and performance targets, often using third-party verification. Suppliers must provide ecological data to uphold quality standards and identify issues for resolution.

Renault’s long-term partnerships with first-tier suppliers, focusing on recycling End-of-Life Vehicles (ELV) and components, reflect efforts to reduce waste and enhance recycling. The vehicles' design prioritizes recycled materials, with the ECO_2 range requiring over 7% recycled plastics (Renault Nissan, 2011, as cited in Gaudillat et al., 2018). Ford collaborates with Recycled Polymeric Materials (RPM) to produce seals and gaskets made from 17% bio-renewable soybean oils and 25% recycled tires, significantly reducing vehicle weight and diverting 250,000 tires from landfills (Ford, 2012, as cited in Gaudillat et al., 2018).

The supply chain faces varied environmental pressures influenced by supplier, product/service, and location. Biodiversity impacts are notably challenging to assess. Improvement opportunities exist, especially in regions with lax regulations. Encouraging compliance is challenging, yet buyers recognize innovative suppliers, as demonstrated by Toyota's Green Supplier Guidelines promoting proactive environmental efforts (Zafarzadeh et al., 2012, as cited in Gaudillat et al., 2018).

The circular economy is crucial for improving sustainability in both production and consumption, particularly in the automotive sector. Existing practices frequently equate circularity with recycling, restricting initiatives to disconnected solutions instead of a holistic circularity strategy. The automotive industry largely persists in adhering to a linear model, lacking adequate attention to product design or end-of-life handling. The suggestion for further improvements is incorporating circular principles during the development stage, considering the whole life cycle, and developing universally applicable circular economy approaches via digitalization and hands-on techniques (Prochatzki, G., 2023).

3. Company Characterization

The company on which the professional internship was developed is a French automotive equipment production and engineering group. The company's name will not be disclosed for confidentiality reasons and to protect sensitive data. References to internal data will be cited generically as 'the company,' the group,' or related.

The group, which holds seventh place among the most significant global automotive suppliers and has over eighty clients, was created in 2022 by bringing together two automotive technology leaders. Both brands share complementary performance-driven cultures and are guided by a shared vision for a sustainable future, making them key players in the industry.

It comprises six international Business Groups (BGs), each with a leading position in its market segment: Seating, Interior Systems, Clean Mobility, Electronics, Lighting, and Lifecycle Solutions.

This professional internship was done inside Seating BG, specifically in the Seating Systems Europe Division (SSED). The division oversees seating operations split by industrial sites— Covers, Foams & Accessories, Complete Seat—and R&D offices, summing 26 plants in Europe and North Africa.

Iberic, Eastern, French, and North African perimeters were supported by this author in the Health, Safety, and Environment (HSE) activities. Regarding the environmental area, the focus was mainly on the Iberic industrial sites in Portugal and Spain for this report.

The case study on plastics management and circular economy occurred in the Spanish context in Seating, Interior Systems, and Clean Mobility BGs, emphasizing Seating as the field of the professional internship.

Seating solutions are developed and built with a priority on safety and onboard comfort. This BG is number one in seat structure systems and number three in assembly worldwide. It comprises 77 industrial sites and represents 31% of Group sales. The seating industrial sites covered by the environmental management activities and the plastics case study are in the Spanish cities of Vigo, Valladolid, Pamplona, and Vitoria.

Interior Systems solutions represent complete systems capability, supplying full instrument panels, door panels, and center console systems. They also ensure seamless, premium-quality integration encompassing sustainable materials and innovative functionalities. The company comprises 58 industrial sites and represents 18% of Group sales. The industrial sites contemplated in the present plastics case study are in the Spanish cities of Abrera, Tarazona, Incalplas-Ourense, and Paterna-Almussafes.

The clean mobility segment offers a range of innovative solutions encompassing energy storage and distribution and a complete technology offer for the transition to ultra-low (ULE) and zero-emission vehicles. It comprises 74 industrial sites and represents 18% of Group sales. The industrial sites contemplated in the present plastics case study are in the Spanish cities of Vigo, Pamplona, Figueruelas, and Almussafes, showcasing the company's commitment to environmental innovation.

The company has implemented a management strategy for a system of excellence called FES. FES comprises six principles: people development, stable conditions, just-in-time conditions, Built-in Quality, efficiency, and drive improvement. The FES system's HSE-related bricks are people engagement and driving improvement, the latter being the focus of the environmental area.

In the scope of Sustainability, the company Group takes a holistic approach to reducing carbon emissions and minimizing environmental impact, intending to accelerate the transition to sustainable mobility. As automakers strive to create more sustainable vehicles, the Group aims to be a driving force focusing on decarbonization and initiatives to preserve biodiversity and reduce water and natural resource consumption. All of this is done by adapting to the effects of climate change, a promising sign for the future of the automotive industry.

The Company's Environmental Policy states its comprehensive environmental commitment and sustainable development, including reducing carbon emissions, minimizing environmental impact, and preserving biodiversity while ensuring compliance with regulatory and customer requirements. Moreover, it gives the importance of the Group in creating sustainable value for all stakeholders through the four pillars of planet, business, people, and governance, alongside committed leadership. To achieve these ambitions, a set of goals are displayed:

- By implementing the Group's Ten Green Fundamentals, the reduction of the environmental impacts from the design of our products and processes until the serial life in plants.
- Report monthly on each plant's key impacts and take action to meet the Group's reduction targets for CO_2 waste, water, and biodiversity impacts.
- Sustain and continuously improve the Group's performance by implementing ISO 14001 certification in all techno-plants by 2025.
- Ensure all pollution is prevented appropriately and strictly follow remediation actions on historically contaminated sites.
- Integrate, from the building phase, all requirements of the Group's Green Factory White Book guides to the design, construction, and operation of new and existing sites or expansions.
- Adapt the sites to Climate Change.

These goals are achieved by deploying a high level of training and awareness, applying Group and external standards, performing appropriate audits, and conducting regular results reviews.

Related to the path to CO_2 neutrality, the climate objective is to reach net-zero CO2 emissions in 2045 with two intermediate steps:

- By 2025, the target will be carbon neutral in scopes 1 and 2.
- By 2030, the target is to reduce scope 3 emissions by 45%.

The Group is the first French and global automotive company to receive the new Science Based Targets initiative (SBTi) Net-Zero Standard certification. To reduce its environmental footprint, the Group follows an eco-design approach encompassing every aspect of the environment, from waste management and water use to protecting local biodiversity. Its commitment to biodiversity begins with concern about its direct role in preservation since 24 sites are located within 3 km of protected areas. The group has started biodiversity audits to define local action plans. It is also committed to the international Act4Nature initiative - led by the Enterprises for the Environment association - which promotes practical business actions that benefit nature based on ten standard commitments and individual pledges.

Health, Safety, and Environment Management in the Group are the fundamental base of the ESG Strategy (Figure 15) as people and market assets, which are composed of:

- Business sustainability: to meet customers' needs.
- Company´s attractiveness: to attract and retain talents.
- Investors: to face the challenges of future generations.

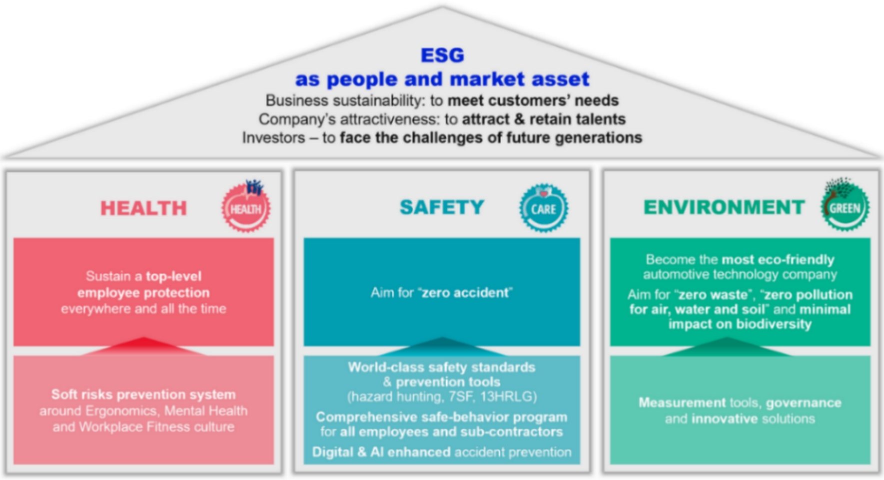

Figure 15. Group´s ESG Strategy

Source: Company´s internal data (2024).

As seen in Figure 15, environmental protection and impact reduction are part of the Group's Strategic plan and targets. The environmental approach is based on the steps of "I know, I care, I reduce," and themes such as zero waste, zero pollution for air, water, and soil, and minimal impact on biodiversity are the main strategy goals.

The environmental approach is based on implementing ISO 14001. It includes guidelines to promote implementation actions to increase energy efficiency, prevent pollution, reduce hazardous materials, minimize waste, and develop sustainable resource use.

The Ten Green Fundamentals gather all the significant environmental topics that industrial sites must comply with. These fundamentals were created based on analyzing group activities and their impact on the environment and global commitments. They comprise themes such as protecting the climate, keeping the soil and water clean, saving water, reducing waste and increasing recycling, protecting the air, protecting biodiversity, acting compliantly, managing impact, managing performance, and training. Figure 16 comprises the ten actual action plans for each green fundamental.

This dissertation will present further the environmental management activities carried out given this strategic company base, as well as the case study on plastics management and circular economy.

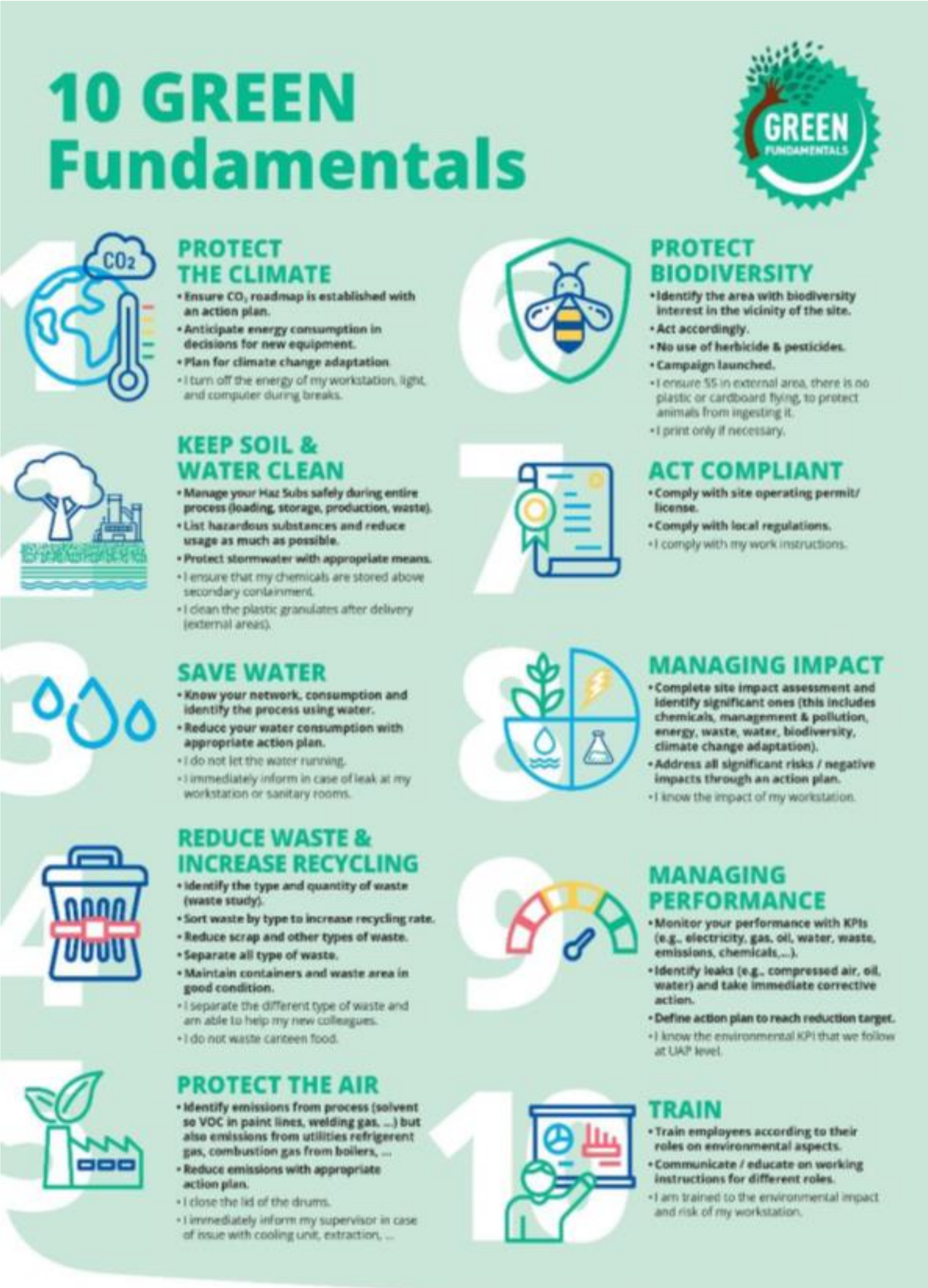

Figure 16. Ten Green Fundamentals and each action plan

Source: Company’s internal data (2024).

