Politecnico di Torino

Master of Science Thesis

Engineering and Management

Enhancing supply chain sustainability through packaging design: Espressoh case study

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Acknowledgement

Abstract

Over the last years, the topic of sustainability has spread into many aspects of daily life.

CO_2 emissions and waste are significant societal problems due to their profound impact on global climate change. Recent data underlines that CO_2 emissions reached a record high of over 40 billion tons in 2023, of which almost 37 billion tons came from fossil fuels. This represents an increase of 1.1% compared to 2022 [1]. Hence, it is fundamental for companies to become more sustainable. Enforcing sustainable supply chain management practices is key to achieve organizational sustainability , due to the significant proportion of 'Scope 3 emissions', which include indirect emissions from activities such as procurement, transportation and product use that contribute significantly to a company's total emissions.

Aiming to contribute towards sustainable supply chain management, this thesis treats about the importance of assessing the environmental impact of alternative packaging solutions.

This assessment led to the definition of a more sustainable packaging design, that considers both its primary role in the supply chain as a tool that contains, preserves and enables transport of a product, but also its environmental impact, in terms of waste generation and CO_2 emissions.

A case study is presented, in which different repackaging solutions for 3 products of Espressoh cosmetics company were evaluated to identify improved alternatives with respect to two KPIs, namely CO_2e emissions and waste generated, through a methodology that includes both qualitative and quantitative analysis and by means of a dedicated software, Bluebird Climate.

For 2 out of 3 of the analyzed products, with respect to the AS-IS scenario, the repackaging solutions shows an improvement both on CO_2e (-10% and -36%) and waste impact (-80% and -13%), while the third product shows a worsening on CO_2e indicator (+4%), due to greater emissions in the supply chain design, which is counterbalanced by an improvement on waste impact (-27%).

This study illustrates the efficacy of advanced sustainability assessments in repackaging evaluation, highlighting several tangible possibilities of improvements, but also underscores the need for businesses to carefully evaluate trade-offs between carbon footprint and waste reduction in their approach towards sustainability.

Contents

Chapter 1

Introduction

The issues of sustainability and sustainable development have been in the spotlight with great debates both at national and international levels for several years now. Indeed, the increasing awareness of environmental sustainability has become a pivotal concern in modern industries, with products' packaging standing at the forefront of this paradigm shift.

The packaging industry plays a significant role in global sustainability efforts. This is primarily due to the substantial environmental footprint associated with packaging materials and processes. As noted by the United Nations Environment Programme (UNEP), packaging contributes significantly to the global waste problem, often resulting in adverse environmental impacts due to the use of non-renewable resources, excessive packaging of products, energy consumption, the emissions they create throughout manufacturing and disposal and waste generation [2].

In this thesis a detailed study is conducted about the importance of choosing a proper packaging for reaching better performance for environmental footprint and waste impact, with a specific focus on the cosmetics industry, that is one of the sectors that most contribute to the overall ecological impact of packaging [3]. According to the latest reports from Zero Waste Week, in fact, beauty packaging amounts to 120 billion units every year [3]. That includes plastic, paper, glass, and metals, all of which end up in landfills year after year. Moreover, packaging in the beauty industry is less practical and more fanciful and often the more expensive or luxurious a product is, the more nonessential packaging we may expect to find. About 70% of the beauty industry's waste comes from packaging, hence there is a great margin for improvement in the adoption of more sustainable packaging solutions [4].

This thesis aims to understand how complex is the process of creating a product starting from its initial design, through the research of suppliers and the right choices to have both satisfying aesthetics and a longer and sustainable life and its distribution on the market. Special focus is a repackaging evaluation of current products in a cosmetics company through two key performance indicators (KPIs) – CO2e (carbon dioxide equivalent) and waste impact. This evaluation is critical in guiding the selection of new raw materials, suppliers, and packaging solutions.

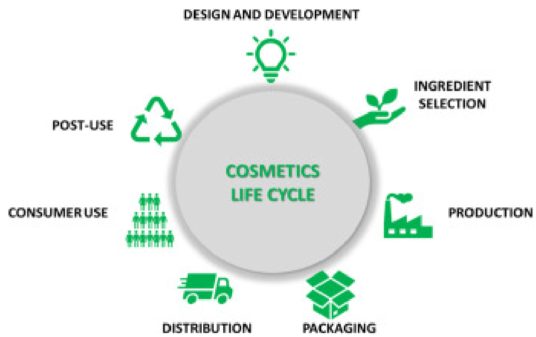

Figure 1.1: From [5]

1.1 Thesis structure

The thesis is structured as follows:

- Chapter 2 review the literature review to explain basic concepts about supply chain and sustainability, following with a focus on the cosmetic industry
- Chapter 3 defines the methodology used to collect and analyze data about different kind of packaging and to evaluate possible repacking solutions
- Chapter 4 the Espressoh case study is presented, focusing on its main practices about sustainability in the context of sustainable supply chain management. A methodology for repackaging based on the Bluebird software is presented
- Chapter 5 the results are presented, comparing current and future scenarios
- Chapter 6 the conclusions of this thesis work are presented

Chapter 2

Literature Review

This chapter provides a comprehensive examination of the concepts, evolution, and current practices within the field of supply chain management (SCM), with a particular emphasis on sustainable supply chain management (SSCM) and its application in the cosmetic industry. It begins by outlining the fundamental principles of SCM, highlighting the process from raw material sourcing to the delivery of the final product or service to the end-user. It then transitions to explore how SCM has expanded to incorporate sustainability, discussing the shift from traditional economic and operational focuses to a broader consideration of social, economic, and environmental impacts.

In order to find and select the best material (papers, reports, . . .) for the literature review phase, a set of keywords was selected: supply chain management, sustainability, cosmetics, life cycle of cosmetic products, sustainable packaging.

2.1 Sustainable Supply Chain Management

A supply chain is an entire system for producing and delivering a product or service, from the very beginning stage of sourcing the raw materials to the final delivery of the product or service to end-users. The supply chain lays out all aspects of the production process, including the activities involved at each stage, information that is being communicated, natural resources that are transformed into useful materials, human resources, and other components that go into the finished product or service.

Figure 2.1: supply chain life cycle [6]

Supply chain management (SCM) is defined as "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements." [7]

Traditional SCM has gradually evolved from being a concept that solely addresses economic and operational issues to being one that comprehensively embraces the broader social, economic and environmental matters associated with a company's supply chain.[8]

Specifically, in 2000 John Elkington [9] provided a framework for measuring the success and performance of the business using the three pillars: environmental, social and financial. These 3 concepts, also referred as Triple Bottom Line, are particularly relevant for corporate sustainability:

1. Environmental protection is the most frequently discussed element. It is concerned with the reduction of carbon footprints, water usage, non-decomposable packaging, and wasteful processes as part of a supply chain. These processes can often be cost-effective, and financially useful as well as important for environmental sustainability.

2. Social development is about treating employees fairly and ensuring responsible, ethical, and sustainable treatment of employees, stakeholders, and the community

in which a business operates. This may be achieved through more responsive benefits, like better maternity and paternity benefits, flexible scheduling, and learning and development opportunities. For example, business should operate using sustainable labour, which involves fairly-paid, adult employees who can operate in a safe environment.

3. Financial or economic development is probably the simplest form of sustainability. To be economically sustainable, a business must be profitable and produce enough revenues to be continued into the future. The challenge with this form of sustainability is achieving an equilibrium. Rather than making money at any cost, companies should attempt to generate profit in accordance with other elements of sustainability.

Figure 2.2: Dimensions of Triple Bottom Line [10]

After the companies became more aware of sustainability related issues, they have adopted Sustainable Supply Chain Management (SSCM) as their core business paradigm, and diverse strategies and frameworks have been developed to establish sustainability on their supply chains [11].

Sustainable supply chain management (SSCM) can be defined as "strategic, transparent integration and achievement of an organization's social, environmental, and economic goals" [12].

This shift is driven by a multitude of factors that push the companies to become more responsible with respect to social and environmental concerns, for instance energy consumption, an increased understanding of the science behind climate change, and greater transparency concerning environmental and social actions of organizations [13]. Adopting sustainability practices not only improves organizations' and their supply chains' environmental and social performance, but also provides an opportunity for organizations to acquire a new set of competencies that can help them achieve a competitive advantage by undertaking sustainability initiatives both within and outside of organizational boundaries.

Studies have shown that investments in SSCM initiatives can improve company's performance and competitive advantage [14]. A clear identification and classification of the drivers of SSCM can help practitioners to understand better sustainability issues, how to identify difficulties, and to determine the improvements that are required [15].

2.2 Sustainability in the cosmetic industry

The cosmetics industry is increasingly concerned with the environmental, social and economic impacts of the manufacture and use of its products [16]. The transition to more sustainable products started by substituting synthetic materials/ingredients with more natural ones [16]. Currently, the cosmetics industry is trying to address the whole life cycle of its products, including the ethical and responsible use of ingredients, fair trade, resources used during the manufacture, management of waste and residues, and the use of recyclable, reusable or biodegradable packaging. Hence, increasingly, cosmetic companies are addressing not only economic sustainability options but also embracing social and environmental sustainability.

The sustainability of a cosmetic product is defined at the initial phase of its life cycle, the design phase, which influences all subsequent ones. It starts with selection of the raw materials, which must be as natural as possible and come from responsible, sustainable sources. Synthetic ingredients that are extremely challenging to substitute, such as solid surfactants for solid shampoos and preservatives, may benefit from compounds developed by green chemistry [16]. The production processes must be optimized to save energy and resources, while producing less waste and contributing to a circular economy. Making packaging more sustainable includes using less packaging (or no packaging at all), using innovative materials that are recyclable or compostable, and/or reuse and refill solutions. As important as the previously mentioned approaches is the role that companies have in consumer education: how to use the product in the most sustainable way and how to deal with the packaging, emphasizing how these practices affect the environment and the society.

Currently there are hundreds of cosmetic companies that integrate sustainability in one or several phases of the life cycle of their products.

For example, beauty giants such as Garnier and L'Oréal introduced sustainability along the entire life cycle of the product. In 2019, the L'Oréal group was recognized as Global Compact LEAD, due to its program "L'Oréal For The Future – Sustainability Commitments for 2030", reasoned on 3 different premises [16]:

1. the transformation and evolution of the industry should respect the limits of the planet;
2. the capacity building of the business ecosystem should be promoted to help the transition to a more sustainable world;
3. there should be a contribution for the resolution of the challenges that the world is facing, supporting the urgent environmental and social needs.

2.3 Sustainable life cycle

Within the life-cycle of a cosmetic product, several phases are crucial to enforce sustainability: raw materials selection, manufacture, packaging, distribution, post-use.

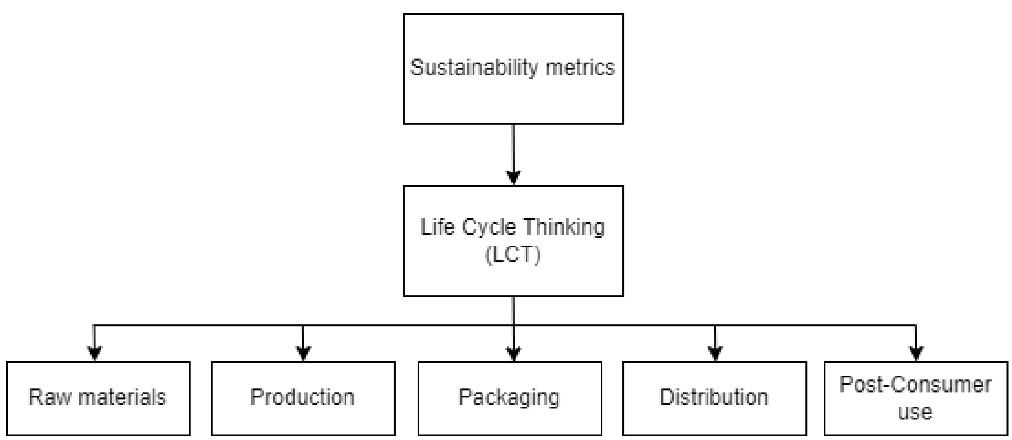

Figure 2.3: Life cycle of a cosmetic product. Adapted from [17]

2.3.1 Raw materials selection

The selection of raw materials as ingredients for cosmetic products is crucial to ensure their sustainability . Natural, naturally-derived, nature-identical, organic and green, are some of the definitions that are normally associated with sustainability cosmetic products. However, the concept of sustainability goes beyond the use of natural, green or organic ingredients. A raw material is only classified as natural, organic and/or green, based on the type of agriculture and/or lack of synthetic substances used to produce it [17]. Thus, an ingredient is considered sustainable if it has environmentally preferable attributes that meet also an ethical, social and economic responsibility. In fact, several key points should be addressed when selecting raw materials for achieving sustainability:

- what is their composition and biodegradability
- what are their sources (animal, vegetable or microbial origin, synthetic, naturally-derived)
- how they were extracted, purified, synthesized
- what are the social and economic impacts of obtaining and using such materials

The ingredients in a cosmetic formulation fulfil several functions such as safety, efficiency, sensorial attributes, and a typical cosmetic product contains from 15 to 50 ingredients (including water, emollients, solvents, preservatives, colorants, fragrances).

When substituting any ingredient by a sustainable alternative it is always necessary to fully research how this change will affect the overall characteristics of the formulation, due to ingredients interaction.

2.3.2 Production

The main sustainability issues during the manufacture of cosmetics are related to energy consumption, water use, and waste management [16]. Thus, industries are increasingly pursuing the development and use of innovative technologies that reduce the environmental, carbon and water footprints.

The main strategies adopted by the cosmetics industry to address sustainability issues during the manufacture phase are visible in the figure below. These includes:

- use of renewable energy sources
- insulation of building to reduce energy consumed in climatization
- use of more energy-efficient modern equipment
- decrease water use during the product manufacture

	Strategy	Examples
Energy	Use of renewable energy sources	Geothermal Solar Wind
	Decrease energy loss during the manufacture	Insulation of buildings and water pipes
	Decrease temperature of processes	Cold emulsification
	Use of energy-efficient equipment	Energy management systems to control heating, ventilation, air conditioning
Water	Use of different water sources	Capture and storage of rainwater
	Recycle and reuse production water	Waterloop factories
	Waterless products	Solid bars, sticks, oils and butters, powders, BYO Water products
	Optimization of production and cleaning processes	Sequential production of batches of the same product
Waste	Treat and reuse wastewater	Wastewater treated in phytoremediation tanks Zero-waste policy

Figure 2.4: Sustainability strategies for the manufacture of cosmetic products [16]

2.3.3 Distribution

The distribution phase also greatly affects the sustainability of cosmetic products. Although distribution usually refers to the transport of the finished products, a more effective approach is to consider the transport throughout the entire life cycle of the products, that includes:

- transport of raw materials to the production plant
- transport involved in the manufacture of packaging materials
- transport of the packaging to the cosmetics factory
- transport of the finished packaged products to distribution centers and to retailers
- transport associated to the consumer use
- transport involved in the post-use phase

To address the sustainability of the various transport phases, companies may choose to switch from trucks and planes to trains and ships, or to introduce electrical, hybrid or alternative energy vehicles. The use of larger trucks to transport more compact products also reduces the number of journeys needed. Another approach that several companies use is to reduce the distance between distribution centers and retailers by building large-scale warehouses where the products are stored until needed by the retailers [16].

2.3.4 Packaging

Packaging refers to an enabling system designed to protect and ensure the effective and efficient transport, handling, and storage of a product throughout the supply chain. It has been playing a pivotal role in the economy by enhancing product safety and shelf-life, and therefore its definition is expanded further beyond a simple denotation of a material to contain and preserve the product to that of a coordinated system designed to prepare and protect goods along the supply chain while ensuring efficiencies and optimized sales [16].