4. Methodology

This chapter presents the research methodology, divided into three phases: research on the existing European Union strategies and plastic-related policies within the circular economy framework, environmental management activities, and a case study on plastics performed in the automotive industry. The research phase was conducted to contextualize this dissertation and accomplish the two first specific objectives of the case study.

4.1. Literature Review

The literature review began with the gathering of the primary EU official documents (strategies, policies, and related) regarding the Circular Economy, especially Plastics, considering recent years, from 2015 onwards, considering the recent growth in the relevance of this topic and Spanish national legislation regarding plastics, the focus of the project within the company. A literature review is defined by Hart (1999) as:

> "…the selection of available documents (both published and unpublished) on the topic, which contains information, ideas, data and evidence written from a particular standpoint to fulfill certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents about the research being proposed."

According to Templier and Paré (2015), conducting literature reviews pass through six steps of developing the framework and performing research synthesis: (1) formulating the problem, (2) searching the literature, (3) screening for inclusion, (4) assessing quality, (5) extracting data, and (6) analyzing and synthesizing data.

Formulating the problem involves the definition of the review's objectives and key concepts to justify the research. The data collection phase begins with searching the literature by identifying a range of information sources and the pertinent studies covering the research scope. Moreover, the literature preidentified is evaluated according to its applicability to the study, resulting in included and excluded works. The quality of the included primary articles is assessed based on the criteria defined. Therefore, the pertinent information is gathered from the selection, and the data is organized, compared, summarized, and aggregated into the research to evidence the line of knowledge pretended (Templier & Paré, 2015). Thus, to have an overall and critical analysis of the issues, a narrative review was made using two scientific databases: Web of Science (WoS) and Scopus.

While not seeking generalization or cumulative knowledge, a narrative review aims to summarize what has been written on a particular topic meticulously. The research strategy is selective, with authors choosing studies that support their views. In the case of a narrative review, a formal quality or risk of bias assessment of included primary studies is not required. The narrative employs thematic analysis, chronological order, conceptual frameworks, content analysis, or other classification criteria (Cronin et al., 2008; Green et al., 2006; Levy & Ellis, 2006; Webster & Watson, 2002).

This review was conducted comprehensively, ensuring a thorough topic exploration. The selection of literature was carefully considered, focusing on key topics relevant to environmental management's main actions and circular economy focused on plastics in the automotive industry. These included an assessment of generic EU policies and strategies regarding Circular Economy and more specific topics related to plastics, such as plastic valorization within the automotive industry. The rationale for these topics was their direct relevance and significant impact on the environmental management and sustainability fields. Key issues included the European strategy for plastics in a circular economy, plastic and waste policies, EU plastic policies, Spanish plastic policies, circular economy in the automotive industry, and plastics valorization.

The key topics were meticulously searched on the Web of Science and Scopus databases, following comprehensive initial sorting criteria by relevance. This thorough search process ensured that all relevant literature was considered for the review.

The pre-selection was made within a range of the first 100 articles sorted by relevance, ensuring that the articles were highly pertinent to the research topics: European Union (EU) and related circular economy, policies, plastics, and legal requirements. This pre-selection process involved carefully reviewing the abstracts and keywords to ensure the articles were directly related to the research topics, therefore, Table 1 shows the primary selection results, before and after the removal of duplicates.

Table 1. Number of articles found in the search of literature - WoS and Scopus databases

Key topics used for the search	**Nº of articles found in WoS**	**Nº of articles found in Scopus**
European Strategy for Plastics in a Circular Economy	33	18
Plastic and Waste Policies	23	4
EU Plastic Policies	17	23
Spanish Plastic policies	3	2
Circular Economy in the automotive industry	23	36
Plastics Valorization	18	6
Total of Articles	**117**	**89**
Total of Articles (without duplicates)	**146**	

Source: The author (2024).

Right after the abstract analysis of the primary 146 articles collected, the screening inclusion phase was made by splitting the included and excluded ones, and the ones focusing only on sustainable measures related to the use of plastics from a circular economy point of view. Consequently, the literature included the EU strategy on plastics in a circular economy, policies related to plastics, and sustainability implications (environmental and economic scopes) associated with plastics consumption in the context of a circular economy in the automotive industry.

Moreover, the excluded literature represented those focusing on materials other than plastic, that did not contemplate the European context, did not bring the legal element into the discussion, analyzed different businesses other than industries, focused the analysis on stakeholders and the supply chain, focused only on plastic waste policies, or focused on tools related to logistics, material, and engineering improvements. Articles focusing on plastic valorization, such as alternative materials, current technologies regarding upcycling and recycling, and others, were also selected. These articles will serve as references for further use in developing the project as part of this traineeship.

In summary, the narrative literature research had the following outcomes:

- 65 articles included.
- 33 articles excluded.
- 48 articles gathered for further use related to sustainable measures on plastics consumption.

The quality of the 65 articles was assessed, and the data gathered on the pertinent topics was synthesized in section 2 of this thesis.

4.2. Environmental Management Activities

The report's methodology, in the context of the professional internship in the HSE area and focusing on the environment, was split between describing the environmental management activities performed or supported by this author within the company and developing a case study on plastics management and the circular economy.

In the environmental management section, the activities around environmental performance indicators and their reports, procedures, training, awareness initiatives, and compliance audits will be described, considering this author's contribution to the actions and actual examples of industrial sites' data within the Seating System Europe Division (SSED).

4.3. Case Study

The case study on plastics management and circular economy arose due to a Spanish legal requirement on plastics—Law 7/2022 (Spain, 2022)—which affected the use of packaging plastics at the company's Spanish industrial sites by having a financial impact on the quantity of non-recycled plastic consumed.

A project was created around this subject, and a task force from diverse areas within the company was involved concerning the Seating, Interior Systems, and Clean Mobility BGs.

The project's active actors were at the BG, Division, and Site levels, and the areas involved were HSE, Environment and Sustainability, Purchasing, Controlling, Tax Management, Transport and Packaging Productivity, and Commodity.

The project was first organized by its purposes, split into short-, medium-, and long-term objectives, as presented in Figure 17.

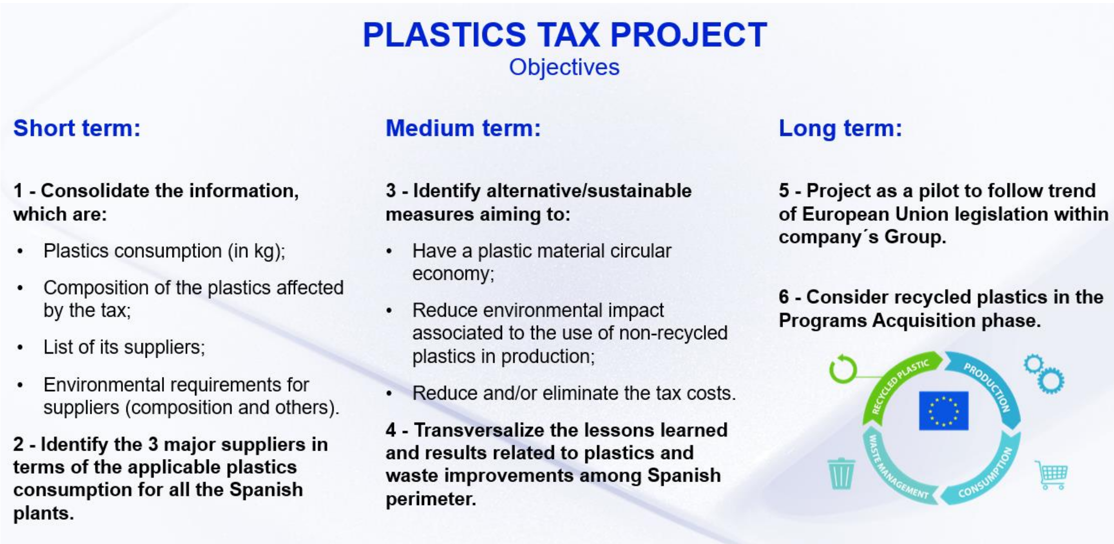

Figure 17. Company´s Plastics Tax Project Objectives

Source: Adapted from the company´s internal data (2024).

The actions to achieve the proposed objectives were discussed and then assigned to the pertinent workgroup participants. Project actions were followed up through bi-weekly or monthly meetings, and specific alignments were made according to the demands.

For this report, the focus was on completing the two short-term objectives due to the internship period. Therefore, the company's remaining four objectives are being further pursued.

The first objective of the Consolidation of Plastic Information was to define an equal data collection period (2023) and map the consumption of packaging plastics, their composition, suppliers, and the tax costs associated with industrial sites involved. The second objective, to identify the three major suppliers regarding plastics consumption, was accomplished by analyzing the mapped data.

The workgroup is following medium-term objectives and actions to identify alternative and sustainable measures related to more circular plastics and fewer environmental and financial impacts through contact with the current stakeholders of the value chain.

Three scenarios and the carbon footprint measurement method were first established to assess the environmental and financial impacts of different percentages of recycled plastics.

The scenarios established were:

- Scenario 1: 100% primary plastic
- Scenario 2: % of primary and secondary plastic
- Scenario 3: 100% secondary plastic

Scenario 1 considers the beginning of the project, with the consumption of only primary (virgin) packaging plastics. Scenario 2, conversely, considers the obtained status of packaging plastics consumed with some percentages of secondary (recycled) plastic. Scenario 3 represents a future scenario that involves completely using secondary packaging plastics.

To assess the carbon footprint - representative of the environmental impact calculation for the present case study - associated with the company's consumption of packaging plastics, CO_2 emissions (in kilograms of CO_2 equivalent per kg of plastic material) were measured.

Packaging Plastics emissions are part of Scope 3, defined by the GHG Protocol Corporate Standard (2015) as all indirect emissions (not included in Scope 2) that occur in the reporting company's value chain, including upstream and downstream emissions.

For this assessment, the packaging plastics consumed were considered in the Material use phase inside Scope 3. This way, the calculation of CO_2 emissions was done by considering emission factors (in kilograms of CO_2 equivalent per kilogram of material used), which refers to the type of plastic used, as shown below.

Equation for Scenario 1 (100% primary plastic):

$$CO_2 emissions\ (kg\ CO_2 eq) = Q\ virgin\ (kg) * EF_{virgin\ plastic}$$

Equation for Scenario 2 (% of primary and secondary plastic):

$$CO_2 emissions\ (kg\ CO_2 eq) =$$

$$\left(Q\ (kg) * \%\ recycled * EF_{recycled\ plastic}\right) + \left(Q\ (kg) * \%\ virgin * \ EF_{virgin\ plastic}\right)$$

Equation for Scenario 3 (100% secondary plastic):

$$CO_2 emissions\ (kg\ CO_2 eq) = Q\ recycled\ (kg) * EF_{recycled\ plastic}$$

In which, Q represents the plastic quantity (in kg), $EF_{virgin\ plastic}$ represents the Emission Factor of virgin plastic (in $kg\ CO_2 eq/kg$) , and $EF_{recycled\ plastic}$ represents the Emission Factor of recycled plastic (in $kg\ CO_2 eq/kg$).

In this case, these conversion factors were used to report on the consumption of procured materials based on their origin (comprising primary or recycled materials). For primary materials, these factors cover the extraction, primary processing, manufacturing, and transportation of materials to the point of sale, not the materials in use. Secondary materials include sorting, processing, manufacturing, and transporting to the point of sale, not the materials in use (Department for Energy Security and Net Zero, 2024).

The database used for the plastic material emission factors was the Greenhouse Gas Reporting—Conversion Factors 2024, provided by the Department for Energy Security and Net Zero of the United Kingdom (UK) Government (Department for Energy Security and Net Zero, 2024).

5. Environmental Management Activities

This chapter links some of the activities performed actively or supportively by the author during her internship in the company, as characterized in Chapter 3. The Health, Safety, and Environment (HSE) area was the scope of action within the Seating System Europe Division (SSED); this thesis focused on activities developed with an Environmental focus.

The environmental management process encompasses—after the environmental aspects and impacts assessment of each activity in the industry sector—performance indicator measurement and reports (section 5.1), procedures, training, and awareness initiatives (section 5.2), and the measurement of the results through environmental and legal compliance audits (section 5.3). The responsibilities and actions of this author on the environmental activities will be displayed accordingly in each section.

5.1. Performance Indicators and Reports

As mentioned in section 3, the group has set environmental ambitions, such as zero waste, zero air, water, and soil pollution, and minimal biodiversity impact.

To keep up with those, key drivers are put in place to improve the group's standards and mindset, which are: deploy no landfill, only recyclable wastes, and no plastic policies; environmental reporting tool and related site/division/BG governance; machine environmental specifications; updated environmental standards; ISO14001 certification; among others.

Yearly targets for measuring environmental performance are defined through key performance indicators (KPIs). The current environmental KPIs followed monthly are composed by the water and waste intensities (considering both monthly and six months rolling - 6MR results), waste recycling rate, and the percentage of certified plants in ISO 14001. Those KPIs are calculated and analyzed according to the following:

- Water Intensity (m^3/M€) = Water Consumption (m^3) / Product Sales (M€)

- Waste Intensity (t/M€) = Waste Generation (metric tons, t) / Product Sales (M€)
- Waste recycling rate (%) = Quantity of Waste destined to reuse/recycling (t) / Total Quantity of Waste (t)
- ISO 14001 Certified Sites (%) = quantity of industrial sites that are ISO 14001 certified within the division and the business units (Covers, Foams & Accessories, and Complete Seats)

Environmental data—waste generation, water consumption, wastewater discharged, and related costs—are reported monthly by each industrial site through the Environmental Reporting Tool (ERT) application. Figures 18 and 19 exemplify the industrial site's waste and water data reporting.

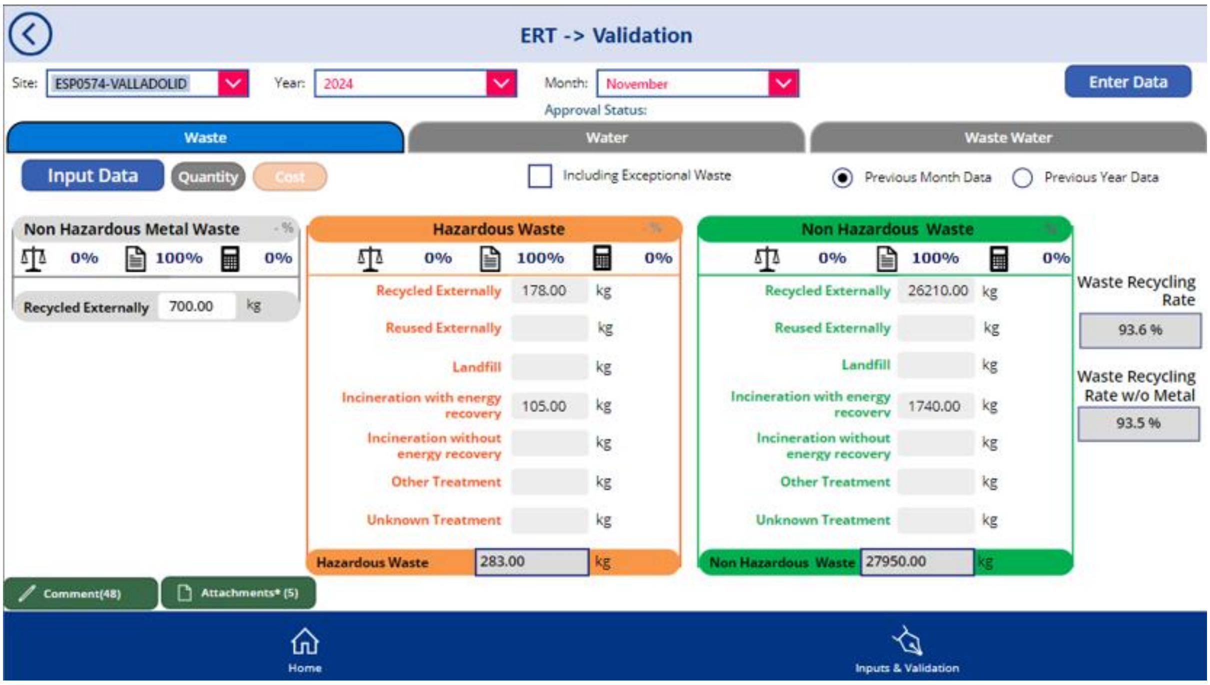

Figure 18. Waste data reporting in the ERT tool

Source: Company's internal data (2024).

Waste is categorized by Metal, Hazardous, and Non-Hazardous types. Regarding waste destinations, each plant adds its generations following the European Waste Code regarding waste descriptions and further treatments. In ERT tool are added the specific suppliers' invoices as evidence e reliability to the data and treatment codes. Consequently, the data is summarized between external reuse/recycling, incineration with energy recovery, incineration without energy recovery, other treatment, landfill, and unknown treatment.

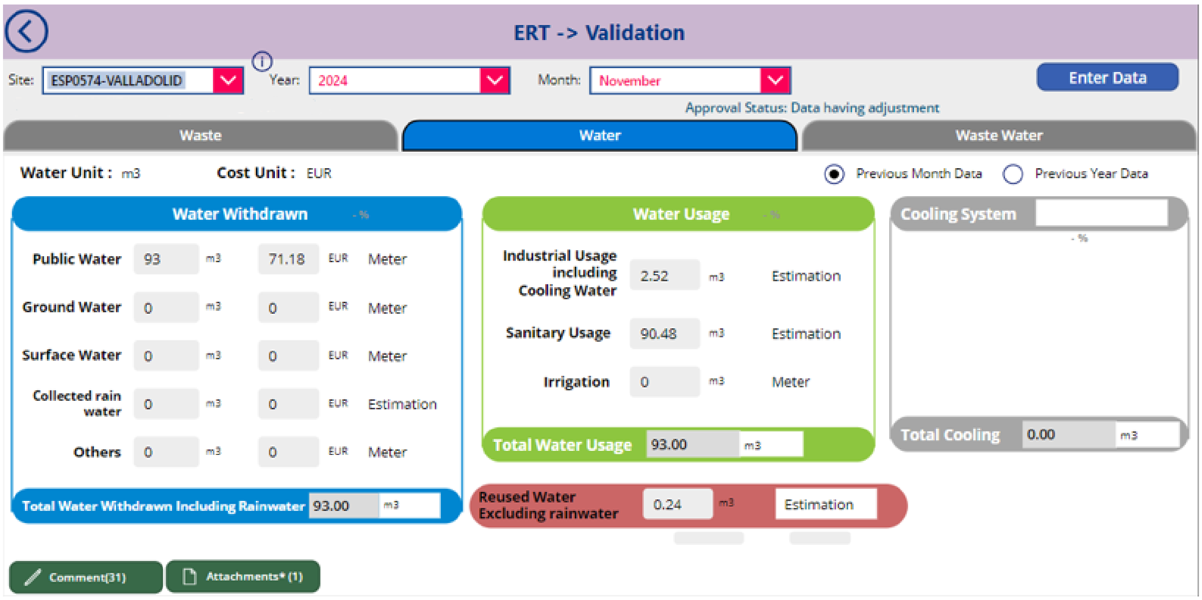

Figure 19. Water data reporting in the ERT tool

Source: Company's internal data (2024).

Water data is added according to the plants´ consumption in cubic meters (Water Withdrawn), depending on the source (public, ground, surface, collected rain waters, or others). Water usage is identified, splitting between the water for industrial, sanitary or irrigation purposes. Furthermore, wastewater data is added accordingly to the proper residual water destination.

This author, as being part of the HSE area at the division level, was responsible for the validation of some industrial sites' data inside ERT, as well as for the gathering, analysis and reporting of the SSED environmental monthly data. Based on ERT monthly inputs, the reporting data results are followed through dashboards for Waste, Water, and Wastewater. Industrial site results are analyzed and compared, allowing the definition of significant impact contributors and deviations caused by factors other than production increase or decrease. Figures 20 and 21 show a sample of the Dashboard.

Figure 20. Dashboard on the waste of SSED division

Source: Company's internal data (2025).

Waste dashboard contemplates graphs regarding the total of waste generated, the generation per type of wastes and their treatments, and the recycling rate, among others.

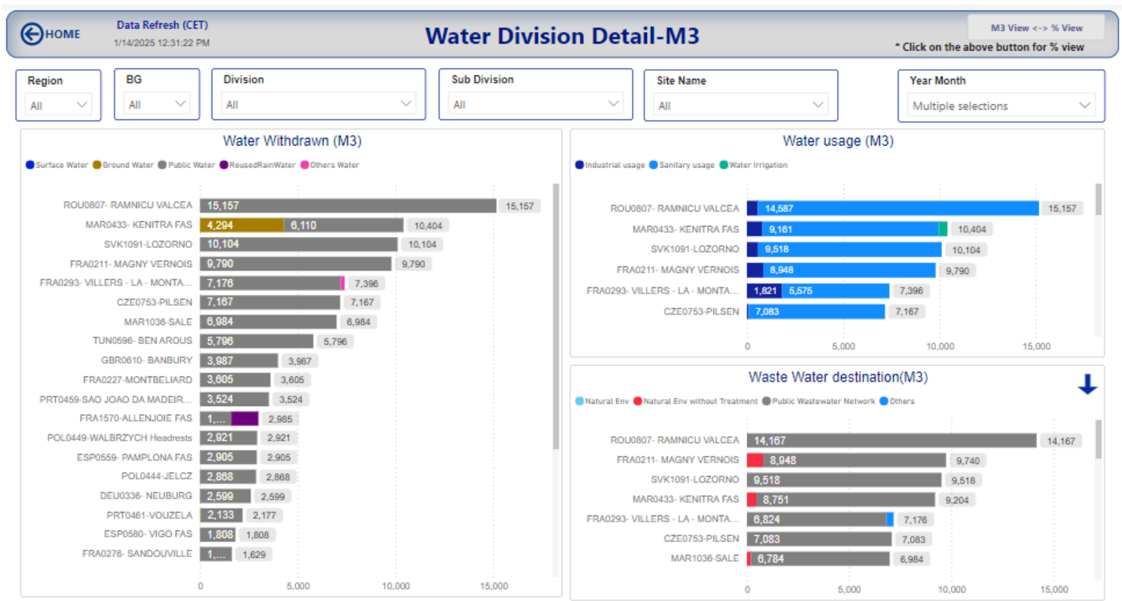

Figure 21. Dashboard on the water of SSED division

Source: Company's internal data (2025).

Water dashboard visually demonstrates the plants with highest consumption of water, the characteristics of this water use, as well as the overview of the wastewater destinations.

Thus, figure 22 shows the KPI results summary of the monthly environmental reporting, considering SSED, Components (Covers + Foams and Accessories), and Complete Seats (JIT) results. It is accomplished through dashboard analyses and calculations on the intensities and recycling rates. The entire environmental presentation is performed by this author, contemplating the KPI results and the industrial sites´ individual performance through the waste and water graphs, followed each month and in the last 6 months rolling.

SSED - ENVIRONMENTAL KPI

October Data

KPI RESULTS

OCTOBER 2024	SSED	Components	Components target	JIT	JIT target
ISO 14001 certification	92% →	100% →	100%	86% →	85%
Water Intensity (6MR)	31,06 ↗	102,69 ↗	115,0	15,81 ↘	-
Water Intensity (monthly)	24,25 ↘	89,36 ↘	115,0	10,86 ↘	-
Water Consumption (m3) (monthly)	9176,19 ↘	5766,22 ↗	-	3409,97 ↘	-
Waste Intensity (6MR)	5,30 ↗	16,70 ↗	12,7	2,87 ↘	3,45
Waste Intensity (monthly)	5,24 ↘	17,38 ↗	12,7	2,75 ↘	3,45
Waste Production (ton) (monthly)	1984,27 ↗	1121,26 ↗	-	863,01 ↗	-
Waste recycling (%)	56% ↗	38% ↗	17%	79% ↘	79%

Figure 22. SSED environmental KPI summary of October 2024

Source: Company’s internal data (2024).

Each KPI is followed at the division level according to its specific target to check compliance or not, and previous data is compared through green and red arrows to track tendencies and deviations. The increases on waste production and intensity and water consumption and intensity are represented by red arrows due to their negative impact on the indicators and the environment. On the other hand, the increasing of the waste recycling rate is a positive set, and it is represented for the green arrows.