The broader term packaging includes:

- primary packaging: it is the material that first envelops the product and holds it. This layer's chief role is to safeguard and maintain the product, often simplifying the product's handling for the consumer [18]. i.e. the one in contact with the formula and delivering a formula dose to the user

- secondary packaging: It stores primary packaged products together, often into boxes or containers. This packaging level serves to protect the primary packages and enables easier handling and storage of products. It's designed for stackability to efficiently use space during storage and transport, and typically contains multiple units of the same SKU for organizational purposes [18]. i.e. the one first seen by the consumer and used to protect the primary packaging

- tertiary packaging: It is used to consolidate secondary packaging items into larger units for more efficient bulk handling in logistics. This packaging level is primarily intended for storage in wholesale or retail facilities and facilitates the loading and unloading process during transport. Tertiary packages, which contain a high volume of products, are not designed for direct consumer interaction and focus on maximizing space efficiency and transport stability [18]. i.e. the one called 'pack-in' used to protect packaging items arriving at the product manufacturing plant and the other one called 'pack-out' used to group products and protect them during transport, storage and handling

2.3.5 Post-Consumer use

Post-consumer use phase is a phase dependent on the strategies created and implemented by the company (e.g., recyclability, reusability and biodegradability of the packaging), as well as the actions taken by the consumer [17]. Further details about this phase will be discussed in the following section, where concrete examples and strategies are analyzed.

2.4 Towards sustainable packaging

To make packaging sustainable, companies are embracing various strategies that focus on materials and circular practices. One of the primary approaches is to emphasize the full recyclability of products and incorporate a significant amount of recycled content within them. Companies are also working on reducing the total use of plastics and innovating packaging usage, which involves complete redesigns and rethinking of delivery chains, such as adopting circular delivery models and exploring the use of metal and glass in returnable systems [19]. Another critical strategy is to invest in the innovation of packaging materials. Efforts are being made to develop mono-materials that have high-barrier properties for recyclability or incorporate recycled content. Innovations in paper and board are also underway, focusing on high-barrier materials to replace plastics using bio-derived products that are recyclable and compostable. For example, specialty paper producers are working on flexible paper-based packaging with water-based coatings as barriers against vapor, oxygen, and oil, aiming to replace less sustainable packaging types [19].

Sustainable packaging indicates that the packaging materials have been sustainably sourced and produced, and once it has served its purpose, holds the potential for resource recovery through recycling practices or by possessing compostable properties [20]. Sustainable packaging has appeared as a minor area of interest before 2015 in studies within the field of packaging and supply chain management. However, the sustainable packaging topic has been revealed to be attracting significant interest in more recent years, and as such, the topic is expected to attract further investigation as a relevant research topic in the field of supply chain management due to its growing importance, as well as amplified attention from stakeholders [21].

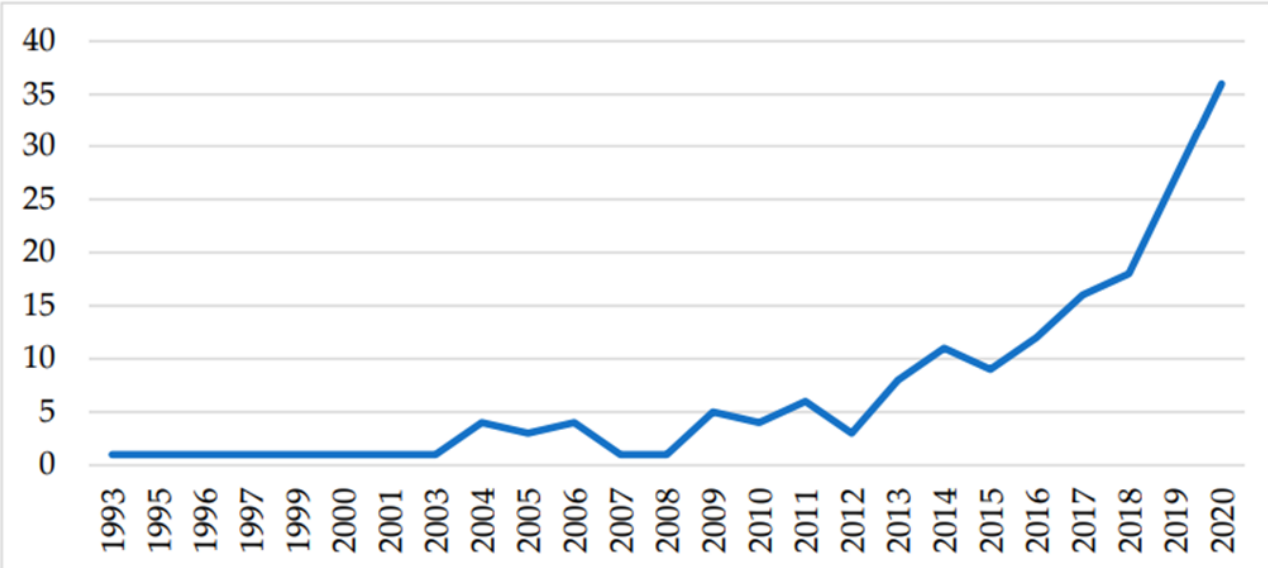

Figure 2.5: Number of publications about sustainable packaging in supply chain management [22]

2.5 Sustainable Packaging in the Cosmetics Industry

Most cosmetic products are still provided in plastic packaging [23],since plastic has several desirable properties such as being resistant, flexible, and having a good strength-to-weight ratio.

The packaging has such a strong impact on the sustainability of the cosmetic products that there are initiatives dedicated to deal only with this aspect. For instance, in May 2018, L'Oreal and Quantis launched SPICE (Sustainable Packaging Initiative for CosmEtics), aiming at creating methods and tools for sustainable packaging for cosmetics. SPICE includes 25 corporate members that work collaboratively "to develop and publish business-oriented methodologies" and data to support resilient decision making to improve the environmental performance of the entire packaging value chain" [24].

The post-use phase has a great impact on sustainability and any successful strategy is based on the so called 3 Rs: Reduce, Reuse and Recycle [25]. The Reduce strategy aims to lower the quantity of materials required for packaging.

During the development and design phase, not only the type of packaging but also the amount of material matters. Using less material is cheaper, less polluting and has advantages in terms of transport, due to decreased weight and space [26].

Reusing packaging is another efficient strategy to decrease carbon footprint. Providing cosmetics in packs that can be refilled could decrease the greenhouse gases emissions by 80-85% [26].

There are four different business-to-consumer (B2C) reuse models. They differ depending on the ownership of the packaging — i.e. whether the packaging is refilled or returned — and where the refill/return occurs [26]:

1. "Refill at home", where users refill their reusable container are home (for example, with refills delivered through a subscription service).
2. "Refill on the go", where users refill their reusable container away from home (for example, at an instore dispensing system).
3. "Return from home", where packaging is picked up from home by a collection service (for example, by a logistics company).
4. "Return on the go", where users return the packaging at a store or drop-off point (for example, in a deposit return machine or a mailbox).

Besides their environmental advantages, the refill systems are also valuable for the companies, because they engage client loyalty and decrease packaging and transport costs. Finally, recycling can also contribute to the sustainability of cosmetics packaging.

This strategy involves both the use of recycled materials as feedstock for packaging and the recyclability of packaging following consumer use.

Broadly, recycling methods fall into two categories:

1. Mechanical, operations that circulate plastics via mechanical processes (grinding, washing, separating, drying, re-granulating, compounding), without significantly changing the chemical structure of the material [26]
2. Chemical, operations that break down plastics into their chemical components, which are then used to produce a new material [26].

While such processes involve numerous downstream elements, (such as collection, sorting, etc.), upstream innovation (such as material selection and packaging design) is key to ensuring the technical, practical, and economic viability of the recycling system. Post-Consumer Recycled (PCR) plastics have gained popularity as a sustainable option for cosmetic packaging, helping to reduce waste and promoting a circular economy. PCR plastics are made from recycled plastic waste, such as used water bottles or food containers, that have been processed and cleaned to remove impurities. Although there are several recyclable plastics nowadays, companies are increasingly turning into non-plastic recyclable materials. The problem is that several plastics lose structural integrity when recycled and their quality decreases. Thus, an alternative is to use aluminum, an environmentally friendly choice for packaging due to its high recyclability. In fact, 75% of all produced aluminum is still in use today [27]. Aluminum cosmetic packaging provides an effective barrier against external contaminants, such as light, air, and moisture, preserving the quality and effectiveness of skincare products. This protection is essential for maintaining the integrity of sensitive ingredients in cosmetic formulations, ensuring that they deliver the desired results. Another reason why aluminum packaging is relatively popular is because it is light in weight, even though it is very strong.

The literature review emphasizes the critical role of packaging within sustainable supply chain management, particularly in the cosmetics industry. It suggests that packaging isn't merely a container but a complex system that plays a vital part in product safety, efficiency, and conservation throughout the product's lifecycle, from production to consumer handling and post-use.

Sustainable packaging is becoming increasingly central due to its potential for resource recovery via recycling and its compostable properties. The shift to sustainable packaging materials is noted as a significant area of interest, as it offers avenues to minimize environmental impact and align with consumer expectations and regulatory requirements.

In the cosmetics sector, the movement towards sustainable packaging includes the use of materials that are responsibly sourced and produced, such as post-consumer recycled (PCR) plastics. Efforts to reduce, reuse, and recycle are essential in mitigating the environmental footprint of packaging. The reduction in packaging materials not only curtails waste and pollution but also presents logistical and cost benefits due to lighter and more compact transport solutions.

Moreover, the use of innovative materials like aluminum is highlighted for its high recyclability and protective qualities, which contribute to the sustainability of cosmetic products. The literature underscores that the choice of packaging material and design is pivotal and can significantly influence a product's sustainability.

In summary, by choosing the right packaging materials, the weight and the size of their products, companies can contribute to an environmentally responsible use of cosmetics, favoring also the post-use phase through recycling practices and/or reuse and refill solutions.

Chapter 3

Methodology

This chapter outlines the methodology that could be used by a company to make its products' packaging more sustainable (i.e. a green re-pack). When searching for sustainable re-packaging solutions, first it is fundamental to have an overview of the most common practices in the industry, by means of a literature review. Then it is essential for a company to adopt a detailed methodological approach that integrates qualitative and quantitative analyses and that can be applied to the specific case of interest.

3.1 Research design

The figure presents a methodological flowchart for achieving sustainable improvements in a company's packaging process. It starts with the overarching question of how to sustainably improve a company and points to two main phases: a qualitative and a quantitative phase.

In the qualitative phase, the focus is on the design of more sustainable repackaging. This involves three key activities: exploring customer expectations, selecting potential products to be repackaged, and researching suppliers, which includes both new and current suppliers. These activities are informed by data sources such as focus groups and packaging and supply chain literature.

The quantitative phase builds on the qualitative insights and involves a series of analyses. Initially, there is a collection of packaging measures, followed by a CO2e (carbon dioxide equivalent) assessment and a waste generation assessment, both reflecting the current state (as-is). Subsequent to this analysis, a potential repackaging evaluation and scenario analysis are conducted to forecast the outcomes of implementing different repackaging strategies.

The final step involves defining the final approaches, leading to sustainable repackaging recommendations. These recommendations aim to combine insights from both qualitative and quantitative research to provide a holistic strategy for the company to improve its packaging in a sustainable way. The legend clarifies the types of information in the flowchart: activities (rounded rectangles), data sources (ellipses), outputs (rectangles with a wave on the bottom side), and techniques (shaded rectangles).

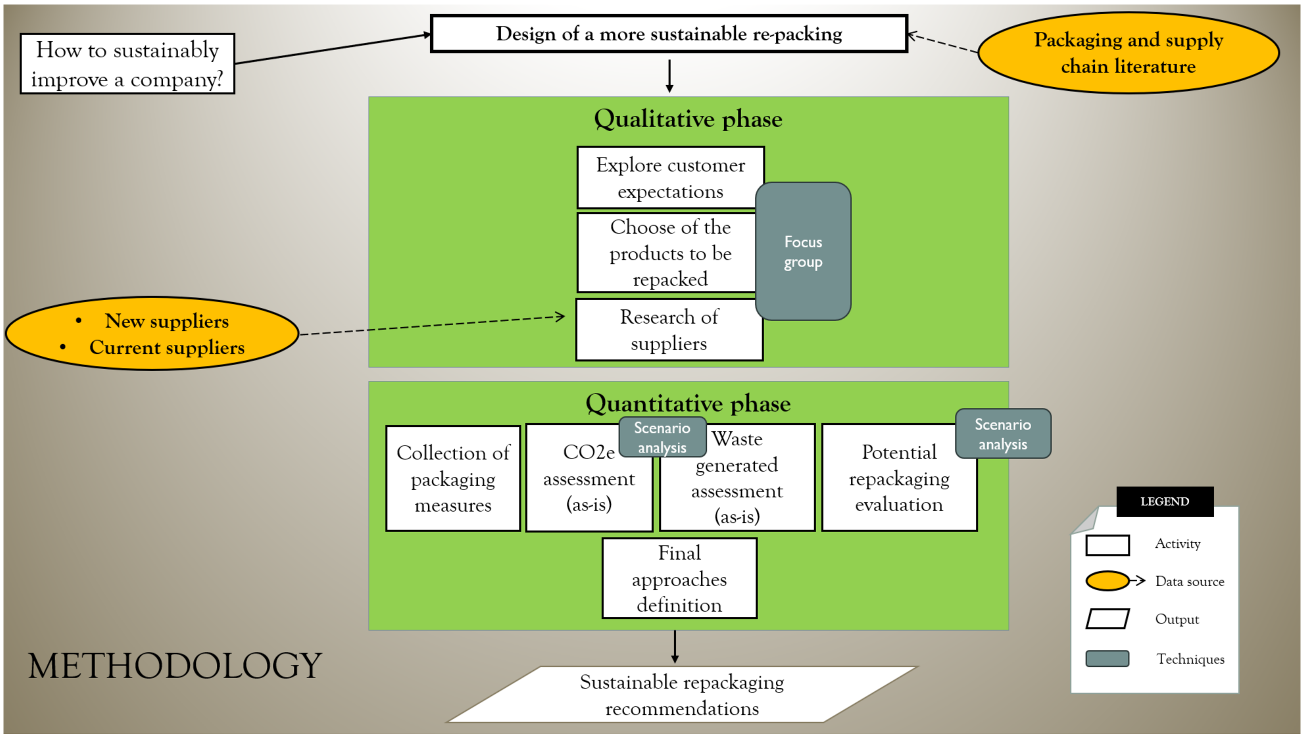

Figure 3.1: Research design schema

3.1.1 Qualitative analysis

The goal of qualitative analysis is to gain a comprehensive and nuanced understanding of the subject matter and to get some initial insights that could be useful to lay the foundations for a subsequent exploratory analysis.

The qualitative analysis mainly consists of three steps:

1. Exploration of customer expectations,
2. The selection of products that could benefit most from some packaging improvements,
3. The research and the choice of a list of suppliers who can meet the company's needs.

Explore customer expectations

This phase is crucial to capture the preferences and concerns of consumers regarding the sustainability and functionality of packaging.

By means of focus groups, a diverse representation of the target market will be analyzed. Discussions are centered around packaging preferences, environmental concerns and the functionality of current packaging solutions to gain in-depth insights.

The feedback collected will be analyzed to identify common themes and consumer priorities. This analysis serves as the basis for the subsequent steps of the qualitative phase, in which the packaging innovations are aligned with consumer expectations and company goals.

Product selection

In this step, the company's product range is evaluated to identify candidates for packaging improvement. Products are selected based on various criteria, including market demand, environmental impact, and potential for sustainability improvements.