As already mentioned, 6MR means the average data from the last six consecutive months of the report. Analyzing the KPI results of October 2024, not only the waste intensity (6MR and monthly) of Components increased compared to September data, but they were also way above the target set of 12,7. Thus, through this analysis is possible to investigate the existence of non-conformities and stablish action plans to be on target.

The industrial sites add their environment-related official documents and analyses inside an internal tool called the Footprint, Risk, Environment Database (FRED). Figure 23 shows an example of the storage of São João da Madeira plant ISO14001 certification, showing its compliance in the related KPI.

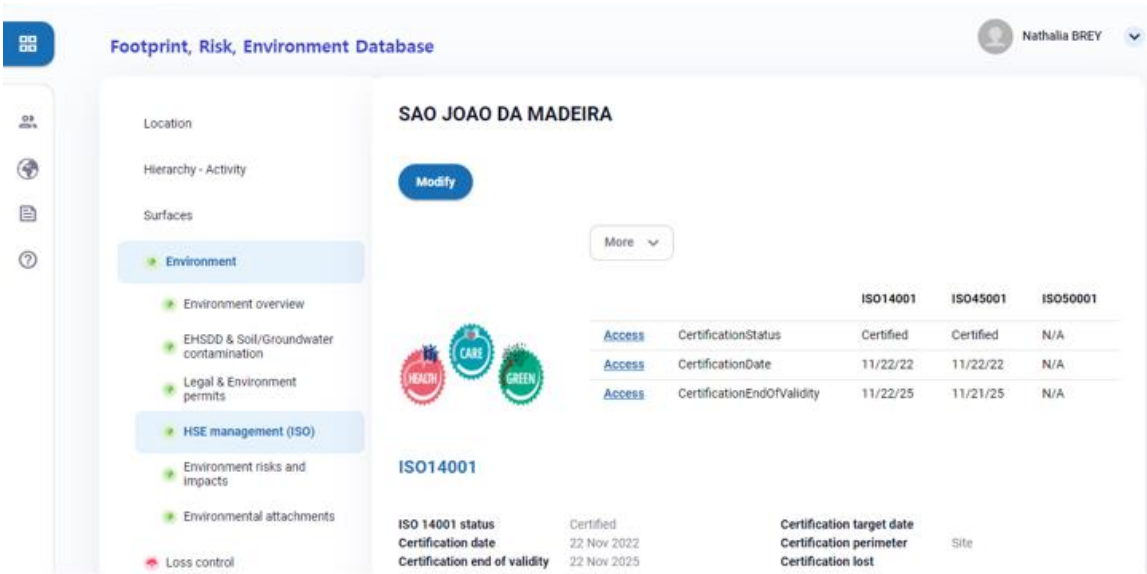

Figure 23. ISO 14001 certification of SJDM plant inside FRED

Source: Company’s internal data (2024).

After keeping stored the ISO 14001 certifications, the SSED division controls the percentage of certified plants, as seen below (Table 2), considering their compliance in each business unit. The author supported these sorts of updates on the SSED management files. From the presented table is observed that in Components’ industrial sites the ISO 14001 is fully implemented. Considering Complete Seats, the perimeter of France is remaining 50% of its plants to be certified, demonstrating the need of continuous environmental management improvement in this division area.

Table 2. ISO 14001 certification status of SSED

Components (Covers + Foams&Acc) % of certified plants			**Complete Seats (JIT) % of certified plants**				**Division (SSED) % of certified plants**
Covers	**Foams & Acc**	**Components**	**JIT Iberia**	**JIT Eastern**	**JIT France**	**JIT**	
100%	**100%**	**100%**	**100%**	**100%**	**50%**	**86%**	**92%**

Source: Company's internal data (2024).

Beyond the monthly report, there is also the yearly environmental report organized by the group, and all industrial sites must insert specific data under the management of the referred divisions and BGs. For this reporting, the Tennaxia tool comprises all environmental data required for internal and external requirements. There is a connection between the databases ERT and FRED to resume the existing internal data.

Tennaxia is a questionnaire with about 150 environment-related questions that plants should answer according to their process applicability and the general theme in the automotive sector activities. The data is split into general information (Plant organization and general data): 1. Environmental Management & Compliance, 2. Environmental Compliance, 3. Environmental Management System (ISO 14001 standard), 4. Waste, 5. Energy, 6. Atmospheric Emissions, 7. Water resources, 8. Wastewater, 9. Biodiversity, land use, and pollution, 10. Environmental costs, 11. Environmental Facts, Official Complaints, notices, etc.

Regarding the yearly reporting, this author supported in the demanded actions of the Division and Plants HSE managers. Afterward, this data reported serves as a basis for attending to legal requirements and the company's demands with reliable and transparent environmental data such as the Sustainability report.

5.2. Procedures, Training, Awareness Initiatives

The importance of having controlled documentation and records to comply with legal and internal requirements and build precise action plans is known in the HSE management area. In this context, internal HSE-related procedures established by the company applicable to the SSED Division are controlled in the scope of this internship.

These documents are grouped by their names and purposes, with the document owner and publication dates described. They are categorized by key process, entity, scope, type, version, and theme. The HSE area is defined as a key process inside Operations Systems. The entity is Seating in this case; the scope is either Group or Seating Business Group. Related to the type of documents, they are categorized as:

P – Core Procedure: a procedure managed at the Group level, describing the general operations and responsibilities related to any work within the company.

C – Charter: a document to explain general policies or commitment

I – Instruction: document to describe each step required to perform a specific task

F – Form: format to record results achieved or provide evidence of tasks performed or template to prepare a document

S – Standard: template of form to list methods, specifications, and tools defined as rules

Figure 24 shows an example of the procedure "FAU-S-LSG-5850: 10 Green Fundamentals" inside the Core Procedures application.

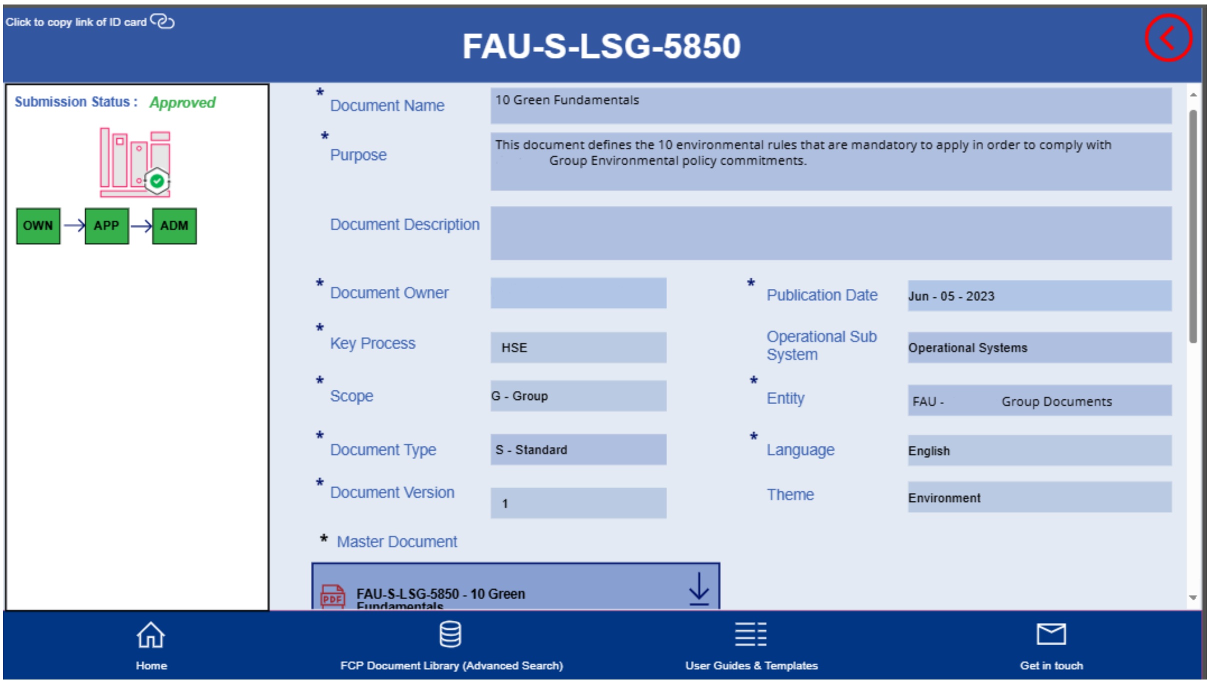

Figure 24. Procedure FAU-S-LSG-5850 inside Core Procedures application

Source: Company's internal data (2024).

Internally, in the HSE division area of SSED, the applicable procedures were controlled by this author through an Excel file. Figure 25 exemplifies the environment-related documents currently in existence.

Category	Level	Code of document	Type of Document	Name of Document	Issue	Date
Environment	FAS	FST-S-LSE-5821	S	Environmental Assessment	3	17/10/2022
Environment	FAS	FST-F-LSE-5822	F	Environmental Assessment Scoring Support	5	01/07/2024
Environment	FAS	FST-C-DSE-0003	C	Environmental Reporting Supplier Requirements	9	27/11/2023
Environment	Group	FAU-I-LSG-3904	I	Instruction for non-financial data reporting- Environment chapter (DPEF in French)	12	25/11/2024
Environment	Group	FAU-F-LSG-3904	F	Questionnaire for non-financial data reporting- Environmental Data Collection Form	7	29/11/2021
Environment	Group	FAU-S-LSG-5850	S	10 Green Fundamentals	1	05/06/2023
Environment	Group	FAU-F-LSG-3908	S	10 Green Fundamentals Audit	3	28/10/2024
Environment	Group	FAU-P-LSC-5802	P	CO2 Footprint, LCA & Cost	2	10/10/2022
Environment	Group	FAU-S-LSG-5888	S	new Plant Handbook	1	25/11/2014
Environment	Group	FAU-P-LSC-5803	P	Energy Management	1	03/10/2022
Environment	Group	FAU-S-LSG-5806	S	Green Factory Whitebook	1	03/10/2022
Environment	Group	FAU-C-LSG-5840	C	Environmental Policy	2	29/04/2024

Figure 25. Division file with environment-related documents

Source: Adapted from the company's internal data (2024).

Training is essential for implementing internal procedures, remaining legally compliant, and establishing common environmental knowledge among all company parts. Environmental education through training and awareness initiatives is key, given that the industry comprises people who are the keepers of sustainable change and continuous improvement.

Environmental Training is performed according to the group's strategies and the demands of each site/division/BG. Environmental KPIs, 10 Green Fundamentals, HSE overview rules and reports, Tennaxia annual reporting, environmental incidents, and Management systems are covered at least once a year within the division. The author supported the organization and preparation of several HSE-related trainings.

Regarding awareness initiatives at the Group level, Best Practices Contests are organized. A different topic related to Health, Safety, and Environment is released each month, and industrial sites contribute sharing their practices among several plants. In this contest, a jury selects one best practice based on the evaluation of five criteria, and the plant is awarded a trophy and recognition from the group. This author participated in these contests, by presenting the SSED industrial sites´ when not in presence of the respective HSE managers.

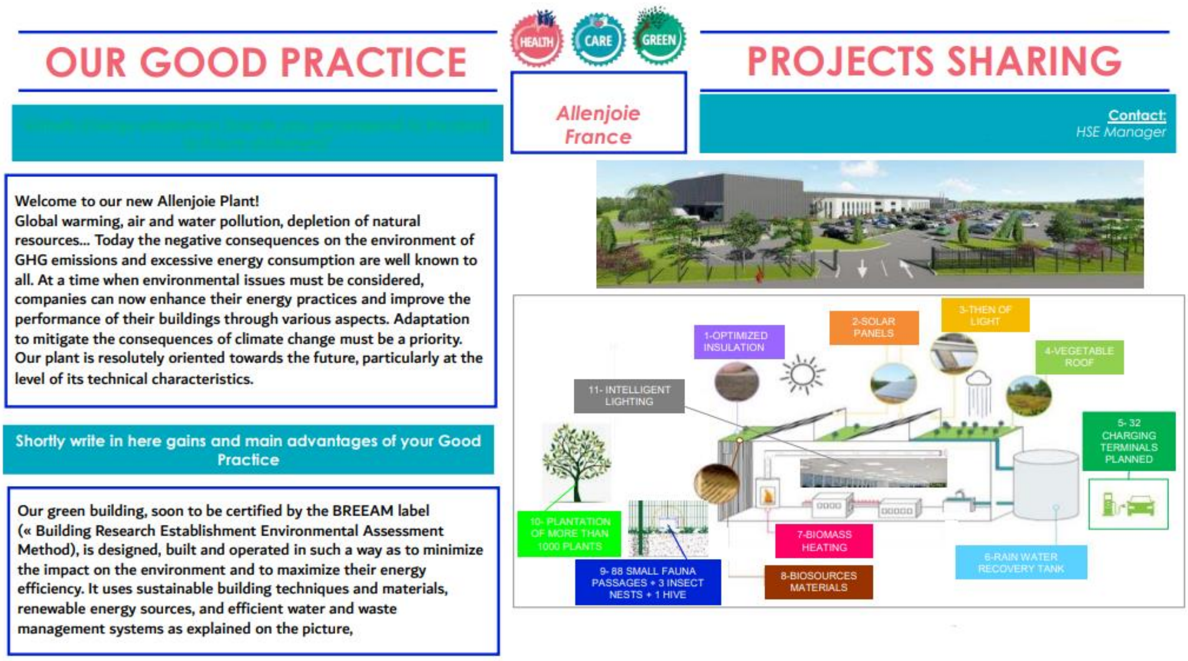

Figure 26. Best Practice on Climate Change Adaptation: Allenjoie Plant

Source: Company's internal data (2025).

With a dedicated best practice sharing platform, knowledge is shared, ensuring the possible expansion of environmental improvement actions throughout the sites. Figure 26 exemplifies one best practice of the Allenjoie plant, a French site of the SSED division, around the theme of "Climate Change Adaptation: How do you prepare the plant for future challenges?" The plant shows how its industrial building was already planned to meet 'green' standards, minimizing environmental impact, and maximizing energy efficiency.

Weekly awareness actions on HSE are performed on the shop floor and in the offices. This author prepared these presentations for Iberic and North African perimeters. Meetings are organized, and reuniting workstation leaders with their teams is mandatory. This aims to spread the main production-related highlights and HSE-related events (such as incidents or procedure updates), reinforce existing and applicable procedures and rules, and critically examine specific topics inside the HSE field.

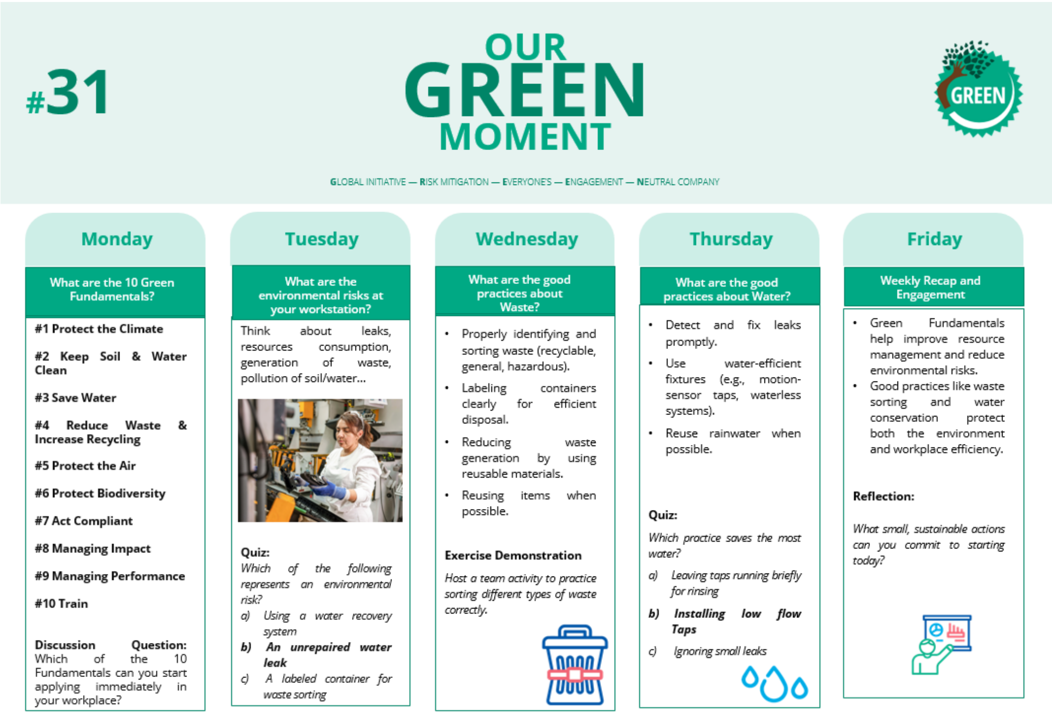

Figure 27. Green moment 'Environmental Awareness in Action'

Source: Company's internal data (2025).

Beyond the weekly awareness meetings, there is the Green Moment, bringing environmental subjects with a close perspective on all company parts; an example can be seen in Figure 27 on the topic of ‘Environmental Awareness in Action.’ It is visible that daily questions are proposed around the weekly environmental topic, and this one considers the Ten Green Fundamentals and issues related to them, like Waste management.

5.3. Environmental and Legal Compliance Audits

Regarding legal requirements, all plants must comply with permits and laws due to the legal watch. This topic is followed at the program manager level, but the HSE area is also involved. Legal Audits by third-party experts are done at least once per year on each plant, according to European and specific national requirements, and always have the presence of the HSE team.

Audits are robust tools to measure the results and status of industrial sites related to the environment. Certification audits are conducted internally and externally to maintain or comply with the ISO 14001 requirements of established environmental management. Audits of the Group's Excellence System are conducted considering all production areas. There are five HSE-related topics: compliance with HSE rules, HSE engagement, and environmental care, among others related to the environment.

- **Compliance with HSE Rules**

- Expectation: All sites must ensure compliance with each Country's HSE regulations.

- **HSE Engagement**

- Expectations: Each level of management (site management teams, supervisors, gap leaders) must share health, safety, or environmental information at the beginning of each TOP5 and openly discuss what their teams can improve in their areas.
- In addition, each meeting must start with an HSE moment. These actions reinforce health, safety, environmental knowledge, and everyone´s commitment to a positive HSE culture.
- Perform HSE Campaigns.

- **Environmental Care**

- Expectations: 1. Compliance with 10 Green Fundamentals; 2. alert on environmental deviations; 3. environmental impact assessments known, and actions implemented to control impact; 4. environmental aspects are part of the HSE communication and shopfloor inspection routines.

Table 3 shows how each Environmental Care Fundamental expectation aspect is measured and scored as Fully Applied, Partially Applied, or Not Applied.

Table 3. FES Audit score requirements - Environmental Care Fundamental

Fundamental: Environmental Care			
Exp.	**Fully applied**	**Partially applied**	**Not applied**
1	For 10 EGF, the audit was done over the last 12 months. The site is ISO 14001 certified. All operational 10 EGF are respected while performing the audit. Operators can explain the impact of their workstations. Waste segregation is well respected. Hazardous substances and waste are placed under secondary containment.	The audit was not performed last year but is not older than 24 months. The site is not ISO 14001 certified but has checked compliance in the last 12 months. One slight deviation from the operational 10 EGF was observed.	No audit in the last 24 months or no action plan or severe deviations were observed.
2	Each environmental incident is handled using a problem-solving, 8D, or recognized alternative method, and actions are promptly implemented. At least for red/yellow alerts, LLS is created and communicated inside the plant and through Divisions or Regions.	For each environmental incident, a problem-solving or recognized alternative method is used with actions on delay and no monthly follow-up. At least for red/yellow alerts, LLS is created and communicated inside the plant.	No formalized problem-solving, 8D, or recognized alternative was used; only containment actions were applied. LLS was not created.
3	The assessment covers identifying environmental impacts and aspects, and it is reviewed in case of applicable transversal memos/lessons learned from Group/BG, significant changes, or yearly changes. Actions are defined yearly to reduce the most significant impacts	Partial identification of the environmental effects (missing air emission, water, waste, implications for energy) or the action plan is incomplete (missing actions to identify impact).	No environmental impact assessment was done, and no action Plan.

Fundamental: Environmental Care			
Exp.	Fully applied	Partially applied	Not applied
4	The searching process includes environmental hazards. Green Moment equivalent is given during the HSE message. Campaigns have been launched in the last 12 months. Plant participates in the Best Practice contest at least once a year.	One of the items is missing.	Two or more items are missing.

Source: Adapted from the company's internal data (2024).

Regarding HSE campaigns in the environmental scope, Audits on the Ten Green Fundaments are planned and performed at the division level in each industrial site. The following tables present the follow-up done by SSED on the results and audit dates per plant and business unit (Table 4, Components; Table 5, Complete Seats), updated accordingly by this author based on the official reports post-audit. It is observed that some plants still were not audited, and others obtained a down score (<60%), which represents how important it is to check how the plants are progressing in the environmental topics to propose precise action plans to comply with the external and internal requirements to protect the environment.

Table 4. 10 GF Results and Follow-up – Components Campaign

Date Last 10GF Audit	Year	Date Nex Planned Audit	Plant	BU	10 GF Results (%)
June-24	**2024**	June-25	**Salé**	Covers	**79%**
May-24	**2024**	February-25	**Valcea**		**Not Audited**
April-24	**2024**	April-25	**Vouzela**		**77%**
April-24	**2024**	January-25	**Ben Arous**		**58%**
September-24	**2024**	September-25	**Kenitra**		**66%**
July-24	**2024**	April-25	**Jelcz**	Foams & Accessories	**Not Audited**
July-24	**2024**	January-25	**Magny**		**53%**
May-24	**2024**	February-25	**VLM**		**58%**
January-25	**2025**	January-26	**SJDM**		**83%**
December-24	**2024**	February-25	**Walbrzych Acc**		**70%**
December-24	**2024**	February-25	**Walbrzych Pn**		**71%**

Source: Adapted from the company's internal data (2024).

Table 5. 10 GF Results and Follow-up – Complete Seats Campaign

Date Last 10GF Audit	Year	Date Next Planned Audit	Plant	Cluster	10 GF Results (%)
June-24	2024	March-25	**Pilsen**	Eastern	**69%**
May-24	2024	April-25	**Banbury**		**Not audited**
November-24	2024	May -25	**Lozorno**		**71%**
January-24	2024	-	**Neuburg**		**Not audited**
January-24	2024	February-25	**Neuenstadt**		**Not audited**
May-24	2024	January-25	**Sandouville**	France	**Not audited**
October-24	2024	April-25	**Allenjoie**		**80%**
October-24	2024	October-25	**Rennes**		**71%**
September-24	2024	February-25	**Flers-En-Escrebieux**		**79%**
May-24	2024	April-25	**Vitoria**	Iberia	**75%**
March-24	2024	February-25	**Vigo**		**62%**
February-24	2024	February-25	**Valladolid**		**69%**
January-25	2025	January-26	**Nelas**		**87%**
October-24	2024	September-25	**Pamplona**		**73%**

Source: Adapted from the company's internal data (2024).

As mentioned, the division, BG, or the Group performs the Ten Green Fundamentals Audits. The process follows an established procedure in form format. The first six fundamentals (climate, soil, water, waste, air, and biodiversity related) are part of the Operational Control activities inside the plant, and the last four are more focused on compliance and impact (compliance, impacts, performance, training, and awareness).

ID	Check points (non-exhaustive list)	OK/NOK/NA	Who to interview?	How to assess?
	1.PROTECT THE CLIMATE	**67%**		
1	The site has an energy reduction plan as per CO2 requirements	OK	M	Check that action plan exists and that actions are scheduled or implemented. If actions have more than 6 months delay, it is considered as NOK
2	Workstations where energy is identified as significant environmental impact are identified and employees trained on the energy management.	OK	O	Check at the workstation if a logo exits or if requirement appear in the SW. Ask one employee to explain
3	Climate change adaptation preparedness : the site has identified the risks for 2030 (Natural hazard study from insurer or other available studies) and has defined an action plan & emergency procedure. The site keeps green area to keep humidity in case of heat waves.	NOK	M	Ask for risk assessment related to climate change and action plan. If only the risk assessment exists it can be considered as OK until end of 2024. Check evolution of green areas of the site.

Figure 28. Example of the audit on Fundamental 1. Protect the Climate in one SSED plant

Source: Company's internal data (2025).

Figure 28 brings an example of a 10GF Audit done in one of the SSED industrial sites, by the Division HSE manager, with participation of this author in the shop floor and audit meetings. The 10 GF audit form is organized in the points to be checked for each fundamental, to be considered okay (OK), not okay (NOK), or not applicable (NA). It explains who should be interviewed in each question depending on the scope: managers (M) or operators (O). Further, the group's recommendations on how the auditor should assess the points are included. Last, the auditor adds the pertinent comments and actions that resulted from the audit.