A systematic approach is taken to evaluate the packaging of each product, considering factors such as material consumption, recyclability, and environmental impact over the entire life cycle. The products with the greatest potential for improvement are prioritized. It is also useful at this stage to cross-check with the suppliers who present the best offer in terms of environmental and aesthetic improvements so that there is no waste of time if a new or existing supplier does not reflect the objectives chosen by the company.

The outcome of this assessment will guide the strategic planning of repackaging, focusing on the products that have the greatest impact on sustainability and consumer appeal.

Selection of suppliers

The search for suppliers will look for those that can offer innovative, sustainable packaging materials and technologies. This includes both existing suppliers who are willing to adapt and new suppliers who are leading the way in sustainability. Keeping the same suppliers can strengthen long-term relationships, make it easier to negotiate better terms and ensure a stable supply chain. However, exploring new suppliers can introduce innovation, improve sustainability, and optimize costs. The company must carefully consider these aspects to make an informed decision that supports its strategic and sustainability goals.

Suppliers are evaluated based on their sustainability credentials, material quality, production capacity and compliance with the company's environmental and ethical standards. It is important to consider suppliers who could grow in the future and who are willing to collaborate by updating themselves with the rest of the world in a sustainable way.

Finally, a list of preferred suppliers is drawn up. The selection is based on a comprehensive assessment of their ability to meet the company's requirements for sustainable packaging solutions and thus ensure the success of the project in achieving its sustainability goals.

3.1.2 Quantitative analysis

The quantitative analysis phase focuses on the collection of relevant data and the evaluation of environmental indices such as CO2 emissions and waste impact, which are crucial for determining the sustainability performance of packaging options.

This structured approach enables companies to make data-driven decisions aimed at reducing their environmental footprint and promoting sustainability in its operations.

This phase is described in detail in the following steps:

Collection of packaging measures

This step includes accurately determining the weight, dimensions (height, width, and depth), material thickness, and any other relevant physical attributes of the packaging. By doing so, a comprehensive baseline of the existing packaging specifications is established. This data not only aids in identifying areas where improvements can be made (such as reducing material use, optimizing space, or enhancing protection for the product) but also serves as a critical reference point for comparing the efficiency, sustainability, and cost-effectiveness of potential new packaging designs.

CO2e and waste generated assessment and potential repackaging evaluation

The environmental index assessment in the quantitative phase of a repackaging methodology focuses on assessing the specific environmental impacts of packaging options. This includes analyzing key indicators such as carbon footprint or waste generation. The aim is to quantify the environmental advantages or disadvantages of different packaging designs or materials to identify the most sustainable packaging solutions. This assessment serves as a basis for strategic decisions aimed at reducing the environmental footprint of packaging processes. Specifically analyze CO2 emissions and waste impacts to identify areas where improvements can significantly reduce the environmental footprint.

This assessment is conducted by means of a scenario analysis and involves creating models or simulations that compare the environmental, economic, and social impacts of current packaging methods with alternatives that are potentially more sustainable. By evaluating multiple scenarios, companies can predict the potential outcomes of implementing different repackaging solutions to determine the most effective strategies for reducing environmental impact while meeting business objectives. This analytical approach supports informed decision making by highlighting the trade-offs and benefits associated with each repackaging option.

Final approaches definition

It involves synthesizing data from packaging measures, environmental assessments and repackaging evaluation to develop actionable plans to improve the sustainability of packaging. This step requires integrating insights also from the qualitative phase to propose viable solutions for secondary packaging that align with sustainability goals.

All the steps involved in the methodology described in this chapter will be further detailed in the Chapter 5, with concrete examples and scenarios for several products.

Chapter 4

Espressoh case study

4.1 History of Espressoh

Espressoh was founded in 2018 to indruce a different approach in the cosmetics world.

With a clear and inspired vision, the Espressoh cosmetics line is an authentic expression of the Italian lifestyle, known for its unmistakable balance between quality and beauty. This vision reflects a deep appreciation for Italian cultural aesthetics and a desire to infuse the essence of this lifestyle into the brand's products, offering a unique beauty experience that reflects the values and traditions of Italy.

Espressoh's philosophy is based on the belief that beauty should be accessible, practical and of high quality to reflect the experience of enjoying an Italian espresso. This approach is reflected in the innovation of the products, which are designed to be effective and easy to use, meeting the needs of people who have stressful lives and do not want to give up moments of beauty and self-care [28].

Espressoh's journey into the world of cosmetics began with a line of lipsticks, the first step in an ambitious mission to bring simplicity and effectiveness to the daily make-up routine. These lipsticks, enriched with the essence and properties of caffeine, promise exceptional durability and undeniable comfort, while telling a story of passion and tradition. The decision to start with lipsticks reflects Espressoh's intention to emphasize the importance of essential but meaningful products that can be easily integrated into everyday life. Spurred on by its initial success, the company has gradually expanded its range and introduced other make-up products that follow the philosophy of simplicity, quality and everyday beauty. Each new product, from foundation to mascara, follows the same logic as the lipsticks: easy to use, effective and enriched with the invigorating properties of caffeine. This approach allows Espressoh to stay true to its original vision while offering a wider range of beauty solutions for its customers.

4.2 Sustainability practices in Espressoh

Espressoh has taken several important steps towards sustainability, reflecting a strong commitment to reducing its environmental impact while continuously looking for ways to improve. Here are some of the company's sustainability initiatives [29]:

- Local production: Espressoh ensures that all the ingredients of formulas are 100% made in Italy. This practice not only reduces emissions associated with long-distance transportation but also supports local businesses, contributes to the local economy and maintains high quality standards.

- Packaging innovations: In 2020, Espressoh achieved a key sustainability goal by eliminating plastic from all secondary packaging, including delivery materials. This significantly reduces the amount of plastic waste generated by the company and its products.

- Carbon neutrality: By March 2021, Espressoh became a carbon-neutral company. This milestone was achieved by investing in reforestation projects in countries such as Cambodia, Peru and Kenya, which offset the company's CO2 emissions and make a positive contribution to global reforestation efforts.

- Carbon and waste impact analysis: From June 2022, Espressoh is working with Bluebird Climate to analyze its carbon and waste impact. The aim of this partnership is to identify further improvements in the company's operations to reduce its environmental footprint.

- Product design and packaging: Also in June 2022, Espressoh highlighted the environmental benefits of its best-selling product, ABC Concealer, which generates 87% less carbon emissions and 84% less waste than a typical concealer on the market. This is achieved through compact and lightweight packaging designed without an applicator. This underlines the company's efforts to reduce waste and emissions at product level.

- Refill packs: In 2022, product Ohily introduced refill packs that allow customers to refill their glass bottles instead of buying new products. This initiative encourages reuse, significantly reduces waste and promotes a more sustainable consumption model among its customers.

With these initiatives, Espressoh demonstrates a proactive and holistic approach to sustainability, from production and packaging to carbon neutrality and product design.

By continuously looking for ways to reduce its impact on the planet, Espressoh is setting a commendable example in the cosmetics industry for integrating environmental responsibility into its business model and product offering.

4.3 Espressoh supply chain

This section describes Espressoh's supply chain in depth. The processes from initial production to the distribution of the finished products are emphasized. The company's strategy includes cooperation with third-party companies for bulk production, the filling process and the manufacture of primary and secondary packaging. This choice is determined by several key factors:

- Specialization and expertise: external suppliers often have specialized knowledge and expertise in their respective fields, such as bulk production, packaging or logistics. This specialization is critical to the integrity and performance of Espressoh's cosmetic products and is consistent with the brand's reputation for excellence.

- Flexibility and scalability: by working with external suppliers, Espressoh remains flexible and can respond to market demands and trends. It allows the brand to scale its operations up or down without the constraints of managing production facilities. This flexibility is crucial in the fast-moving cosmetics industry, where consumer preferences and trends can change quickly.

- Concentration on core competencies: by outsourcing certain processes to external providers, Espressoh can concentrate on its core competencies such as product development, marketing and customer experience. This strategic focus ensures that the brand continues to innovate and excel in areas that have a direct impact on customer satisfaction and brand loyalty.

- Sustainability: Espressoh's commitment to sustainability and ethical practices is a key factor in the selection of its suppliers. The brand selects suppliers who share its values and gives preference to those who adopt sustainable practices.

these principles are applied throughout the Espressoh supply chain, which includes several stages as detailed in:

- Creating and filling the bulk

- Production and quality control

- Finished product and their distribution

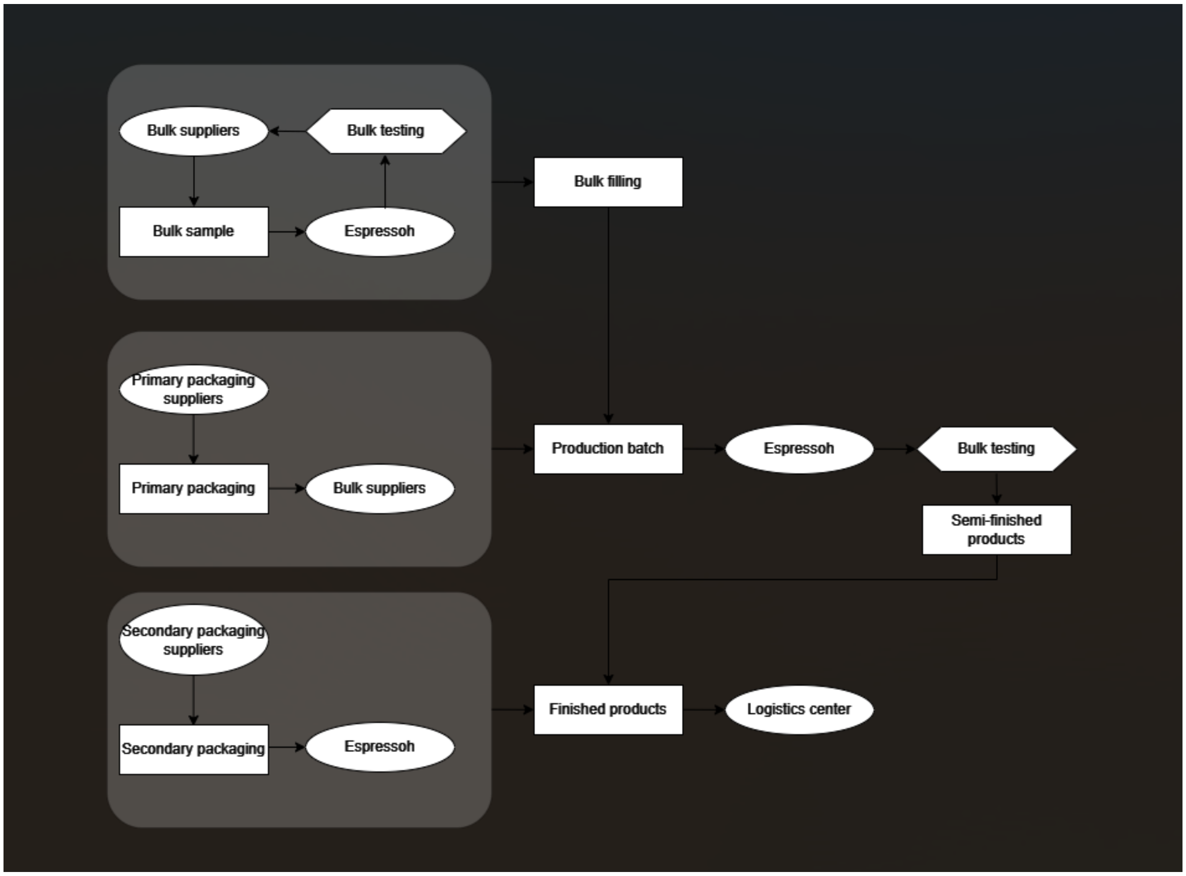

Figure 4.1: Stages of Espressoh supply chain

4.3.1 Creating and filling the bulk

The journey of every Espressoh products begins with a crucial phase involving the production and filling of bulk material. This critical step requires close collaboration with an external company specializing in bulk production to ensure the high quality of the raw materials. Before filling begins, the external supplier sends special samples of the production batches to Espressoh to carry out rigorous quality checks. These tests, which check aspects such as the density, color and brightness of the product, are essential to ensure that each item meets Espressoh's quality standards. In addition, it is of paramount importance for Espressoh to test these samples for nickel to reaffirm the brand's commitment to offering completely nickel-free products that are suitable for consumers with sensitive skin. This collaboration with external large-scale producers underlines Espressoh's focus on the quality and safety of its products and is in line with its promise of accessible and conscious beauty.

4.3.2 Production and Quality Control

Once Espressoh has approved the bulk samples, the supplier receives the primary packaging from a packaging supplier and the bulk supplier proceeds with production according to Espressoh's specifications. Once the production batch is ready, it is sent to Espressoh's headquarters for final inspection. At this stage, a thorough inspection of the batches is carried out, that includes both quality control and release of the semi-finished products. These semi-finished products are then ready to be wrapped in secondary packaging which is sourced from another packaging supplier (different from primary packaging supplier) to further enhance the product's presentation and consumer appeal.

4.3.3 Finished products and their distribution

The next step in Espressoh's supply chain is to prepare the pallets for shipping the finished products. This process is carefully organized to ensure safe and efficient transport to Espressoh's logistics center, the hub of the distribution network. Supported by an advanced Warehouse Management System (WMS), the logistics center is monitored daily, enabling the smooth transportation of products to meet consumer demand through various distribution channels. The implementation of a Warehouse Management System (WMS) and the introduction of minimum and maximum stock levels are key aspects of Espressoh's logistics approach, improving the efficiency and responsiveness of the whole supply chain.

Warehouse Management System (WMS)

Espressoh has decided to implement a warehouse management system (WMS) that integrates stock management based on minimum and maximum stock levels. The minimum and maximum stock strategy is an approach to inventory management that determines the minimum and maximum quantities of each product that must be kept in stock. This method helps Espressoh strike a balance between maintaining sufficient inventory to meet customer demand and the accumulation of excess inventory that could lead to increased storage costs or obsolete stocks.

- Minimum stock level: this is the critical point below which stock should not fall in order to avoid stockouts and possible sales losses. Setting a precise minimum stock level ensures that Espressoh can fulfill customer orders even in the event of fluctuations in demand or supply chain disruptions.

- Maximum stock level: this threshold is set to prevent excessive accumulation of stock, reduce the risk of stock obsolescence and minimize inventory costs. By setting a maximum stock level, Espressoh can optimize its inventory turnover.

4.4 Bluebird software and methodology for sustainable packaging

Sustainable supply chain management at Espressoh is a cornerstone of the company's strategy, which aims to minimize its impact on the environment and promote ethical and responsible practices throughout the production process. A key element of this strategy is the collaboration with Bluebird Climate, a partnership that has significantly advanced Espressoh's sustainability journey, which allows a re-evaluation of some of the company's products.

The methodology for this analysis was based on the Bluebird Climate software, which adopts a data-driven approach to assess the environmental impact of products. Once the decision has been made as to which products are suitable for potential repackaging initiatives, the decisive phase of quantitative evaluation begins. This is where the support of Bluebird Climate Software comes into play.

The Bluebird platform is designed to help sustainability-minded brands reduce the impact of their products. In doing so, Bluebird explores the carbon footprint of product's supply chains, and analyzes the waste streams stemming from the product's life cycle. By conducting these analyses, Bluebird assesses the emissions associated with a product and its components as well as the waste that is produced at the end of life. In this way, the Bluebird platform examines a product's carbon intensity through the cradle-to-gate stage of its life cycle and applies waste considerations to account for gate-to-grave cycles [30].

To reduce the environmental impact in the consumer goods industry, Bluebird has developed a nuanced methodology that is at the forefront of sustainability analysis [30]. In the following, all the information discussed is taken from the methodology report.

This methodology is designed not only to quantify the carbon footprint and waste generation associated with products, but also to provide a clear pathway to reduce these impacts. The success of this approach depends on the meticulous collection of detailed data, each of which serves as a critical pillar in creating an accurate environmental profile for each product analyzed. Before delving into the calculations, it is essential to understand the basic data inputs required by the Bluebird platform. These inputs are fundamental to enabling accurate assessments for environmental parameters.

- Material composition: The cornerstone of the analysis begins with a thorough breakdown of all materials involved in the product and packaging design. Product details, including the product's weight, the fill claim, the number of expected doses in the product and packaging details, including the size, material composition, and weight of each piece of packaging, along with vendor details for each one, and information on whether the product is refillable, reusable, dissolvable, or compostable (at home or industrially). This step is crucial to assess the environmental impact of raw material extraction and the benefits of integrating recycled materials.

- Supply chain logistics: A deep insight into the supply chain provides information on transportation methods, distances travelled for raw materials, intermediate products and end finished goods in particular supply chain details that include what types of transportation the brand is using (air, sea, truck) and how much percentage of each different type of transport is used, locations of their vendors' manufacturing facilities, and locations of the warehouses the brand is storing and shipping the product from.

4.4.1 Calculations of carbon emissions equivalent (CO2e)

At the heart of the Bluebird method is the calculation of carbon emissions or CO2e, which is a measure of the greenhouse gases emitted during the life cycle of a product, expressed as the global warming potential of CO2.

Packaging material emissions

In order to calculate the material processing emissions, Bluebird use primary data from the brand and its vendors on material composition and gram weight of each product component (primary and secondary packaging). Material composition includes both the material mix (if there are multiple materials that are used to manufacture a given component) and percentage of recycled content for each material.

Total Packaging Material Emissions are calculated by summing the material emissions from each individual component:

$$\text{Packaging } CO_2e \text{ (materials)} = \sum \Big(\text{weight of material component}_i\Big) \times \Big(\text{Virgin material of component emissions factor}\Big) \tag{4.1}$$

This formula aggregates the emissions for each material, taking into account its weight and specific emission factor, to calculate the total material-related carbon footprint.

If materials contain PCR components, the formula is refined to take into account the environmental savings associated with recycling:

$$\begin{aligned} \text{Packaging material } CO_{2e}\text{(PCRweighted)} = \sum [&\text{weight of PCR material component}_i \\ &\times (\text{\% composition of material}_i) \\ &\times (\text{\% PCR material}_i \times \text{PCR material emissions factor}) \\ &+ (\text{\% virgin material}_i \times \text{virgin material emissions factor})] \end{aligned} \tag{4.2}$$

Packaging Manufacturing Emissions

The emissions from manufacturing processes and energy use in the supply chain are quantified, highlighting areas where renewable energy and efficiency improvements can reduce carbon footprint and similar to Packaging Material Emissions, are calculated by accounting for the emissions generated during the manufacturing of each component based on its format and materials.

$$\text{Packaging } CO_2e\text{(manufacturing)} = \sum \Big[\text{weight of material component}_i \times (\text{manufacturing material of component}_i \text{ emissions factor})\Big] \tag{4.3}$$

Product emissions are determined by both the materials of the components as well as the carbon intensity of the manufacturing process (sum of 4.1 and 4.3):

$$\text{Combined packaging emissions} = \text{Packaging material emissions} + \text{Packaging manufacturing emissions} \tag{4.4}$$

The packaging emissions are then paired with the transportation emissions across multiple stages of the product's supply chain in order to gather a more holistic assessment of the product's carbon emissions.

Transportation

Transport emissions are calculated in such a way that the final assessment takes into account the distance traveled, the type of fuel used and the type of transport between each facility within a supply chain.

For each transportation route (leg) in the development of a product, the distance traveled is calculated based on the latitude and longitude of the facilities where the components are manufactured and distributed. Each leg is then linked to the mode of transportation(s), an input provided by the Brand, and an emission factor for the corresponding carbon intensity, which is applied to each leg.

$$\begin{aligned}\text{Transportation Emissions of Leg (single component)} = \big(&\text{weight of component}_i \\ &\times \text{distance traveled Leg(km)} \\ &\times \text{emission factors for mode of transportat}\end{aligned} \tag{4.5}$$

Transportation calculations are completed by summing the emissions from each transportation leg. Overall, the carbon emissions for the product are calculated by combining the emissions from materials, manufacturing and transportation emissions.

4.4.2 Waste

The waste metric is a critical part of the Bluebird analysis, which is used to quantify the potential impact of a product or its components on the landfill. This section describes the methodology in detail, focusing on the distinction between dissolvable, reusable, refillable, recyclable, compostable and landfillable components.

Dissolvable

Dissolvable components are considered biodegradable in water, and therefore produce zero solid waste at end of life. The formula for dissolvable components is given as:

$$\textit{Total Waste} = \textit{Weight of Dissolvable Component} \times (1 - \textit{Dissolvability Rate}) = 0g$$

Therefore, components marked ‘Dissolvable’ contribute 0g to a product’s Waste Metric.

Reusable

Reusable products extend the lifespan of the existing product but must be paired with additional products to be properly used. A reusable product has an impact on carbon emissions and waste in itself, but the lifespan of the product is extended as it is reused. However, the reusable product must be paired with a complementary product to apply the usable treatment. There are several steps to correctly account for the reusability of products:

- Collect total number of uses per life cycle: Determine how many times the reusable product can be used during its lifetime.
- Select a benchmark cosmetic product: Choose a complementary product that matches the reusable item for its intended use. Record the total number of uses for this reference product.
- Calculate the ratio of reusable applications to doses of the reference product: Divide the total number of applications of the reusable product by the total number of doses of the complementary product to determine how many bottles of the complementary product will be needed over the lifetime of the reusable product.
- Add up the total carbon and waste impact: Add the carbon and waste impact of a one reusable product to the carbon and waste impact of the required amount of the reference product to get the total environmental impact.
- Determine the carbon and waste impact per use: Divide the total carbon and waste impact by the total number of product uses to determine the environmental impact per use.

Refillable

In contrast to single-use items, refillable containers can be used several times, effectively extending the useful lifespan of the product. The methodology for assessing the impact of refillable products includes a comprehensive analysis of both the original refillable container and the corresponding bulk refill option. This dual assessment enables a holistic understanding of the life cycle impact of the product.

Refillable data flow for a bulk refill:

1. Calculate the total carbon and waste emissions of refillable products. Let:

   - $C_{\text{refillable}}$ = carbon and waste impact of the refillable product
   - U_{total} = total number of uses per lifetime

2. Calculate bulk refill's total carbon and waste impact. Let:

   - C_{bulk} = carbon and waste impact of bulk refill packs
   - R_{bulk} = Total number of refills per bulk pack

3. Determine the number of bulk refill containers needed.

$$number\ of\ bulk\ containers\ needed = \frac{U_{total}}{R_{bulk}}$$

   - N_{bulk} = number of bulk refill containers needed

4. Calculate total impact over the lifespan. Let

   The total impact considering both the refillable product and the bulk refills is:

$$C_{total} = C_{refillable} + (C_{bulk} * N_{bulk})$$

5. Amortize impact across total refills

   Given the total number of fills, including the original refillable product and the refills provided by bulk containers

$$U_{total} + N_{bulk}$$

   the carbon and waste impact per refill is

$$C_{per\ refill} = \frac{C_{total}}{U_{total} + N_{bulk}}$$

6. Compare to disposable alternatives.

   Assess the delta between the per-use impact of the refillable system and the equivalent number of disposable products. Such comparison illustrates the environmental savings.

7. Determine carbon and waste impact per use.

$$C_{per\ use} = \frac{C_{total}}{U_{total}}$$

   This last step gives a clear measure of the environmental efficiency of using a refillable product compared to disposable products and highlights the sustainability benefits of the refillable option.

Recyclable

Bluebird uses the How2Recycle framework created by the Sustainable Packaging Coalition to measure recyclability [31]. This takes into account both the recyclability of the material class of the product and the size requirements for recycling the individual components of a product. This is not only about the recyclability of the product, but also about the probability that the individual components of the product, including the packaging, will be recycled by the consumer (recycling rate).

The general formula for calculating the total waste from recyclable components, taking into account recycling rates based on material class and size requirements for recycling, can be expressed as follows:

$$Total\ Waste = \sum_{i=1}^{n} [weight\ of\ component_i * (1 - recycling\ rate\ of\ material_i)]$$

where:

- n is the total number of components within the product.
- $weight\ of\ component_i$ represents the weight of the i^{th} component.
- $recycling\ rate\ of\ material_i$ is the recycling rate of the material class to which the i^{th} component belongs.

Compostable

When assessing compostability, a distinction is made between home and industrially compostable materials based on their ability to fully biodegrade within six months. This distinction is crucial as it takes into account the different conditions and capabilities of different composting systems.

The general formula to calculate the total waste for compostable components is expressed as:

$$Total\ waste = weight\ of\ component * (1 - composting\ rate)$$

where

- *weight of component* is the mass of the compostable component being assessed.
- *composting rate* represents the proportion of the component that is expected to biodegrade under specified composting conditions (either at home or industrial).

This formula calculates the portion of the component that fails to biodegrade within the specified timeframe, thus contributing to the total waste.

Landfill

Components labeled landfill are components that are not dissolvable, recyclable, or compostable and therefore contribute 100% of their material weight to the waste metric. Landfilling is the least desirable end-of-life outcome for a product from a circular economy perspective, as it contributes directly to municipal solid waste without the possibility of being biodegradable or serving as a feedstock for new products [30].

Chapter 5

Results

After describing the methodology for analyzing the environmental impact of packaging and introducing the case studies in the previous chapters, this chapter illustrates the results emerging from the application of the methodology to the Espressoh case study. Results start with the "as-is" analysis, which highlights the current state of product packaging and emphasizes the significant contribution of material production, use and disposal to CO2 equivalent emissions (CO2e) and waste impact. Using Bluebird Climate software, it was quantified the carbon footprint and waste impact of Espressoh's products, taking into account factors such as product weight, packaging material composition and supply chain practices.

The implemented repackaging solutions are a concrete response to the problems identified in the "as-is" analysis. Specific measures for selected products reflect the constant search for a balance between market needs, product esthetics and environmental sustainability. Espressoh strives to significantly reduce both CO2e emissions and waste. The company is dedicated not only to redesigning existing packaging, but also to developing new scenarios for future products, which is reflected in the choice of more sustainable materials

5.1 Pareto analysis

The Espressoh brand's decision to adopt a more sustainable path for its products was initially addressed in a focus group, where all the members highlighted the following reasons for improving the company's sustainability efforts:

- Consumer demand: growing consumer awareness and concern about environmental issues has led to an increased demand for more sustainable and ethically manufactured products. Companies that favor eco-friendly packaging are more likely to attract and retain environmentally conscious customers.

- Regulatory compliance: Governments and regulators around the world are imposing stricter regulations on packaging waste and sustainability. By adopting sustainable packaging practices, Espressoh ensures compliance with these regulations and avoids potential fines and legal complications.

- Corporate responsibility: As a brand, Espressoh is committed to its responsibility to the planet and future generations. The choice of sustainable packaging is a tangible expression of the company's commitment to reducing its impact on the environment and making a positive contribution to global sustainability efforts.

- Cost efficiency: In the long term, sustainable packaging solutions can lead to savings through the use of recycled materials, reduced packaging weight and lower waste charges. These savings can offset the initial investment in sustainable packaging design and materials.

These reasons led to a comprehensive investigation of the current product range, followed by an evaluation for possible repackaging. The first study of this product range was to determine which products generated the highest sales in calendar year 2022 and in 2023 (up to the time this analysis was carried out). The most effective method to determine which products are the top-selling is Pareto analysis, specifically an ABC analysis.

Pareto analysis, also known as the 80/20 rule, is an economic principle that states that 80% of the effects come from 20% of the causes. ABC analysis is an inventory management technique based on the principles of Pareto analysis. It involves classifying products in stock into three categories (A, B, C) based on their economic value or contribution to the company's total turnover:

1. Category A: includes a small percentage of items that account for a large portion of the value, usually 80% of the total inventory value. These items require careful management and control.

2. Category B: includes items that represent a medium percentage in terms of quantity and total value (about 15% of the value).

3. Category C: consists of the majority of items, but which represent only a small part of the total value of the inventory (5%). These items are less critical and require less intensive management.

The figure below shows a table with ABC analysis data for the year 2022 for the company Espressoh.

	A	B	C	D	E
1	PRODUCT DESCRIPTION	TOTAL SALES (pc) 2022	PROGRESSIVE	% SU TOTAL	CATEGORY
2	GLASSY - Blush by the glass	17241	17241	15%	A
3	The ABC Concealer_shade 1	16333	33574	29%	A
4	Hey Broh_ clear eyebrow fixing gel	11778	45352	39%	A
5	Mascara_Intenso_Black	8903	54255	46%	A
6	OHMYGLOW - Skin Tint_Shade 1	8508	62763	53%	A
7	Hi_liner_black	7324	70087	60%	A
8	Dewy Latte_30ml	4482	74569	64%	A
9	The ABC Concealer_shade 0.5	4123	78692	67%	A
10	Ohily - Oil to milk cleanser	3575	82267	70%	A
11	Mascara_Intenso_Moka	3330	85597	73%	A
12	OHMYGLOW - Skin Tint_Shade 0.5	3165	88762	76%	A
13	Mascara_Intenso_MINI_Black	2420	91182	78%	A
14	Lipstick_Aroma_01Capriccio	2345	93527	80%	A
15	Mascara_Intenso_MINI_Brown	2277	95804	82%	B
16	BohLMY	2036	97840	83%	B
17	Beauty to gOh.	1928	99768	85%	B
18	Oh Cotton Tote	1790	101558	86%	B
19	SWEETandSOUR - eyeshadow palette	1385	102943	88%	B
20	Lipstick_Aroma_02In bed	1370	104313	89%	B
21	Lipstick_Aroma_09Pummarò	1187	105500	90%	B
22	Refill Ohily	1049	106549	91%	B
23	Lipstick_Aroma_08Toasted	839	107388	91%	B
24	Lipstick_Aroma_mat_03Corretto	782	108170	92%	B
25	The ABC Concealer + OHMYGLOW	769	108939	93%	B
26	Lipstick_Aroma_mat_04Rossoh	702	109641	93%	B
27	Lipstick_Aroma_hydra_06Lemon-a-me	670	110311	94%	B
28	espressOh-Baseball cap	666	110977	95%	C

Figure 5.1: ABC analysis data - 2022

The table in figure 5.1 has five columns:

1. Description of the products: listing of the company's products.

2. Total sales 2022: the total number of units sold for each product in 2022.

3. Progressive: the cumulative sales value that increases as you move down the list of products. The "progressive" value represents the cumulative sum of sales, ordered in descending order from the highest to the lowest selling product. This value results from the progressive addition of the sales of the individual products with the cumulative total of the products that come before them in the ordered list. The formula for calculating the progressive value of each product can be expressed as follows:

$$\text{Progressive}_i = \text{Total sales}_i + \text{Progressive}_{i-1} \tag{5.1}$$

where

$$Progressive_i$$

is the progressive value of product i,

$$Totalsales_i$$

are the total sales of product i, and

$$Progressive_{i-1}$$

is the progressive value of the product that precedes i in the ordered list.

4. % OF TOTAL: the percentage that each product contributes to total sales. To calculate this percentage, the progressive value of the product is divided by the total sales of all products and multiplied by 100 to obtain a percentage. The formula is:

$$\text{\% OF TOTAL}_i = \left(\frac{\text{Progressive}_i}{\text{Total sales}}\right) \times 100 \tag{5.2}$$

5. Category: classification of each product according to its economic importance, with the most influential products categorized as 'A', followed by 'B' and then 'C'.

Below the table where the same process was carried out for the year 2023 up to the time of the analysis.