In the three audit questions regarding the first fundamental - Protection on the Climate - presented in the last figure, it is observed that the plant is compliant (ok) with its energy reduction plan (part of CO_2 requirements) with awareness initiatives (CO_2 champion), PDCA (Plan-Do-Check-Act) available and followed KPIs. Also, the workstations with significant energy-related environmental impacts are identified, and the employees are well-trained in energy management. The plant was considered not compliant (nok) regarding climate change preparedness (identification of risks for 2030 goals, action plan, emergency procedure) since only generic actions are included in the contingency plan. This last item, for example, will require an action plan from the plant to be compliant in the next audit.

Considering all checkpoints of the Ten Green Fundamentals, a score per fundamental and then a global score, the audit result, is obtained in table format (table 6) and visual graphics are generated (figure 29).

Table 6. Total and score per fundamental – 10 GF Audit on SSED plant

Recap	Score	Fundamental
Fundamental 1	67%	Protect the climate
Fundamental 2	71%	Keep soil water clean
Fundamental 3	90%	Save water
Fundamental 4	100%	Reduce waste and increase recycling
Fundamental 5	86%	Protect the air
Fundamental 6	63%	Protect biodiversity
Fundamental 7	67%	Act compliant

Recap	Score	Fundamental
Fundamental 8	75%	Managing our impacts
Fundamental 9	100%	Managing your performance
Fundamental 10	100%	Training & Awareness
Total Score	**83%**	

Source: Adapted from the company's internal data (2025).

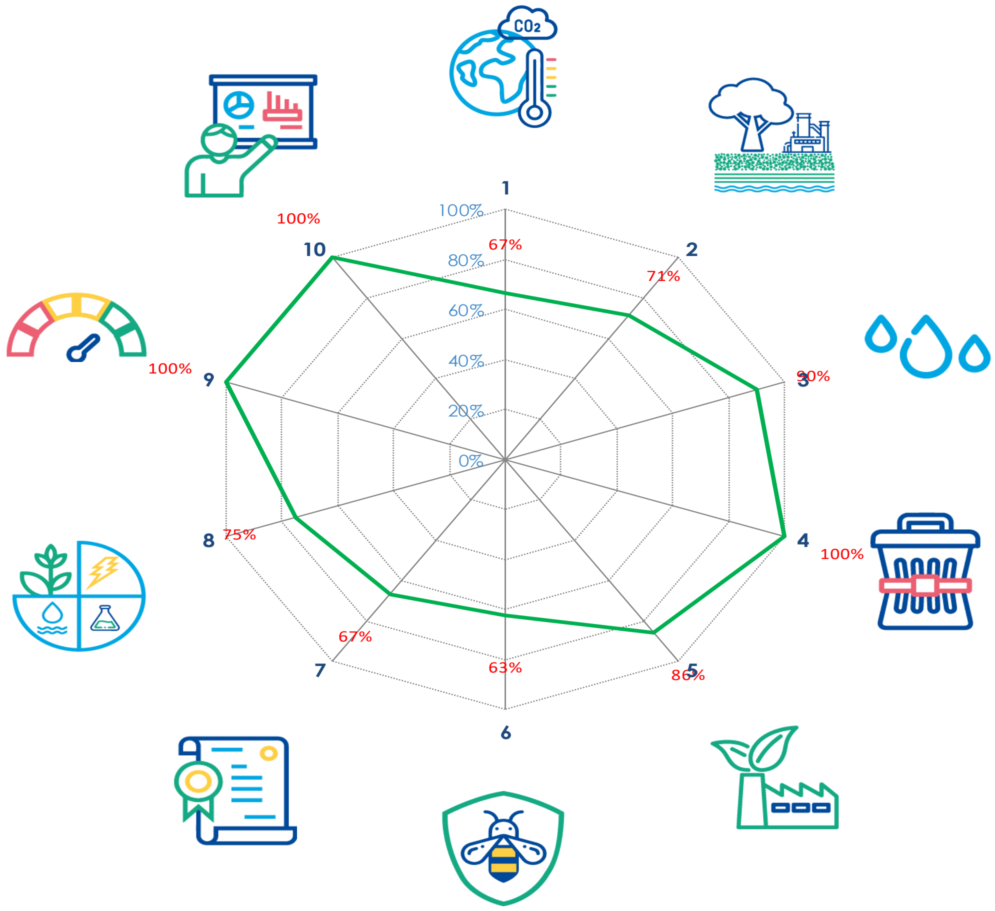

Figure 29. 10 GF Audit result of SSED plant in a visual graph, per fundamental

Source: Company's internal data (2025).

As seen above, the completed audit on the 10 green fundamentals topics inside this specific SSED plant obtained a global score of 83%, above the division average results, demonstrating the plant´s commitment towards environment and the company´s internal rules.

The environmental management activities performed and supported during the internship, including performance monitoring, compliance audits, documentation control, training, and awareness initiatives, represent a core component of the company’s broader sustainability efforts. While these activities were not directly related to the plastics management case study, they reflect the multifaceted nature of environmental management within the automotive industry. These initiatives demonstrate the company´s commitment to improving environmental performance and aligning internal and external sustainability goals.

The following chapter (section 6) presents a case study on plastics management and the circular economy. It focuses on Spanish legislation's legal, environmental, and financial impacts on the consumption of non-recycled plastics. This study provides a complementary perspective on how target strategies can address specific sustainability challenges within the industry.

6. Case Study: Plastics Management and Circular Economy

This chapter links the case study development, results, and recommendations regarding plastics management and circular economy in the Spanish context of the company host of the internship.

6.1. Project Development

The question appeared in the company's Spanish industrial sites in 2023 with the rise of national legislation 7/2022 (Spain, 2022)—so-called "Law 7/2022, from April 8th, on waste and contaminated soils for a circular economy"—which includes the requirement of a tax payment for the use of non-recycled plastic as the raw material of production flow.

The financial and legal impacts of this legislation and the environmental impact of consuming plastics from virgin material brought the Group's attention, considering the European context beyond Spain, and therefore, the project began.

As shown in the methodological part of the present research, the project has been conducted with a collaborative workgroup among diverse areas in the corporate hierarchy and has followed the course of the short—and mid-term objectives presented: 1—consolidation of information; 2—identification of the three major suppliers of plastic consumption; 3—identification of alternative/sustainable measures.

Considering the Circular Economy flow throughout the value chain presented below in Figure 30, the project acted on the reduce/reuse and regenerate/recycle phases.

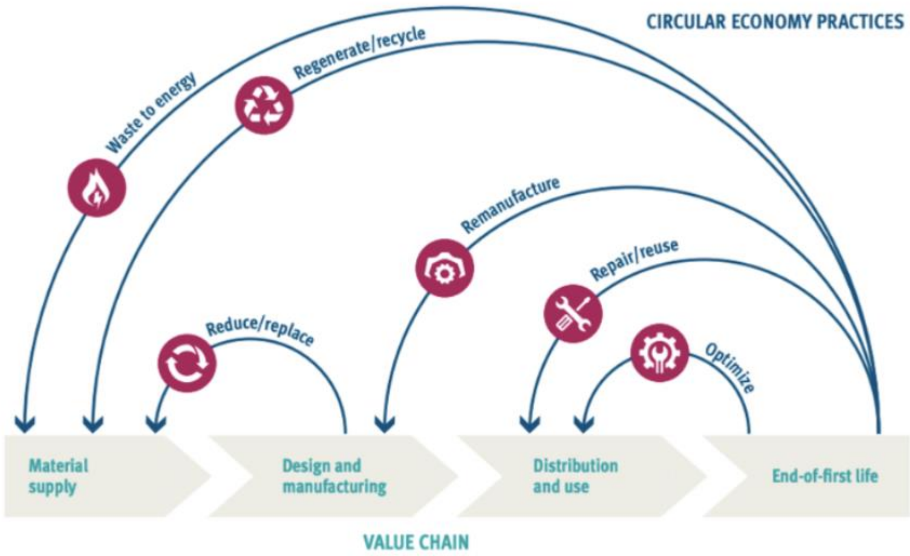

Figure 30. Value Chain in a Circular Economy

Source: UNIDO (2024).

Law 7/2022's imposition is focused on the beginning of the value chain—material Supply Flow—specifically in this case study. According to UNIDO (2024), in a circular economy, the input of virgin raw materials shall be reduced to almost zero, with suppliers from recycled materials.

As explained below, the automotive sector should focus on the reduction/replacement and regeneration/recycling phases for a circular process.

- **Reduce/replace phase:** In circular manufacturing, companies will reduce the material and energy resources used as inputs, replace hazardous materials with non-hazardous materials, and replace virgin raw materials with recycled raw materials (UNIDO, 2024).
- **Regenerate/recycle phase:** A material can be recycled with cost-effective recycling technology, a market for the recyclate, and a lower price than equivalent virgin material (UNIDO, 2024).

Contextualized and in action for legal compliance, the tax management area conducted an internal analysis regarding the legal requirement's applicability in this automotive industry sector. After comprehending that the packaging plastics represented the sort of plastics applied to taxation, the Spanish plants started paying monthly the tax per kilogram of non-recycled packaging plastic consumed, according to a standardized workflow further presented.

The categorizations were based on Law 7/2022 and the company's framework for packaging plastics, regarding the products concepts (plastic source), their codes (categorization), the tax regime imposed, and the fiscal document types (see tables 7-10).

Table 7. Product Concept – Packaging Plastics

Code	Concept
1	Intracommunity acquisition
2	Deduction for shipping outside the Spanish Territory
3	Deduction for inadequacy or destruction (before first delivery)
4	Deduction for return for destruction or reincorporation into the manufacturing process (after delivery or provision)

Source: Adapted from the company's internal data (2024).

Table 8. Product Codes – Packaging Plastics

Code	Product
a	Non-reusable packaging containing plastic is provided for in section a) of article 68.1 of Law 7/2022
b	Semi-finished plastic products are provided for in section b) of article 68.1 of Law 7/2022
c	Plastic product provided for in section c) of article 68.1 of Law 7/2022

Source: Adapted from the company's internal data (2024).

Table 9. Tax Regime for the Packaging Plastics

Code	Tax Regime	Contents of the article in question
a	Subjection and not exemption	This key is applicable when the operation is subject to tax, and none of the following are applicable.
b	No subjection to article 73.c Law	AIB for paints, inks, lacquers, and adhesives is intended to be incorporated into products subject to tax.
c	No subjection to article 73.d Law	AIB for packaging not designed to be delivered together with the goods.

Code	Tax Regime	Contents of the article in question
d	Exemption from article 75.a.1º Law	AIB for packaging intended to contain medicines or medical devices.
e	Exemption from article 75.a.2º Law	AIB for semi-finished plastic products intended to obtain packaging for medicines or medical devices.
f	Exemption from article 75.a.3º Law	AIB for plastic products intended to close non-reusable containers containing medicines or medical devices.
g	Exemption from Article 75.b of the Law	AIB of packaging, introduced into Spain, containing medicines or medical devices.
h	Exemption from Article 75.c of the Law	AIB of plastic rolls for fodder silage or cereals for agricultural or livestock use.
i	Exemption from Article 75.d of the Law	AIB was sent outside of Spain before the deadline for filing the self-assessment.
j	Exemption from article 75.e Law	AIB that are no longer suitable for use or have been destroyed before the deadline for filing the self-assessment.
k	Exemption from Article 75.f of the Law	AIB for packaging if the non-recycled plastic does not exceed 5 kilograms in one month.
l	Exemption from article 75.g.1º Law	AIB for semi-finished plastics is not intended to obtain packaging that is subject to tax.
m	Exemption from article 75.g.2º Law	AIB for plastic products is intended to close non-reusable containers when they are not being used.

Source: Adapted from the company's internal data (2024).

Table 10. Document Type – Packaging Plastics

Code	Description
1	Spanish NIF or NIE
2	Intra-community VAT number
3	Others

Source: Adapted from the company's internal data (2024).

After the previous categorizations, a standardized file was delivered to each industrial site, so the area responsible started to manage the monthly complete filling of the plastics data, accordingly, composing the information of the plastic suppliers, and the values on recycled and non-recycled plastics consumption (Table 11).

Table 11. File from Tax area to fulfillment and payment of the tax on plastics

File	Concept	Product Code	Product Description	Tax Regime	Document Type	Company name	kg	kg Not Recycled
Mandatory Info	Yes	Yes	Yes	No	Buyers: Yes No: Manufacturers	Buyers: Yes No: Manufacturers	Yes	Yes
Possible Values	List Table 7	List Table 8	X	List Table 9	List Table 10	X	X	X

Source: Adapted from the company's internal data (2024).

A map of the Spanish industrial sites (Figure 31) contextualized the project's scope throughout Spain, between Interior System, Seating, and Clean Mobility BGs.