	A	B	C	D	E
1	PRODUCT DESCRIPTION	TOTAL SALES (pc) 2023	PROGRESSIVE	% SU TOTAL	CATEGORY
2	GLASSY - Blush by the glass	26947	26947	14%	A
3	The ABC Concealer_shade 1	15334	42281	23%	A
4	Oh. sole mio - 8AM	12137	54418	29%	A
5	Dewy Latte_30ml	10170	64588	34%	A
6	Hey Broh_ clear eyebrow fixing gel	9941	74529	40%	A
7	aroma light 01 confettOh	9107	83636	45%	A
8	OHMYGLOW - Skin Tint_Shade 1	7551	91187	49%	A
9	Mascara_Intenso_Black	7282	98469	52%	A
10	The ABC Concealer_shade 0.5	6436	104905	56%	A
11	aroma light 03 Ragù	6290	111195	59%	A
12	aroma light 04 Wine-me	6126	117321	63%	A
13	bOhlmy ACQUA	5293	122614	65%	A
14	Hi_liner_black	4854	127468	68%	A
15	Mascara_Intenso_MINI_Black	4524	131992	70%	A
16	Mascara_Intenso_Moka	4466	136458	73%	A
17	bohlmy CAFFE	4072	140530	75%	A
18	aroma light 02 Babà	4067	144597	77%	A
19	Ohily - Oil to milk cleanser	3169	147766	79%	A
20	Lipstick_Aroma_01Capriccio	3150	150916	80%	A
21	OHMYGLOW - Skin Tint_Shade 0.5	3127	154043	82%	B
22	Refill Ohily	3034	157077	84%	B
23	Mascara_Intenso_MINI_Brown	2670	159747	85%	B
24	Oh.olidays - The Essentials: Glassy + Intenso Mas	2296	162043	86%	B
25	Oh Cotton Tote	2262	164305	88%	B
26	ciao discOh.-eyeshadow palette	1968	166273	89%	B
27	Lipstick_Aroma_09Pummarò	1766	168039	90%	B
28	Oh.olidays - Glassy cheeks, glossy lips :Glassy + b	1604	169643	90%	B
29	Oh.olidays - Juicy Nude Lips : Aroma Light Confet	1596	171239	91%	B
30	Beauty to gOh.	1463	172702	92%	B
31	Lipstick_Aroma_02In bed	1398	174100	93%	B

Figure 5.2: ABC analysis data - 2023

It is particularly noteworthy that "GLASSY - Blush by the glass" and "The ABC Concealer shade1" were among the top sellers in both years and were consistently ranked in the 'A' category, indicating their significant contribution to the company's sales. These products have maintained their high status over the two years, demonstrating their continued popularity and sales performance. Additionally, "Ohily - Oil to milk cleanser" is also listed within category 'A' for both years.

The consistent placement of these products in the A category underlines their importance for Espressoh's business strategy. The selection of these products for repackaging reflects the company's commitment to improving the sustainability of its key products. The decision to include "Ohily" in the analysis, even though it is the last product in category A, is justified by its importance in terms of weight. As it is a particularly heavy product, it has a significant impact on transportation and therefore on overall sustainability. This aspect makes it an ideal candidate for repackaging initiatives aimed at reducing the environmental impact associated with its distribution.

5.1.1 Final selection of products

The product Ohily was selected as the first candidate for a repackaging evaluation. It consists of a glass bottle weighing 168 g and a polypropylene pump weighing 11 g. Including the 95 ml/g filling, the total weight of the finished product is 287 g. These components are part of the primary packaging supplied by a supplier with a production site in Italy.

Figure 5.3: Ohily product

The second product analyzed is ABC Concealer, which is the company's second best-selling product. Its primary packaging consists of a tube made of 20% LDPE and 80% HDPE, weighing 2.5 g, and a polypropylene cap weighing 0.7 g.

Figure 5.4: ABC Concealer product

Even if the carbon emissions and waste impact for this product are below average, as shown in the figure above, the decision to focus on this product was mainly influenced by its high sales volume. Given its widespread consumption, it was considered essential to investigate improvements to its primary packaging in order to improve sustainability.

Figure 5.5: Carbon emissions and waste impact – As-is

The last product analyzed is ”Glassy”, the top seller from Espressoh. This product, with a total fill quantity of 3.5 ml/g, weighs 58.08 g and consists of a 45 g glass jar and a 7 g polypropylene cap. This product was chosen not only because of its high turnover, but also because its weight is disproportionately high compared to its content.

Figure 5.6: Glassy product

The sustainability report for this product shows (figure 5.7) that both carbon emissions and waste impact are way above average, indicating room for improvement in sustainability.

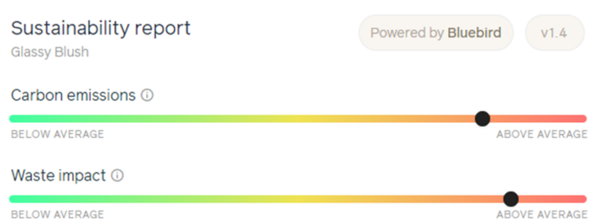

Figure 5.7: carbon emissions and waste impact – As-is

5.2 Identification of suppliers

The company's supplier selection process was meticulously tailored to prioritize partners who demonstrate a robust commitment to sustainability. These partners had already established a strong foundation with the company, showcasing their ability to meet stringent sustainability criteria through detailed studies of optimal materials. Their assessment was comprehensive, evaluating their sustainability credentials, material quality, production capacity, and adherence to the company's environmental and ethical benchmarks. Particular importance was placed on suppliers with potential growth potential and a willingness to align their practices with global sustainability advancements. In doing so, the company ensured that its network of suppliers could adapt and evolve alongside it in a rapidly changing world. The finalization of the supplier list was a calculated effort, considering the ability of these partners to fulfill the company's need for sustainable packaging solutions. The chosen suppliers are not just vendors but strategic partners poised to contribute to the company's sustainability journey, thereby solidifying the success of the initiative.

5.3 AS-IS analysis

An "as-is" analysis examines the current state of product packaging, focusing on its environmental footprint, in terms of CO2 equivalent emissions (CO2e) and waste impact. This analysis highlights how products are currently packaged and identifies the materials used, transportation, use and disposal methods. It assesses the direct and indirect environmental impacts associated with these stages, including the generation of greenhouse gas and the production of waste that may not be recyclable or reusable. Understanding the "as-is" scenario is critical to identifying areas for improvement and is the basis for repackaging initiatives aimed at reducing CO2e emissions and minimizing waste, thereby improving the sustainability of packaging. The assessments in this chapter were carried out using 'Bluebird Climate' software. The inputs required by the software include:

- Product details, including the product's weight, the fill claim, the number of expected doses in the product
- Packaging details, including the size, material composition, and weight of each piece of packaging, along with vendor details for each one, and information on whether the product is refillable, reusable, dissolvable, or compostable (at home or industrially).
- Supply chain details, including what types of transportation the brand is using (air, sea, truck), locations of their vendors' manufacturing facilities, and locations of the warehouses the brand is storing and shipping the product from [30].

5.4 Ohily

The Ohily product is the first item chosen to evaluate alternative packaging options. The reason behind this choose and the product's details were described in the section 5.1. All the details described in that section contribute to the assessment of the primary packaging. The secondary packaging is also considered, but in this case, it has not been reassessed. However, it still plays a role in the overall assessment of CO_2e emissions and waste impact.

5.4.1 AS-IS

Once we have entered the initial inputs into the platform, Bluebird Climate provides us with the results for the two KPIs of interest (CO_2e and waste impact) using the formulas described in the methodology.

CO2e								waste impact	
on average (g)	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
622,7	873,50	50%	435,40	15%	134,1	12%	105,8	106,90	191,3

Figure 5.8: Table of CO_2e emissions and waste impact of the Ohily product

Table in Figure 5.8 shows the CO_2e emissions and waste impact of the Ohily product. It includes information on average CO_2e emissions and CO_2e emissions per unit, with percentages for materials and product design, supply chain design and distribution emissions. It also includes information on the impact of waste on average and per unit. In the context of the thesis, "on average" refers to the typical amount of CO_2e emissions and waste impact associated with the product's refill option. However, the thesis concentrates specifically on the emissions attributed to the product on a "per unit" basis. The data shows that materials and product design contribute significantly to overall CO_2e emissions (50%), which could indicate the need for new design with more sustainable materials.

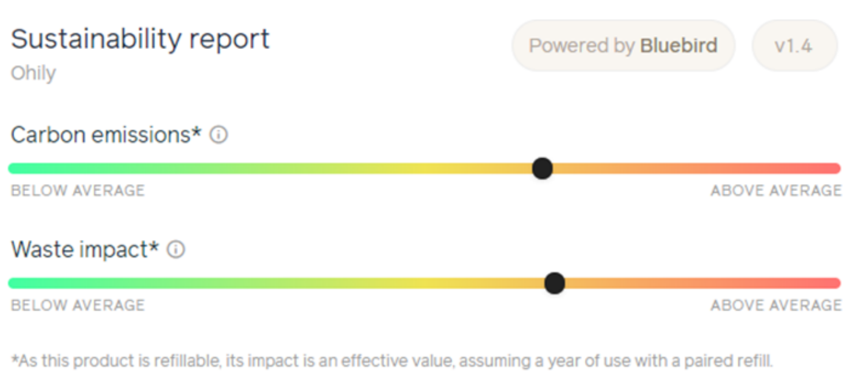

Figure 5.9: Carbon emissions and waste impact for Ohily product

Both the carbon emissions and waste impact per unit are above average, suggesting a good margin for sustainability improvements.

		Bottle		Pump		Secondary packaging		DTC	
	Materials and product design CO2e (g)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)
As-is	435,4	353	81%	39	9%	12	3%	31,4	7%

Figure 5.10: materials and product design emissions – As-is

The table in figure 5.10 shows the breakdown of materials and product design (g CO2e) emissions for the current packaging ("As-is").

The figure 5.8 also shows the CO2e value that can be attributed to the design of the supply chain and this value includes the transport of bottle and pump components to the production site where the final product is assembled, as well as the transport of the final product to the logistics centers.

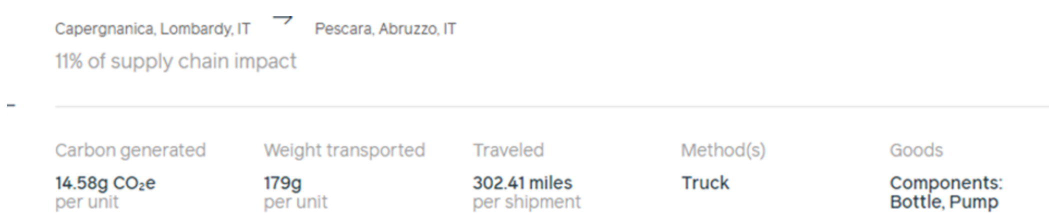

Figure 5.11: CO2e generated during transportation

In figure 5.11 it is visible that the CO2e generated by the bottle and pump component along the path from the primary package provider to the company, where the product is assembled.

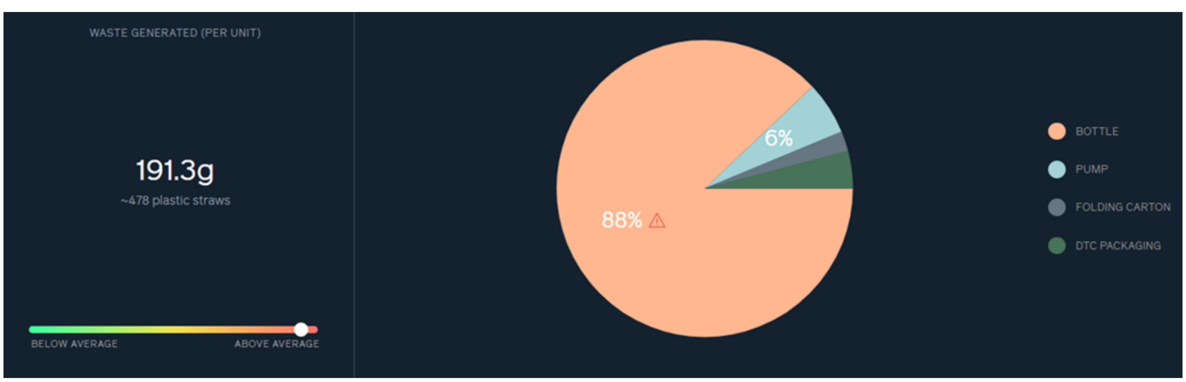

Figure 5.12: waste generated breakdown – As-is

Figure 5.12 shows the amount of waste that is expected to end up in landfill for each component included in the product ohily. The figure highlights that bottle component is responsible for the largest share of waste. The chart includes:

- Bottle and pump, the 2 components of primary packaging
- Folding carton, the secondary packaging
- DTC packaging, that stands for "direct-to-consumer" packaging. It is used for direct-to-consumer shipments to ensure product protection during transportation and to make unpacking easier for the customer

5.4.2 Repackaging solutions 'Ohily'

The two repackaging scenario for the Ohily product involve sustainable changes to reduce environmental impact of Co2e emissions and waste generated.

Repackaging Ohily 1:

- Transition from glass to PET material for primary packaging.
- Incorporation of 50% Post-Consumer Recycled (PCR) content in PET.
- Significant reduction in bottle weight leading to lower CO2e emissions and waste.
- Retention of the existing pump.
- Overall 46% weight reduction of the final product.

Repackaging Ohily 2:

- Continuation of PET use with an increase in PCR content to 100
- Maintaining the original pump from the as-is scenario.
- Further weight reduction of the bottle leading to a 53% weight reduction of the finished product.
- Dramatic decrease in waste per unit, attributing to efficient material usage.

			Refill	Materials				Weight		Dimensions	Sourcing country
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	WEIGHT pf(g)	weight component pp(g)	dimension component PP(LxWxD)	source
ohily	As-is	95	180	glass		NA	bottle ----->	287	168	3x3x18,5 cm	ITALY
			180	PP | Polypropylene		0%	pump------>		11	3x3x10 cm	
	RP1		180	PET		50%	bottle ----->	154	35	3x3x18,5 cm	ITALY
			180	PP | Polypropylene		0%	pump------>		11	3x3x10 cm	
	RP2	95	180	PET		100%	bottle ----->	135	16	3,4x3,4x13,5 cm	ITALY
			180	PP | Polypropylene		0%	pump------>		11	3x3x10 cm	

Figure 5.13: As-is vs RP1 vs RP2 comparison – Primary packaging

The table in figure 5.13 shows how Repackaging ohily 2 represents further progress in the efforts towards sustainability. The weight of the Ohily bottle drops from 168g to 16g (90% weight reduction) and leading to a 53% weight reduction of the finished product.

Repackaging Ohily 1

In the repackaging process of the Ohily product, the decision was to remove the glass component of the bottle due to its significant contribution to CO2 emissions and the high waste impact, primarily due to its weight. The higher weight of glass increases CO2 emissions during transportation, as more energy is required to transport the product with respect to lighter materials. Also, despite glass is recyclable, the recycling process can be energy intensive and not all glass makes it to the recycling plant due to contamination or logistical issues, which can increase the waste impact.

In all subsequent evaluations, it has been decided to retain the same fill volume of g/ml for the product.

In the first repackaging scenario, the most important sustainable change is the transition from glass to PET material for the primary packaging of the Ohily product. The switch to PET with a 50% Post-Consumer Recycled Content (PCR) is a conscious effort to reduce the carbon footprint of the product, as PET is lighter and requires less energy than glass to be produced and transported. The weight of the Ohily bottle drops from 168g to 35g (79% weight reduction). Despite keeping the existing pump, this change is expected to contribute to a significant 46% weight reduction in the final product. This is a significant reduction that lowers the overall weight of the product.

			Refill	CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
ohily	As-is	95	180 180	873,50	50%	435,40	15%	134,1	12%	105,8	106,90	191,3
	RP1		180 180	523,8	36%	190,6	14%	75,4	11%	59,6	38,60	58,3

Figure 5.14: As-is ohily vs RP1 ohily comparison – CO2e and waste impact

The total percentages of CO2e emissions detailed in the table for the Ohily product's materials, supply chain, and distribution do not tally up to 100%. This discrepancy is because the remaining percentage is attributed to the product's formula.

Comparing the AS-IS and the first proposed repack of the Ohily product, the PET solution shows a significant reduction in CO2e emissions and waste impact.

For the glass bottle version (as-is), the CO2e emissions per unit are significantly higher (873.50 g) than for the PET version (523.8 g), which represents a reduction of approximately 40% and so a significant optimization improvement in terms of environmental sustainability. The switch to PET also led to a reduction in waste from 191.3 g per unit to 58.3 g per unit.

Overall, the table indicates that the choice of PET with PCR (post-consumer recycled) material significantly improves the sustainability profile of the product and is in line with the goals of reducing the carbon footprint and waste generation.

Co2e material and product design

		Bottle		Pump		Secondary packaging		DTC	
	Materials and product design CO2e (g)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)
As-is	**435,4**	353	81%	39	9%	12	3%	31,4	7%
RP1(50% PCR PET)	**190,6**	108,2	57%	39	20%	12	6%	31,4	16%

Figure 5.15: Comparison on materials and product design emissions

The specific CO2e emissions data for materials and product design in the table of figure 5.15, show a significant reduction when switching from the "As-Is" packaging to the "RP1" packaging. In the "As-Is" scenario, the bottle contributes to 81% of CO2e emissions in this category, which is significantly reduced to 57% in the "RP1" scenario. This indicates that the use of recycled PET has effectively reduced the CO2e emissions associated with the material and design of the bottle, representing a positive impact on the environment using more sustainable materials. As already mentioned, the secondary packaging, the pump and the DTC elements were not considered in the reassessment and as the emissions from the bottle decrease, the relative share percentage of emissions from the unchanged components in the overall emissions profile naturally increases. This shift illustrates the impact that improvements in one component of a product's life cycle can have on the relative importance of other components.

Co2e supply chain design

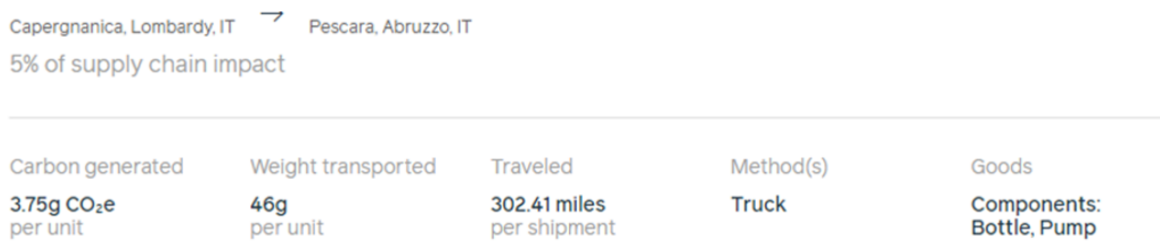

Figure 5.16: CO2e generated during transporation – RP1 ohily

In this figure it is highlighted that along the same path considered above, the repackaging leads to a significant reduction in the CO2e generated from the bottle and pump components, from 14.58g (as visible in the figure 5.7) to 3.75g.

Repackaging 2

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
ohily	As-is	95	180	glass		NA	bottle ----->	873,50	50%	435,40	15%	134,1	12%	105,8	106,90	191,3
			180	PP | Polypropylene		0%	pump------>									
	RP1		180	PET		50%	bottle ----->	523,8	36%	190,6	14%	75,4	11%	59,6	38,60	58,3
			180	PP | Polypropylene		0%	pump------>									
	RP2	95	180	PET		100%	bottle ----->	443,1	26%	114,9	15%	67	12%	53	28,90	39,3
			180	PP | Polypropylene		0%	pump------>									

Figure 5.17: As-is vs RP2 comparison – CO2e and waste impact

Table in figure 5.17 above highlights even more the significant reduction in CO2e emissions per unit from 873.5 g (as-is scenarios) to 443.1 g (RP2 scenario). This corresponds to a reduction in total Co2e emissions of almost 50%˙

Regarding the waste impact, "RP2" shows a decrease in waste per unit from 191.3 g to 39.3 g compared to the "as-is". This reduction is attributed to the more efficient use of materials in the 100% PCR PET which has an optimized end-of-life scenario minimizing the amount of waste that ends up in landfills.

Co2e material and product design

		Bottle		Pump		Secondary packaging		DTC	
	Materials and product design CO2e (g)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)
As-is	**435,4**	353	81%	39	9%	12	3%	31,4	7%
RP1(50% PCR PET)	**190,6**	108,2	57%	39	20%	12	6%	31,4	16%
RP2(100% PCR PET)	**114,9**	32,5	28%	39	34%	12	10%	31,4	27%

Figure 5.18: Comparison on materials and product design emissions

The table in figure points out how RP2 represents an improvement with respect to the original "As-Is" packaging and the intermediate RP1. With RP2, CO2e emissions for materials and product design have fallen to 114.9 g compared to 435.4 g for "As-Is" and to 190.6 g with RP1. The pump remains the same in all versions, but its relative share of total emissions increases in RP2 due to the drastic reduction in bottle emissions.

Co2e supply chain design

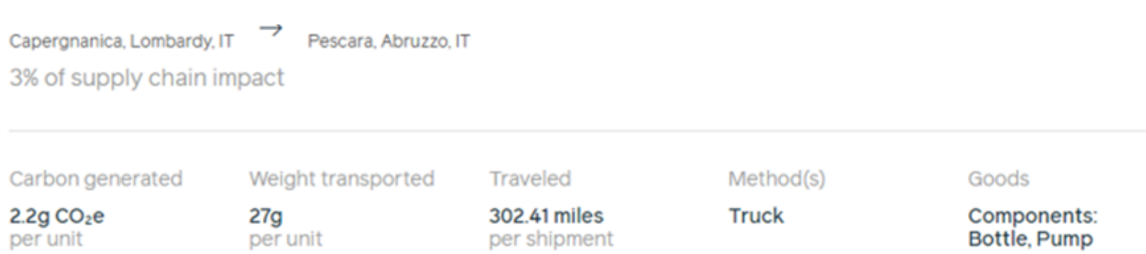

Figure 5.19: CO2e generated during transporation – RP2

Figure 5.19 highlights that along the same path considered above, the repackaging leads to a significant reduction in the CO2e generated from the bottle and pump components, from 14.58g (as-is scenario) to 2.2g (82% carbon generated reduction).

Waste impact

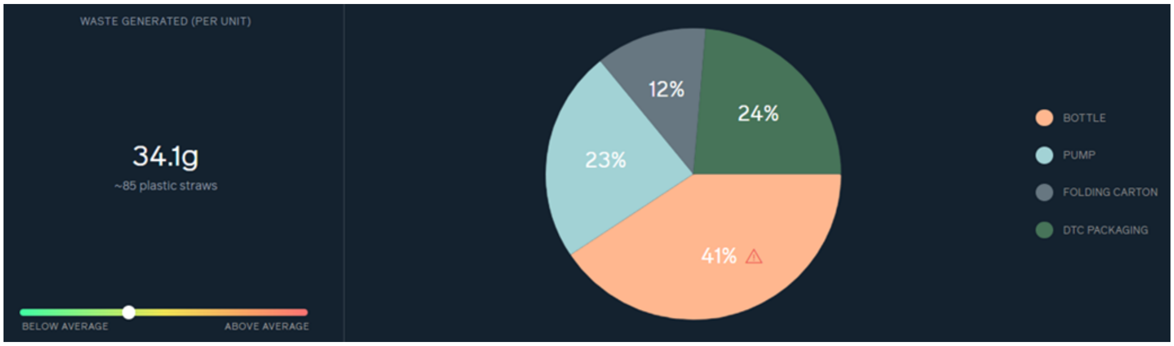

Figure 5.20: Waste generated breakdown – RP2

Comparing the "As-Is" scenario with a waste impact of 191.3 g per unit with the "RP2" scenario with a waste impact of 39.3 g per unit, there is a clear reduction of 80%. This scientifically significant reduction underlines the ecological effectiveness of the introduction of new packaging strategies.

5.4.3 Summary results

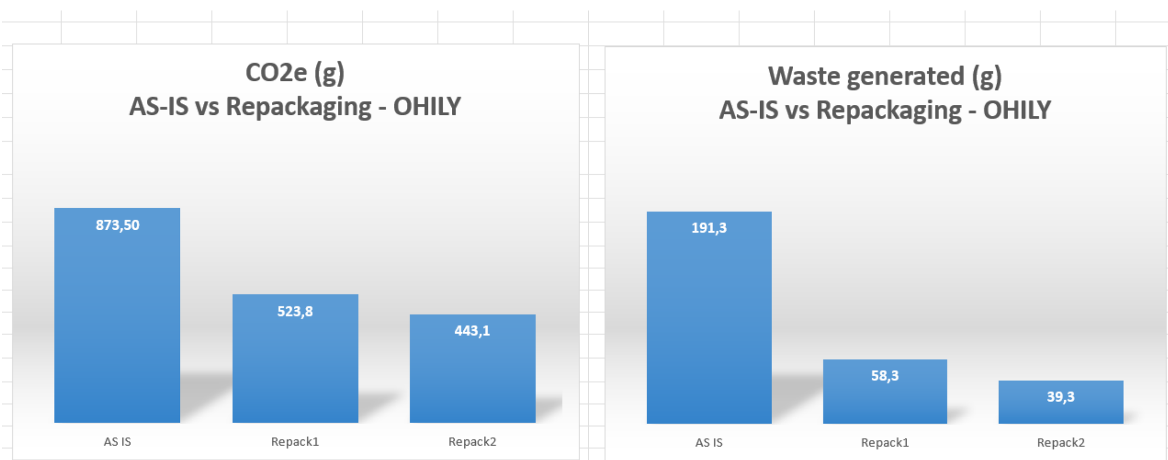

Figure 5.21: Comparison of CO2e and waste generated metrics for the Ohily product

Figure 5.21 depicts the environmental impact of Ohily's product repackaging in terms of CO2e emissions and waste generation. The original packaging (AS-IS) shows the highest environmental impact with CO2e emissions at 873.5 grams and waste generated at 191.3 grams. The first repackaging initiative (Repack1) makes significant strides in reducing the carbon footprint, lowering CO2e emissions to 523.8 grams—a 40% reduction. This approach also substantially reduces waste generation to 58.3 grams, achieving a remarkable 69.5% decrease. The second repackaging (Repack2) yields even further environmental benefits, with CO2e emissions trimmed down to 443.1 grams and waste generation to 39.3 grams. This represents a drop of approximately 49.27% for CO2e emissions and 79.5% for waste generated with respect to AS-IS. Overall, the transition from AS-IS to Repack1 and Repack1 marks a notable improvement in reducing the product's environmental impact.

5.5 ABC Concealer

The ABC product is the second item chosen to evaluate alternative packaging options. The reason behind this choose and the product's details were described in the section 5.1. All the details described in that section contribute to the assessment of the primary packaging and secondary packaging as it plays a crucial role in the overall assessment of CO2e emissions and waste impact.

5.5.1 AS-IS

Once the initial inputs were entered into the platform, Bluebird Climate provides the results for the two KPIs of interest (CO2e and waste impact) using the formulas described in the methodology.

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
ABC Concealer (1,100 g/ml)	As-is	12	0	PP | Polypropylene HDPE | High density polyethylene LDPE | Low density polyethylene	 80% 20%	 0% 0%	cap tube	120,4	41%	49,3	18%	21,6	14%	16,9		13,5

Figure 5.22: As-is – CO2e and waste impact ABC concealer

The primary packaging of the ABC Concealer is currently manufactured and supplied in China, and the supply chain design accounts for 18% of the overall CO2e emissions. The materials and product design contribute to 41% of these emissions. It is worth noticing (as in the Ohily scenario) that the combined percentages for materials, supply chain and distribution do not add up to 100% as the remaining 14% relates to the formula of the product.

		Tube		Cap		S.P		DTC	
	Materials and product design(co2e) g	g CO2e	g CO2e (%)	g CO2e	g CO2e (%)	g CO2e	(g CO2e) S.P. %	(g CO2e) OTHERS(DTC)	(g CO2e) OTHERS(DTC) %
AS-IS(HDPE+LDPE/PP)	49,3	9	18%	6	12%	2	4%	32,3	66%

Figure 5.23: materials and product design emissions – As-is

The table in figure 5.23 above shows the CO2e emissions for materials and product design for ABC product in AS-IS scenario and illustrates the major impact of direct-to-consumer (DTC), which accounts for 66% of total emissions. Nevertheless, it was decided to prioritize the re-evaluation of primary packaging and secondary packaging.

Supply chain design

Xiamen, Fujian, CN → Pescara, Abruzzo, IT

4% of supply chain impact

Carbon generated	Weight transported	Traveled	Method(s)	Goods
0.86g CO_2e per unit	3.2g per unit	5,753.63 miles per shipment	Sea	Components: Cap, Tube

Figure 5.24: CO2e generated during transportation

The figure 5.24 shows that for a shipment from China to Pescara (the location of the company where the finished products are assembled), the carbon emissions per unit are relatively low at 0.86 g CO2e, despite the long distance (5,753.63 miles) traveled by sea. The weight transported per unit is quite low at 3.2 g, which contributes to lower emissions per unit.

Castel San Pietro Terme, Emilia-Romagna, IT → Pescara, Abruzzo, IT

2% of supply chain impact

Carbon generated	Weight transported	Traveled	Method(s)	Goods
0.35g CO_2e per unit	7g per unit	188.08 miles per shipment	Truck	Components: Folding Carton

Figure 5.25: CO2e generated during transportation – As-is

In Figure 5.25 is visible the as-is CO2e generated by the folding carton component along the path from the secondary package provider to the company, where the product is assembled.

Waste

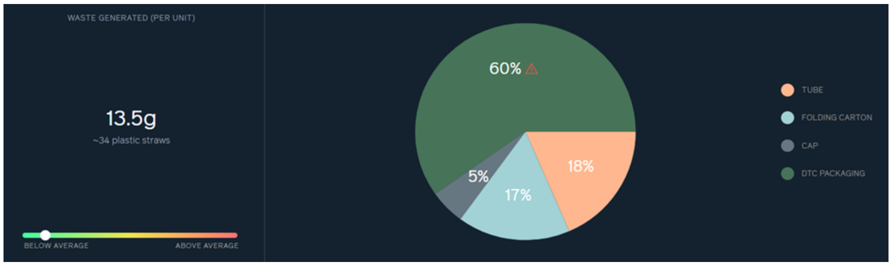

Figure 5.26: Waste generated breakdown – As-is

The figure 5.26 indicates an analysis of the amount of waste per product ABC unit, which indicates a total of 13.5 grams of waste, corresponding to approximately 34 plastic straws. The waste is divided into four categories: DTC packaging (60%), folding carton (17%), tube (18%) and cap (5%). This breakdown indicates that DTC packaging contributes the most to waste, while the cap has the least impact. In general, waste generated per unit is below average.

5.5.2 Repackaging solutions 'ABC Concealer'

The two repackaging scenarios for the ABC Concealer product involve sustainable changes to reduce environmental impact of Co2e emissions and waste generated.

Repackaging ABC concealer 1:

- Transition from a mixed material composition in the tube to a single material, specifically LDPE, with 60% post-consumer recycled (PCR) content.
- Reduction in the cap's weight from 0.7g to 0.5g, maintaining the polypropylene material.
- Slight decrease in CO2e emissions per unit from 120.4 g to 116.9 g.
- Small reduction in waste impact due to the switch to a single, more sustainable material and a lighter cap.