Figure 31. Representation of the Spanish sites involved in the project

Source: Company's internal data (2024).

After meetings with the areas involved in the mentioned plastics data collection workflow, a general process flow was designed as shown in Figure 32 and thus extended to all the industrial sites concerned.

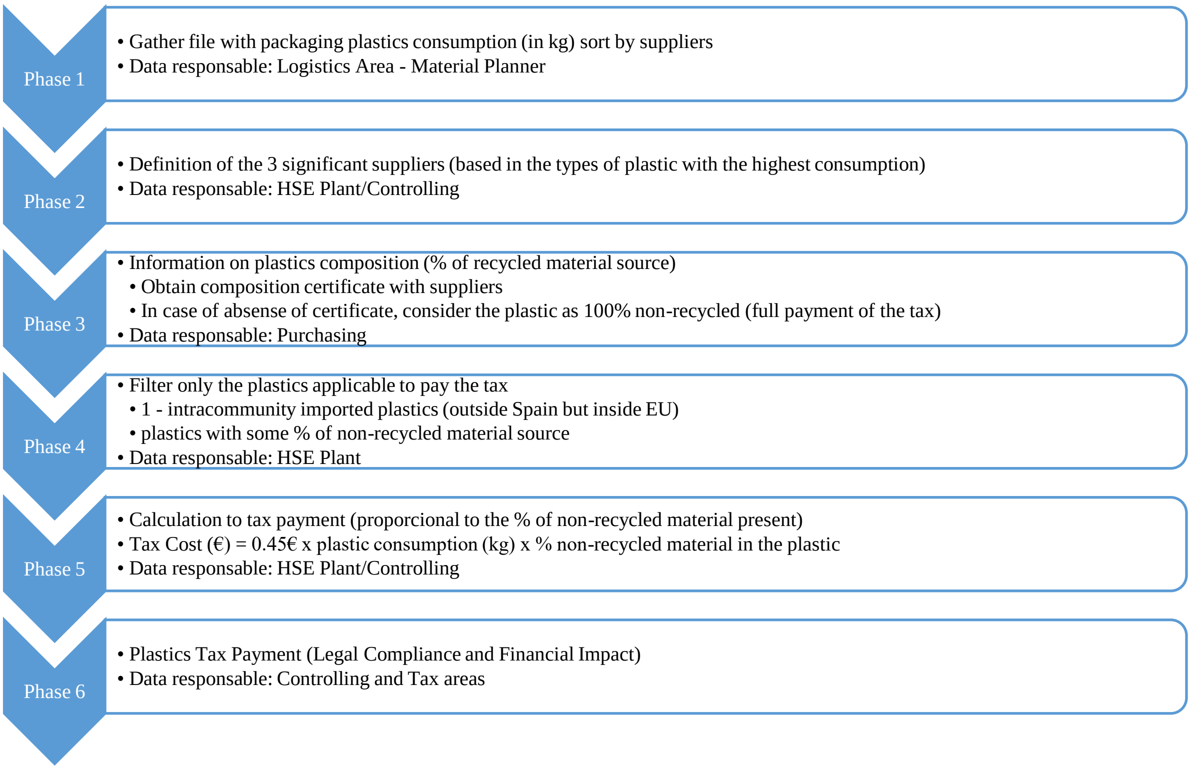

Figure 32. Flow of plastics data collection followed by the Spanish industrial sites

Source: The author (2024).

Seating and Interior Systems BGs plastics data were gathered considering the entire 2023. Clean Mobility BG did not provide any data for the project, so its results will not be demonstrated. Follow-up meetings were held for each project phase, and their minutes and status were monitored.

Section 6.2 will show the results of mapping the consumption of non-recycled plastics in the Spanish industrial sites, its key suppliers, and the costs associated with the legislation. Moreover, the assessment of scenarios' environmental and financial impacts with different percentages of recycled plastics is included.

6.2. Results and Discussion

For Seating and Interior Systems BGs, the 2023 yearly consumption (in kg) of packaging plastics sorted by its three suppliers and the associated tax costs (in Euros) were gathered. Alongside mapping plastic consumption and key suppliers, the composition of plastics also became known. Low-density polyethylene (LDPE) represents the composition of all consumed packaging plastics applicable to the taxation on non-recycled plastic fractions. For example, plastic packaging is used in seat manufacturing processes to make plastic bags for foams and rear seat protection covers (Figure 33 - a, b, c, d).

Figure 33 - a, b, c, d. Types of packaging plastic used in the Spanish plants. (a) Rear seat protection cover, (b) LDPE packaging plastic roll, (c) LDPE plastic bag for foams, (d) covers plastic protection

Source: The author (2024).

Therefore, the carbon footprint was assessed considering the emission factors for LDPE packaging plastic. According to the values of the 2024 GHG Reporting (Government UK, 2024), the emission factors used were:

- Plastics LDPE and LLDPE with primary material production (virgin LDPE): 2959.31834 kg CO_2eq/tons -> $EF_{virgin\ LDPE}$ = **2.9593 kg CO_2eq/kg**

- Plastics LDPE and LLDPE with closed-loop source (recycled LDPE): 1088.91851 kg CO_2eq/tons -> $\boldsymbol{EF_{recycled\ LDPE}}$ **= 1.0889 kg CO_2eq/kg**

The CO_2 emissions were then calculated using the equations for each scenario (1 – 100% virgin LDPE; 2 - % of virgin and recycled LDPE; 3 – 100% recycled LDPE) presented in section 4.3.

Below are 2023 plastics consumption, CO_2 emissions, and Seating and Interior Systems tax costs. Figure 34 represents the graph for Scenario 1, considering the three key suppliers for each plant.

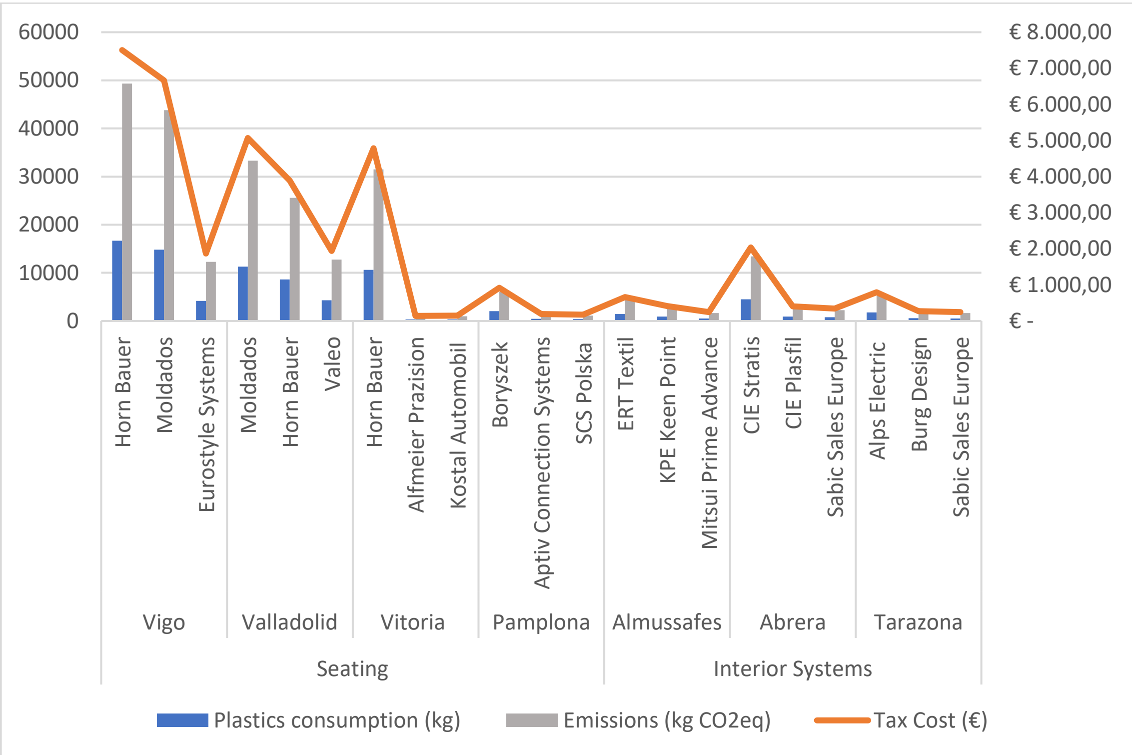

Figure 34. Plastics consumption, CO_2 emissions, and tax cost for Scenario 1(100% Virgin LDPE)

Source: The author (2024).

The graph shows that the industrial sites involved in seat production were the most significant contributors to plastic packaging consumption, CO_2 emissions, and tax costs, with Vigo and Valladolid's plants comprising the most critical proportions.

It is possible to observe that three of the four seating plants share Horn Bauer and Moldados as their plastic suppliers, which are the two most significant suppliers within the analysis of the Spanish plastic value chain.

In 2023, about 86000 kg of plastic packaging was consumed, with seating representing 86% and interior systems 14%. Regarding CO_2 in Scenario 1—considering only primary plastics—about 255000 kg CO_2eq was emitted in the plastic use phase.

Considering the tax costs associated with the quantity of non-recycled plastics consumed (100% in this case), the amount spent was nearly 39000 €/year for the seven plants analyzed.

The project then focused on improving the recycled content of plastics, starting with the most concerned suppliers. In collaboration with the workgroup, a network was created with these stakeholders, who provided packaging plastics contemplating a share of recycled plastic, as shown in Table 12.

Table 12. Plastics Composition Certificate provided by suppliers

Plant	Key Suppliers on Plastics Consumption	Recycled Composition Certificate	% recycled of plastic
Valladolid	Moldados	Yes	50%
	Horn Bauer	Yes	30%
	Valeo	No	0%
Vitoria	Horn Bauer	Yes	30%
	Alfmeier Prazision	No	0%
	Kostal Automobil	No	0%
Vigo	Horn Bauer	Yes	30%
	Moldados	Yes	50%
	Eurostyle Systems	Yes	100%
Pamplona	Boryszew	No	0%

Plant	Key Suppliers on Plastics Consumption	Recycled Composition Certificate	% recycled of plastic
	Aptiv Connection Systems	No	0%
	SCS Polska	No	0%

Source: The author (2024).

Scenario 2 contemplates Horn Bauer plastics using 30% recycled LDPE, Moldados using 50% recycled LDPE, and Eurostyle Systems using 100% recycled LDPE (Figure 35).

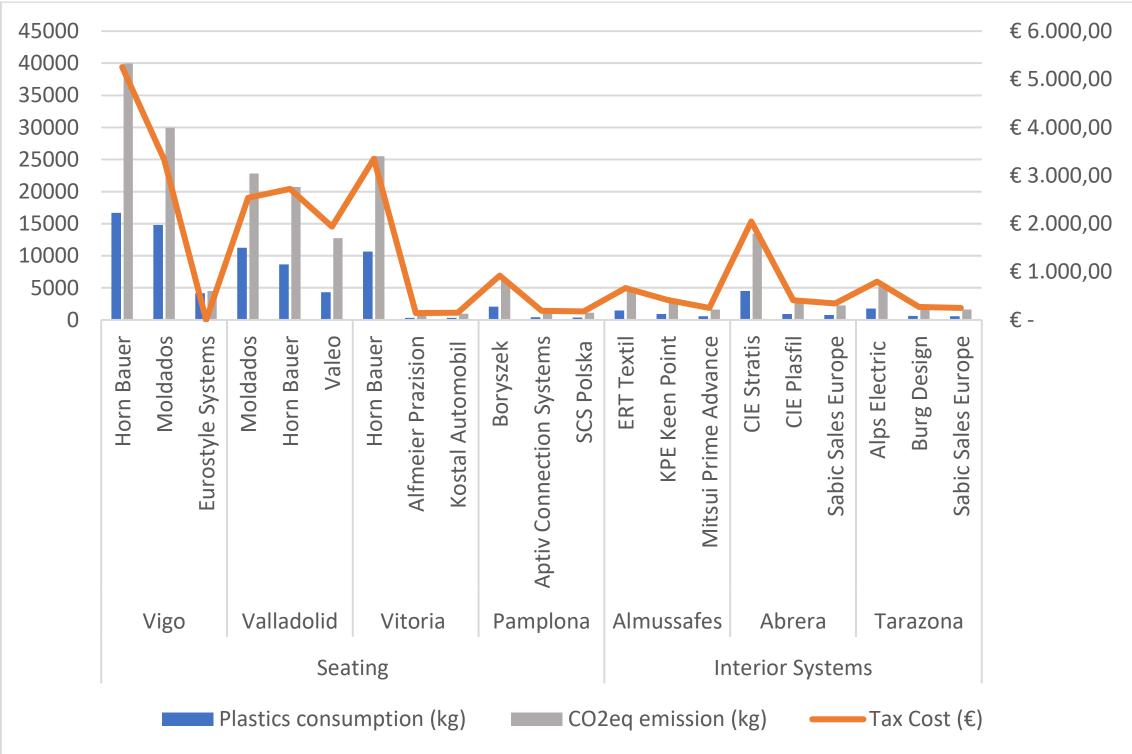

Figure 35. Plastics consumption, CO_2 emissions, and tax cost for Scenario 2 (% of Virgin and Recycled LDPE)

Source: The author (2024).