Repackaging ABC concealer 2:

- Secondary Packaging Adjustment: Made changes to the dimensions and material of the secondary packaging, using thinner and lighter paper.
- Retained the primary packaging from rapackaging abc concealer 1
- Significant reduction (74%) in CO2e emissions during transportation, attributed to the weight reduction of the secondary packaging from 7g to 1.85g.

Repackaging ABC Concealer 1

			Refill	PRIMARY PACKAGING – Materials				Weight		Dimensions	Sourcing country
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	WEIGHT pf(g)	weight component pp(g)	dimension component PP(LxWxD)	source
ABC Concealer (1,100 g/ml)	As-is	12	0	PP | Polypropylene			cap	23,4	0,7	1x1x2 cm	CHINA
				HDPE | High density polyethylene	80%	0%	tube		2,5	2x2x10,2 cm	CHINA
				LDPE | Low density polyethylene	20%	0%					
	RP1		0	PP | Polypropylene		0%	cap	23,2	0,5	1x1x2 cm	CHINA
				LDPE | Low density polyethylene		60%	tube		2,5	2x2x10,2 cm	CHINA

Figure 5.27: As-is vs RP1 comparison – Primary packaging

The first repackaging of ABC Concealer focused on improving the primary packaging by switching from a mixed material composition in the tube to single material, LDPE, that includes 60% post-consumer recycled (PCR) material.The cap component maintains polypropylene material but it is reduced from 0.7g to 0.5g.

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
ABC Concealer (1,100 g/ml)	As-is	12	0	PP | Polypropylene			cap	120,4	41%	49,3	18%	21,6	14%	16,9		13,5
				HDPE | High density polyethylene	80%	0%	tube									
				LDPE | Low density polyethylene	20%	0%										
	RP1		0	PP | Polypropylene		0%	cap	116,9	39%	46	18%	21,5	14%	16,8		13,3
				LDPE | Low density polyethylene		60%	tube									

Figure 5.28: As-is vs RP1 comparison – CO2e and waste impact

The comparison between the ”As-Is” and the ”RP1” of the ABC Concealer packaging shows a slight decrease in CO2e emissions per unit. The ”As-Is” packaging produces 120.4 grams of CO2e per unit, while the ”RP1” packaging has reduced emissions to 116.9 grams per unit. This reduction (both for Co2e and waste impact), even if it is small, is due to the switch to a single material (LDPE) with a recycled content of 60% and a slight reduction in the weight of the cap. It also can be observed that, despite a small reduction in packaging weight from "As-Is" to "RP1", the percentage contributions of CO2e from supply chain design and distribution emissions remain unchanged. This suggests that the reduction in packaging weight was not significant enough to impact the overall carbon footprint associated with these aspects of the product's life cycle.

Repackaging ABC Concealer 2

								SECONDARY PACKAGING			
			Refill	Materials				Material	Dimensions		Sourcing Country
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	material pack secondario	dimension PS	WEIGHT (g)	source
ABC Concealer (1,100 g/ml)	As-is	12	0	PP | Polypropylene			cap	paper	2,7x4,7x13 cm	7	ITALY
				HDPE | High density polyethylene	80%	0%	tube				
				LDPE | Low density polyethylene	20%	0%					
	RP1	12	0	PP | Polypropylene		0%	cap	paper	2,7x4,7x13 cm	7	ITALY
				LDPE | Low density polyethylene		60%	tube				
	RP2		0	PP | Polypropylene		0%	cap	paper	2,5x0,3,x13 cm	1,85	ITALY
				LDPE | Low density polyethylene		60%	tube				

Figure 5.29: As-is vs RP1 vs RP2 comparison – Secondary packaging

The second repackaging can be seen as a continuation of the first, retaining the same primary packaging as in RP1 but making changes to the secondary packaging. This approach suggests a strategic layering in packaging optimization, where the primary elements are kept constant while the secondary elements are adjusted for further improvement.

The changes from the "As-Is" to the RP2 (Repackaging 2) for the ABC Concealer in terms of the secondary packaging are evident in the dimensions and weight.

- Dimension: The dimensions of the secondary packaging have been reduced from "2.7x4.7x13 cm" to "2.5x3x13 cm." This indicates a more compact packaging design that likely results in material savings and possibly reduces the space required for transportation.

- Weight: The weight of the secondary packaging has decreased significantly from 7 grams in the "As-Is" and RP1 designs to 1.85 grams in the RP2 design. This is a substantial reduction and would contribute to the overall decrease in transportation emissions, as lighter packages are more fuel-efficient to ship.

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
			180	PP | Polypropylene		0%	pump------>									
ABC Concealer (1,100 g/ml)	As-is			PP | Polypropylene			cap									
		12	0	HDPE | High density polyethylene	80%	0%	tube	120,4	41%	49,3	18%	21,6	14%	16,9		13,5
				LDPE | Low density polyethylene	20%	0%										
	RP1	12	0	PP | Polypropylene		0%	cap	116,9	39%	46	18%	21,5	14%	16,8		13,3
				LDPE | Low density polyethylene		60%	tube									
	RP2		0	PP | Polypropylene		0%	cap	108,3	38%	41,3	18%	19,4	14%	15,1		11,7
				LDPE | Low density polyethylene		60%	tube									

Figure 5.30: As-is vs RP1 vs RP2 comparison – CO2e and waste impact

The table in figure 5.31 shows that by changing the dimensions of the secondary packaging and consequently its weight— in particular by using thinner and lighter paper — the overall CO2e footprint per unit is reduced by 10% and the waste impact is reduced by 13.3% compared to as-is scenario.

Supply chain design

Figure 5.31: CO2e generated during transportation – RP2

In figure 5.30 is visible the RP2 CO2e generated by the folding carton component along the path from the secondary package provider to the company, where the product is assembled.

It is important to note that along this path, the analysis shows a significant reduction in CO2e emissions of 74% due to the weight reduction from 7g to 1.85g of secondary packaging.

Waste impact

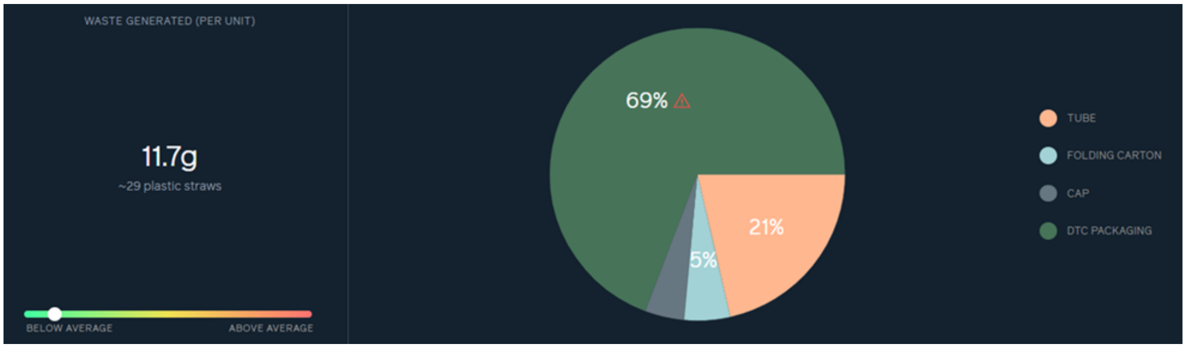

Figure 5.32: waste generated breakdown-RP2

Figure 5.32 shows that in the case of folding cartons (secondary packaging), there has been a significant reduction in the waste generated for unit, from 17% to 5%.

5.5.3 Summary results

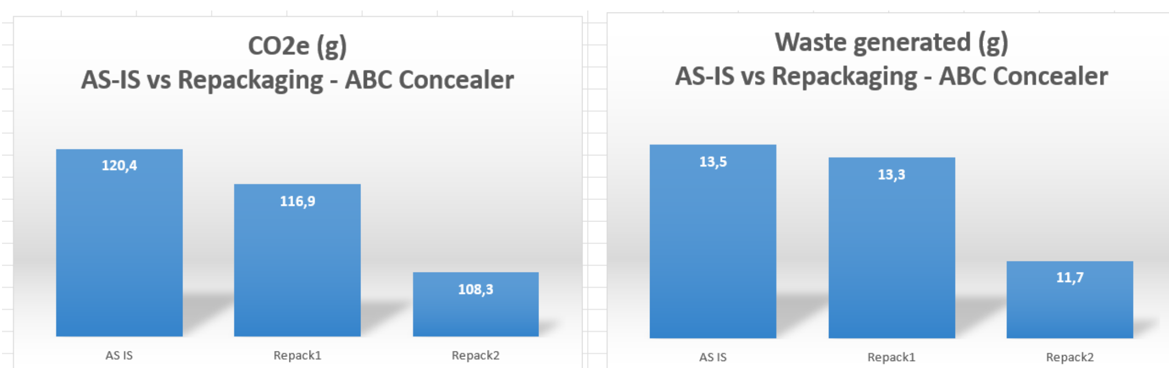

Figure 5.33: Comparison of CO2e and waste generated metrics for the ABC concealer product

The figure 5.33 illustrates the results of repackaging effort for the ABC Concealer product, showing reductions in both CO2e emissions and waste generation. Initially, the "AS-IS" product's state resulted in 120.4 grams of CO2e and 13.5 grams of waste. The first repackaging (Repack1) modestly decreased CO2 emissions to 116.9 grams and slightly reduced waste to 13.3 grams. The second repackaging (Repack2) further cut CO2e emissions to 108.3 grams — a 10% reduction with respect to AS-IS — and waste generation saw a more substantial decrease to 11.7 grams - a 13% reduction. These changes indicate a successful implementation of eco-friendlier packaging options over two repackaging phases, achieving a progressive reduction in both CO2e emissions and waste generated by the ABC Concealer.

5.6 Glassy

Glassy is Espressoh's leading product, known for its premium quality and substantial market presence. Each unit contains 3.5 ml/g of the product, encased in 45 g glass jar, topped with a 7 g polypropylene cap. The total weight of the item is 58.08 g, which is notably heavy for the amount of content it holds. All the details described in that section contribute to the assessment of the primary packaging.

5.6.1 AS-IS

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
Glassy (0,880 g/ml)	AS-IS	3,5	0	PP | Polypropylene		0%	cap	232,9	66%	153,9	16%	36,8	12%	28,9		49,8
				glass		0%	jar									

Figure 5.34: As-is – CO2e and waste impact

The figure 5.34 shows that the CO2e per unit is 232.9 g, with 66% of emissions from materials and product design, 16% from supply chain design, 12% from distribution emissions and an waste impact of 28.9 g per unit and the remain 6% is refers to the formula of the glassy product. Given the significant contribution of 66% of materials and product design to total CO2 emissions, and given the high annual sales volume, it is crucial to focus on improving the sustainability of primary packaging, especially due to its significant weight.

Material and product design

	Materials and product design(co 2e) g	(g CO2e) JAR	(g CO2e) JAR %	(g CO2e) CAP	(g CO2e) CAP %	(g CO2e) S.P.	(g CO2e) S.P. %	(g CO2e) OTHERS(DTC)	(g CO2e) OTHERS(DTC) %
As-is	153,9	94	61%	25	16%	3	2%	31,9	21%

Figure 5.35: As-is – Materials and product design

The table in figure 5.35 provides a detailed breakdown of CO2e emissions associated with a product's materials and product design, highlighting the significant role of jar. It is responsible for 61% of these emissions, highlighting its significant impact on the product's environmental footprint.

Supply chain design

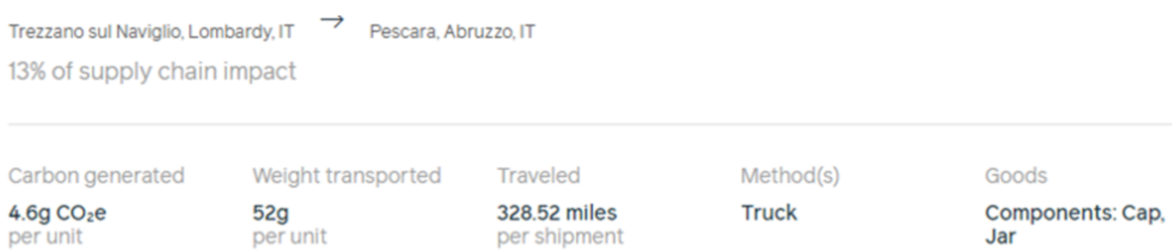

Figure 5.36: CO2e generated during transportation

The figure 5.36 shows that for a shipment of 328.52 miles (from the primary package provider to the company, where the product is assembled), the carbon emissions per unit are at 4.6 g CO2e.

Waste impact

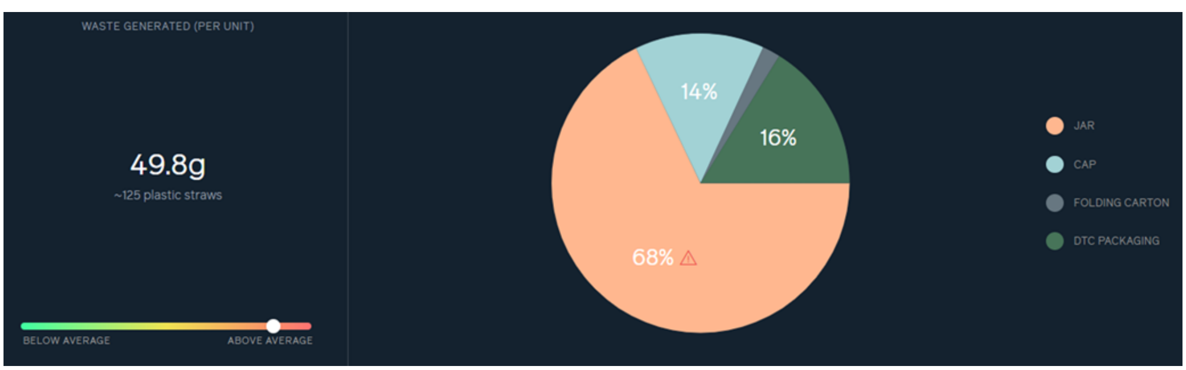

Figure 5.37: Waste generated breakdown-AS-IS

The breakdown for waste generated per unit shows the high percentage caused by the glass jar.

Glass is heavy and bulky, which contributes significantly to the volume and weight of material in landfills and leads to its faster filling.

5.6.2 Repackaging solution 'Glassy'

The repackaging scenario for the Glassy product involve sustainable changes to reduce environmental impact of Co2e emissions and waste generated. Repackaging Glassy:

- It was decided to maintain the glass material of jar for "Glassy" due to its aesthetic appeal, while also moving to a lighter glass option to improve sustainability.
- The repackaging shifted production to China, incorporating 20% air and 80% sea transportation.
- The majority of the supply chain impact (72%) is attributed to the long-distance transport.
- Overall CO2e emissions per unit unfortunately increased from 232.9g to 243.1g due to supply chain changes.
- There was a 27% reduction in the total waste generated per unit.

Repackaging Glassy 1

It was decided to retain glass for its aesthetic value while improving sustainability by sourcing lighter glass packaging. This approach strikes a balance between visual appeal and environmental mindfulness. So there has been a change towards lighter glass, which is produced in China.

				PRIMARY PACKAGING							
			Refill	Materials				Weight		Dimensions	Sourcing country
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	WEIGHT pf(g)	weight component pp(g)	dimension component PP(LxWxD)	source
Glassy (0,880 g/ml)	AS-IS	3,5	0	PP | Polypropylene		0%	cap	58,08	7	4,5x4,5x1,5 cm	ITALY
				glass		0%	jar		45	4,5x4,5x2 cm	ITALY
	RP1	3,5	0	PP | Polypropylene		0%	cap	40,08	7	3,5x3,5x1,3 cm	CHINA
				glass		0%	jar		27	3,5x3,5x2,5	CHINA

Figure 5.38: As-is vs RP1 comparison – Primary packaging

A lighter glass reduced the weight of the jar from 45 g to 27 g (40 % weight reduction) and with a percentage reduction in the total weight of the finished product of 31 %. This change has led to a reduction in CO2e emissions for material and product design from 66% to 48%, but it has increased CO2e emissions for supply chain design (see table in figure 5.39). The increase of CO2e emission in supply chain design leads to an increase in the overall CO2e emissions per unit (from 232,9g to 243,1 g).

			Refill	Materials				CO2e							waste impact	
PRODUCT	Repack Code	fill (ml/g)	REFILL use	Material pack primario	Share of primary material packages based on weight or mixed material [%]	PCR	component pack primario	per unit (g)	Materials and product design (%)	Materials and product design (g)	Supply chain design (%)	Supply chain design (g)	Distribution emissions (%)	Distribution emissions (g)	on average (g)	per unit (g)
Glassy (0,880 g/ml)	AS-IS	3,5	0	PP | Polypropylene glass		0% 0%	cap jar	232,9	66%	153,9	16%	36,8	12%	28,9		49,8
	RP1	3,5	0	PP | Polypropylene glass		0% 0%	cap jar	243,1	48%	116,1	37%	91,1	9%	22,7		36,3

Figure 5.39: As-is vs RP1 comparison – CO2e and waste impact

Supply chain design

The figure 5.40 below shows the transportation of the jar and cap components from China to Italy, 20% by air and 80% by sea. It illustrates that 72% of the impact on the supply chain is due to the transport of this 5753.63 miles shipping route. Compared to the as-is scenario, the carbon produced per unit has increased from 4.6 g CO2e to 65.35 g CO2e, which corresponds to a percentage increase of around 1320.65 %.

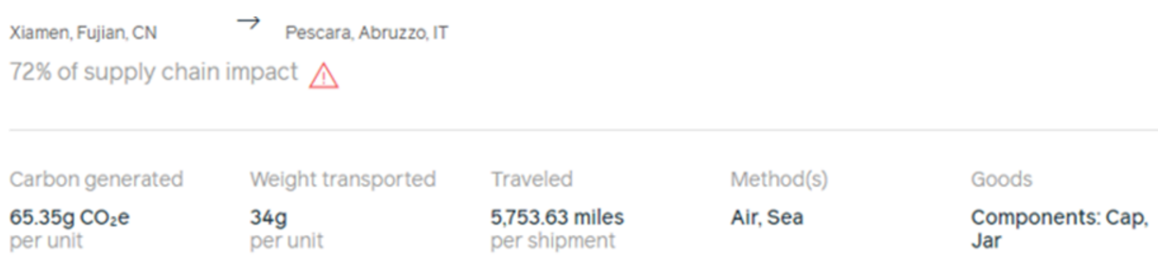

Figure 5.40: CO2e generated during transportation

Waste impact

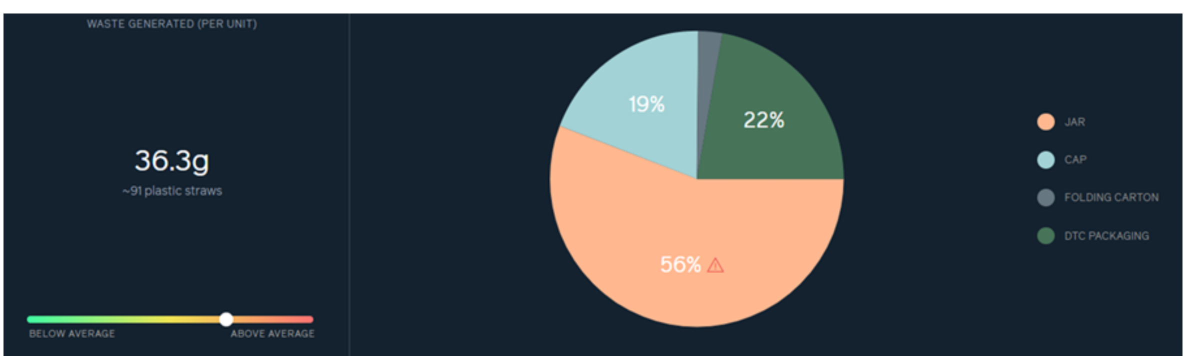

Figure 5.41: waste generated breakdown

The total amount of waste generated per unit was reduced by 27%, with the percentage of waste generated by the glass jar component falling from 68% to 56% but the overall waste impact is always above average.

5.6.3 Summary results

In summary, the repackaging of Espressoh's "Glassy" product illustrates a complex trade-off between reducing packaging waste and increasing CO2 emissions. The decision to switch to lighter glass produced in China achieved a significant weight reduction in the packaging, which reduced the material-related Co2e and waste. However, this benefit was offset by a substantial increase in carbon emissions due to the longer transportation route and reliance on air freight. Despite the waste generated per unit being lowered, the overall impact remains above the average, highlighting the intricate balance between aesthetic, environmental, and logistical considerations in sustainable packaging initiatives.

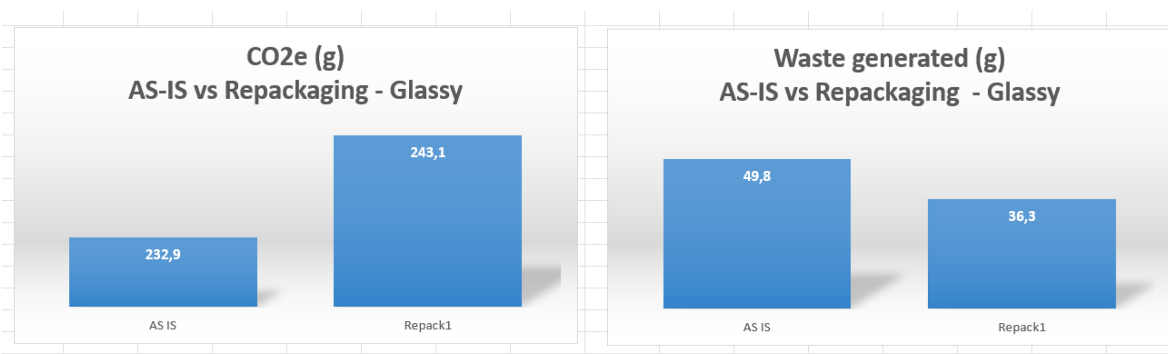

Figure 5.42: Comparison of CO2e and waste generated metrics for the Glassy product

Figure 5.42 presents a contrast between the original and repackaged versions of the "Glassy" product, focusing on CO2e emissions and waste generation. The "AS-IS" packaging results in 232.9 grams of CO2e emissions, while Repack1, despite efforts to improve sustainability, shows an increase to 243.1 grams - a 4.4% increase - caused by the long distance from the supplier of primary packaging. In terms of waste generation, however, the repackaging effort has a positive effect, with a reduction from 49.8 grams in the "AS-IS" to 36.3 grams in Repack1, indicating a successful 27% decrease in the amount of waste produced. The data illustrates a mixed outcome where repackaging has effectively reduced waste but has had an unintended adverse effect on carbon emissions.

5.7 New Collection Environmental Impact

After evaluating current packaging options and exploring repackaging opportunities, Espressoh is ready to launch a new collection of products that embody the company's commitment to sustainability and are informed by the as-is analysis and repackaging decisions discussed in Section 5.4, 5.5, 5.6.

	MATERIAL pack primario	PCR	component pack primario	weight component pp(g)	dimension component PP(LxWxD)	Co2e (per unit) g	waste impact (per unit) g	fill
CREAM	PE	100%	TUBE	6	3X3X11 CM	249,08	23,71	50 ml
	PE	50%	PUMP	5	1,5X1,5X3,7 CM			
	PE	0%	OVERCAP	4,6	2,4X2,4X4 CM			
SPF LIPS	PE	60%	TUBE	3	1,6X1,6X10 CM	134,52	12,96	10 ML
	PP	60%	OVERCAP	1,85	1,6X1,6X2 CM			
HIGHLIGHTER	aluminum	0%	TUBE	4	3X2X10 CM	162,95	12,81	10 ML
	HDPE	0%	OVERCAP	0,7	1X1X1,5 CM			

Figure 5.43: Estimated CO2e emissions and waste impact for future products

The upcoming product line shows a deliberate shift towards the use of Post-Consumer Recycled (PCR) content and the introduction of aluminum as a packaging material. The data provided indicates that this strategic move is justified by the successful reduction of CO2e emissions and waste impact in previous repackaging initiatives.

5.7.1 PCR use in future products

The decision to use PCR materials is a direct result of its capability to reduce the environmental footprint of Co2e and waste generated. PCR materials reduce the need for virgin plastics, which in turn reduces greenhouse gas emissions and dependence on fossil fuels. In the case of the cream, transitioning to 100% PCR PE tubes resulted in CO2e emissions per unit being in the lower range of 249.08g and waste impact of only 23.71g per unit as shown in Figure 5.44, demonstrating the environmental benefits of PCR materials.

In the case of the SPF lip product, the use of 60% PCR in both the PE tube and the PP overcap resulted in CO2e emissions equal to 134.52g per unit and a minimal waste impact of 12.96g per unit, as illustrated in Figure 5.45. These results solidify PCR's role in Espressoh's sustainability strategy and signal a strong preference for recycled materials in future packaging designs to reduce the impact on the environment.

The use of aluminum in the highlighter tube is an innovative step towards the sustainability of Espressoh. Although aluminum does not contain PCR, it is preferred because of its light weight and high recyclability, which can significantly reduce transport emissions and the overall carbon footprint. The analysis shows that despite the traditional manufacturing process, the light weight of aluminum has kept CO2e emissions (162.95g per unit) and waste impact (12.81g per unit) below average (Figure 5.46), indicating its potential as a sustainable packaging option.

The metrics have influenced Espressoh's choice of materials,ensuring that the new collection is not only in line with the brand's aesthetic values, but also meets the increasing demand for environmentally friendly products.

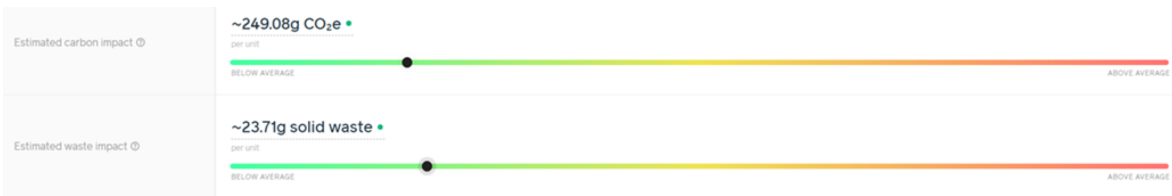

Figure 5.44: Cream estimated carbon and waste impact

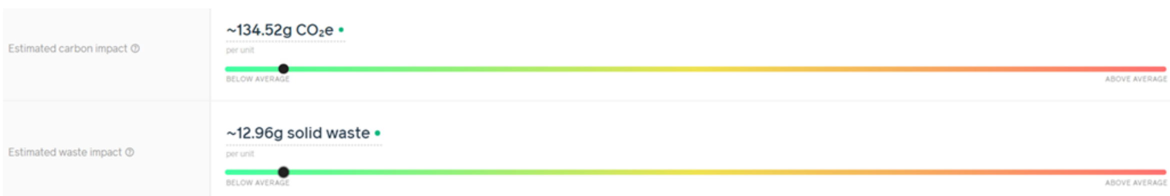

Figure 5.45: Spf lips estimated carbon and waste impact

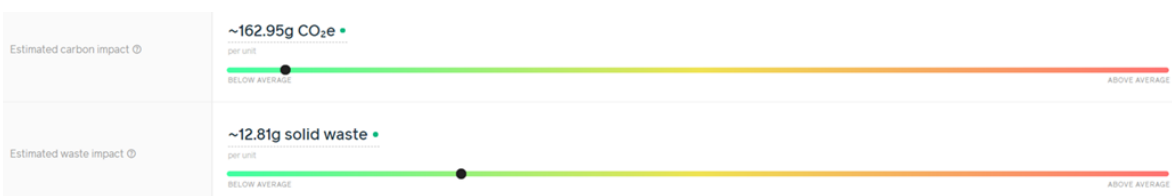

Figure 5.46: Highlighter estimated carbon and waste impact

Chapter 6

Conclusions

The aim of this thesis was to assess the environmental impact of packaging and identify possible alternatives that are more sustainable.

By reviewing the literature in the field of sustainable supply chain management, with a specific focus on cosmetics industries, several strategies along the entire product life cycle were discussed to identify possible aspects that could be improved to have a better sustainability, not only from an environmental point of view, but also from a social and economic perspective.

A complete methodology for evaluating repacking was presented, in order to provide an end-to-end framework for companies that would like first to assess their current situation in terms of CO2e emissions and waste, and to achieve more sustainable packaging for their products.

The presented Espressoh case study illustrates the application of this methodology in a real-world context and shows the impact of packaging decisions on sustainability metrics. Using Bluebird Climate software, different scenarios for emissions and waste in the supply chain were analyzed and the benefits of alternative and sustainable packaging were highlighted.

The results presented a transformative vision for Espressoh's product range. Through careful analysis, we identified opportunities to minimize CO2 emissions and waste, leading to strategic repackaging initiatives. The comparison between the as-is scenarios and the proposed repackaging scenarios showed tangible improvements and highlighted the potential for significant environmental benefits.

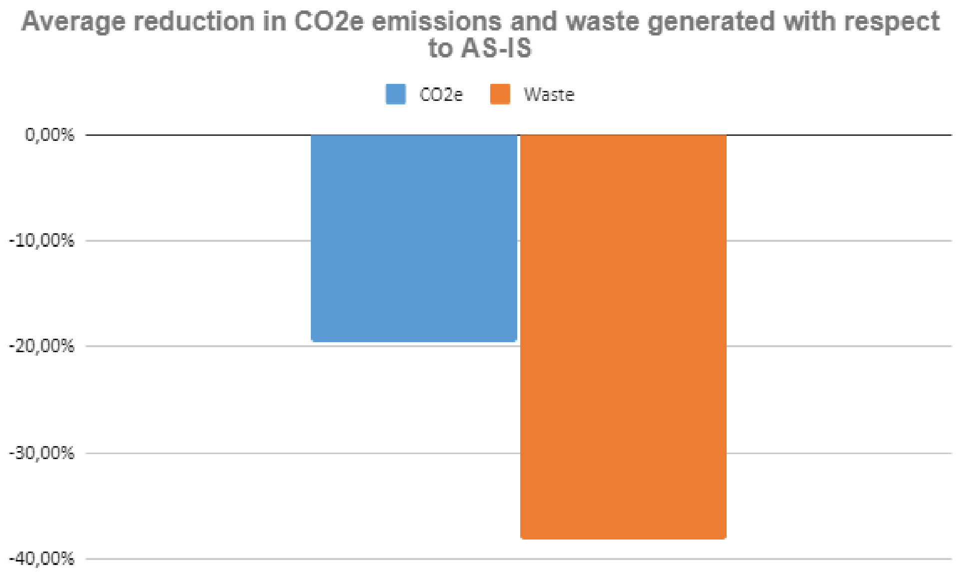

Figure 6.1: Average reduction in CO2e emission and waste generated for the evaluated repackaging options

This work also highlighted that there is no single way for improving sustainability, and many factors should be considered and properly balanced to obtain the best result possible (for instance material substitution, supply chain redesign, etc.).

In summary, this work provides a clear path forward and a collection of sustainable recommendations for Espressoh and other companies in the cosmetics industry seeking to reconcile the aesthetics and the classical benefits of cosmetic packaging with the urgent need to protect the environment. The transition to sustainable packaging, as outlined in this work, is not an end point, but a continuous journey characterized by ongoing evaluation and innovation.

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