The current company scenario (scenario 2) sums up about 202400 kg of CO_2eq emissions. Regarding tax costs, they come to 26140 € for this yearly period.

Finally, scenario 3 was a future perspective stipulated to analyze the hypothesis of having only secondary material as plastic packaging, as presented in Figure 36.

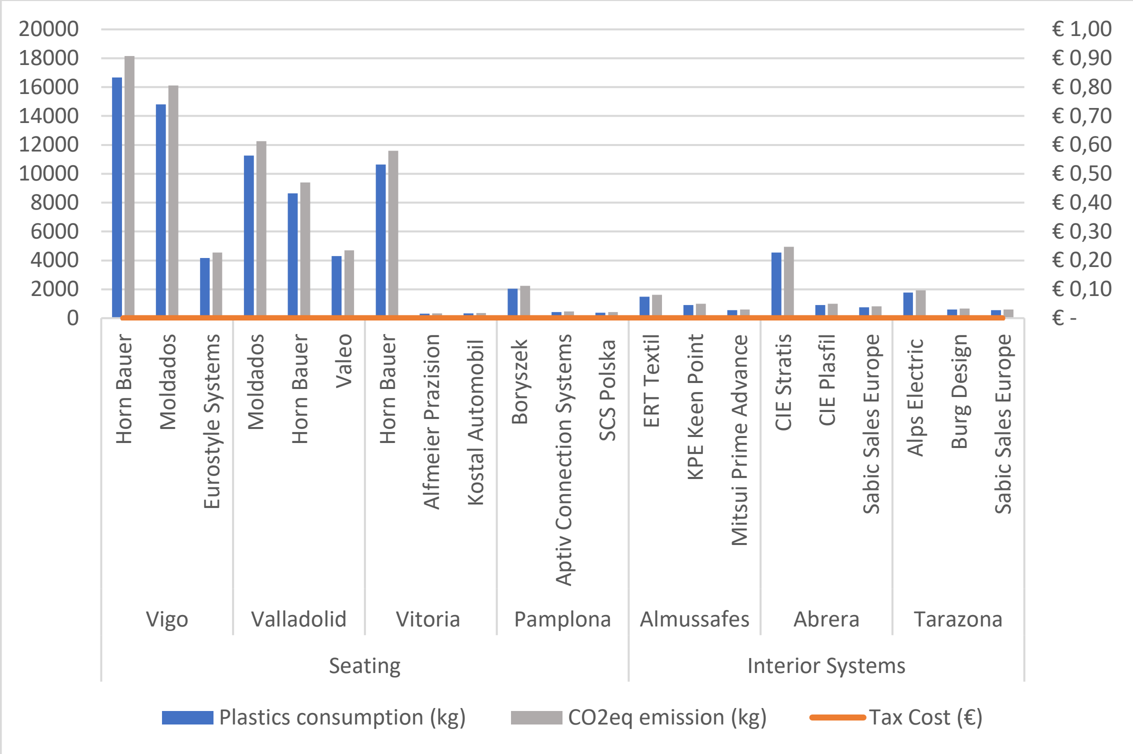

Figure 36. Plastics consumption, CO_2 emissions, and tax cost for Scenario 3 (100% Recycled LDPE)

Source: The author (2024).

Observing the third scenario results, it was estimated that, from a 100% recycled LDPE perspective, 93725 kg of CO_2eq would be emitted. Moreover, eliminating non-recycled plastics will reduce the tax costs to zero.

Enlightened by those three scenarios, depending on the percentages of recycled packaging plastics, the CO_2 emissions (figure 37) and the associated tax costs (figure 38) were then compared proportionally.

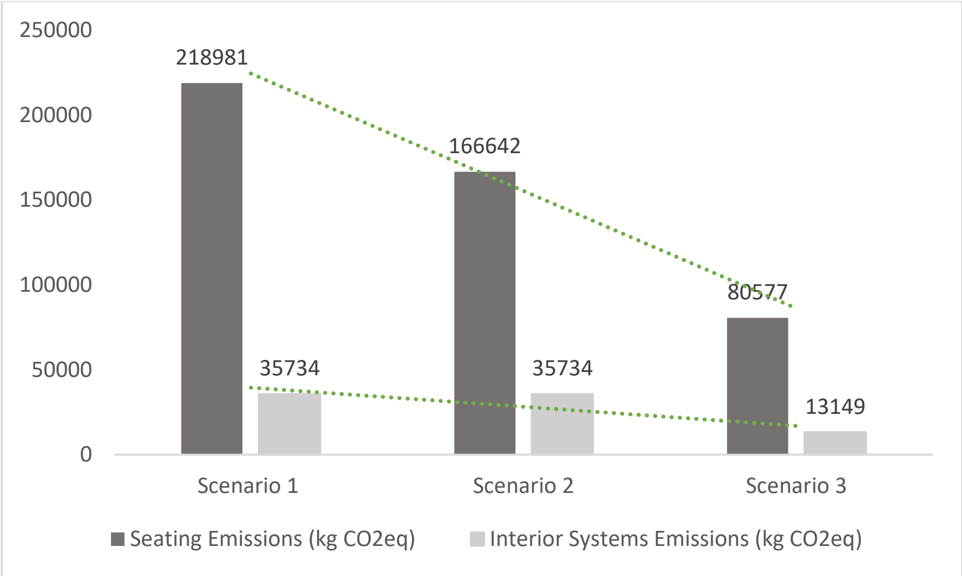

Figure 37. Comparison of LDPE CO_2 emissions per scenario (kg CO_2eq) – Seating and Interiors

Source: The author (2024).

Considering Seating results, where improvements in the recycled share of the plastics were observed, the proportional reduction of the CO_2 emissions through the scenarios is visible since recycled plastics present a lower emission factor and, therefore, less environmental impact from this corporate product's carbon footprint perspective. There was a 24% reduction from scenario one to scenario two and a 52% reduction from scenario two to scenario three. It is seen clearly that a scenario of only secondary LDPE consumption emits 63% less CO_2eq than a scenario considering only primary LDPE.

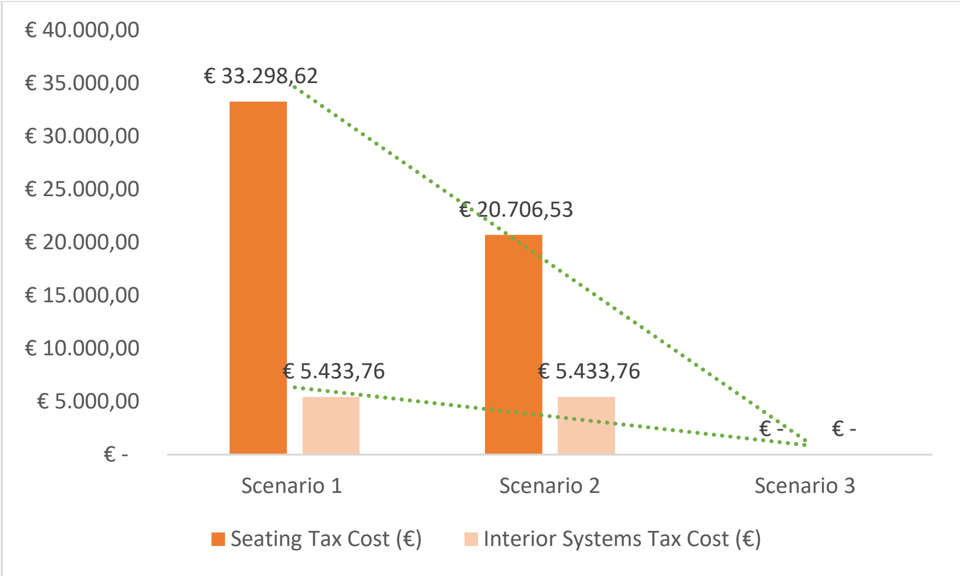

Figure 38. Comparison of tax costs around packaging plastics per scenario (€) – Seating and Interiors

Source: The author (2024).

Each scenario also shows differences regarding the financial impact. Since the percentage of non-recycled plastic consumed directly influences the tax costs, the best scenario is the third, with zero euros (100% less costs). The intermediate scenario with some shares of recycled plastic already brought a 12592.09 € cost decrease, resulting in 33% less costs than the first scenario.

6.3. Conclusions and Recommendations

The case study on plastics management and circular economy within the automotive industry in the Spanish context allowed us to observe the influence of legislation on circular practices inside the companies. Also, through the internal analysis of the packaging carbon footprint, it was proven that recycled plastics can be a viable and better option to substitute plastics from fossil origin in terms of environmental and financial impacts. These findings underscore the potential of recycled plastics to considerably reduce CO_2 emissions and tax costs, providing a compelling case for their adoption in the automotive industry.

This environmental analysis used an internal corporate calculation approach due to the lack of time and resources to complete the packaging plastics' life cycle analysis. Therefore, it is essential to add that from a broader perspective, as there are many more factors and analyses to be considered. All value chain stakeholders must be involved, and several components of the use, production, and disposal of plastics must be assessed so that the major automotive companies can know their exact impacts on the environment and construct meaningful actions toward circular economy and against climate change.

The case study findings highlight the potential benefits and challenges of incorporating recycled plastics into automotive manufacturing. The results show that increasing the percentage of recycled plastics considerably reduces CO_2 emissions, contributing to corporate sustainability goals and compliance with European legislation. This promising outlook underscores the potential for a more sustainable and environmentally friendly automotive industry. However, challenges such as material availability, cost fluctuations, and performance requirements must be considered when adopting circular economy strategies.

Moreover, results demonstrate that transitioning from virgin plastics to recycled alternatives considerably reduces carbon emissions and decreases dependency on fossil-based materials. Additionally, European regulatory frameworks play a crucial role in encouraging the adoption of circular practices, yet they require companies to adapt their supply chains to meet compliance standards. Despite these advantages, market conditions and technological advancements in material processing heavily influence the financial feasibility of integrating recycled plastics into production processes.

Companies should establish stronger supplier partnerships to address these challenges and ensure a stable, cost-effective supply of high-quality recycled plastics. Investing in research and development is essential to enhance the durability and performance of recycled materials, making them viable alternatives to virgin plastics. Furthermore, integrating circular economy principles into corporate sustainability strategies can provide long-term benefits by leveraging regulatory incentives and ensuring compliance. Industry collaborations should also be encouraged to develop standardized methodologies for assessing the environmental and economic impact of plastic recycling, facilitating a more efficient and sustainable transition.

7. Final Considerations

This dissertation underscores the critical role of integrating environmental management with circular economy strategies in the automotive sector. The findings demonstrate that sustainable plastic management can drive significant environmental benefits while aligning with regulatory requirements and corporate sustainability objectives. Nonetheless, achieving a fully circular approach requires overcoming specific economic barriers such as initial investment costs, technical barriers, like developing efficient recycling technologies, and logistical barriers, including establishing a comprehensive recycling infrastructure.

The professional internship in environmental management played a fundamental role in developing the practical understanding necessary to address these challenges. The experience provided valuable insights into implementing corporate sustainability initiatives, compliance strategies, and environmental performance monitoring. These insights included the importance of stakeholder engagement, the challenges of balancing economic and ecological goals, and the need for continuous monitoring and improvement. By engaging directly with industry practices, the internship reinforced the importance of integrating academic knowledge with real-world applications, highlighting the opportunities and limitations of sustainable strategies in the automotive sector.

Future research should explore the long-term implications of adopting recycled materials in large-scale production and developing innovative recycling technologies that enhance material quality and cost efficiency. Additionally, expanding the analysis to include other sustainability aspects, such as energy efficiency and water conservation, would provide a more comprehensive view of environmental impacts in the automotive industry. This call for further investigation invites the audience to continue the conversation and contribute to advancing sustainable practices in the automotive sector.

In conclusion, transitioning to a circular and climate-neutral plastics system in the automotive sector is a complex but necessary endeavor. This conclusion is a call to action, inspiring companies to drive meaningful progress toward a more sustainable future by integrating sustainable material use with robust environmental management practices. It reminds society that each step toward sustainability is in the right direction, no matter how small.

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