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PACKAGING OPTIMIZATION AS A TOOL FOR SUSTAINABLE PRODUCTION ON A GLOBAL SCALE

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Abstract: *Packaging optimization is a key strategy for achieving sustainability, especially as global consumption and packaging use continue to rise. In the automotive industry, packaging ensures safe storage and transport of components but traditionally relies on resource-intensive materials that generate significant waste. Sustainable solutions include reducing material use, adopting recyclable and biodegradable inputs, and introducing modular, reusable, and collapsible systems to improve logistics and efficiency. These practices lower CO_2 emissions, energy use, and costs while supporting circular economy principles. Successful examples, such as Bosch's carbon-neutral operations, show that optimized packaging can cut waste and emissions by up to 30%. Overall, packaging optimization is both a technical and strategic tool for sustainable development in the automotive sector.*

Keywords: *Packaging, Automotive Industry, Optimization, Sustainability, Lean, Logistics*

1. INTRODUCTION

Packaging is the science, art and technology of preparing a product for appropriate transportation, storage, sale and use. [1]

Packaging is an important component of many facets of modern consumption in that it has become part of the delivery system for products and it is generally seen to fulfil four key functions, namely to 'preserve and protect the product', 'to communicate brand image', to 'convey information', and 'offer convenience' (PricewaterhouseCoopers 2010, p.4). Packaging plays a vital role in the protection, storage and hygienic handling of products. At the same time packaging materials require the use of a wide range of natural resources whose disposal has a direct impact on the environment and widespread concerns have been expressed about the negative environmental impact of packaging systems. [2]

Packaging also plays a vital role in conveying a wide range of product information to customers, including information on use by dates, ingredients and health and safety. Packaging is also seen to be vitally important marketing tool in that it is seen to enhance product appeal, to create and enhance brand awareness and to influence consumer buying behaviour. [2]

Due to the currently widespread transformation in the methods of energy production, distribution, and consumption—specifically, the shift from traditional fossil energy sources (such as coal, oil, and gas) to renewable and sustainable energy sources (such as solar, geothermal energy, hydropower, biomass.etc.)—the global supply of materials in various industries is also changing and adapting to new conditions. [3]

Changes in technologies, infrastructure, policies, and social norms, with a focus on reducing negative environmental impact, have posed challenges for the materials industry over the past two to three years. [3]. These changes in material supply and production methods, the transition to digital business practices, and the emphasis on sustainability and environmental protection have directly impacted the packaging industry, which is the topic of this paper and will be discussed further below.

2. CORPORATE SUSTAINABILITY

As investors, consumers, governments, interests groups and the media have become more acutely aware about the environmental, social and economic impacts of business activities so corporate sustainability initiatives have assumed ever increasing importance. KPMG (2012, webpage), for example, suggested that 'the evidence that sustainability is becoming a core consideration for successful businesses around the world grows stronger every day. [2]

More generally corporate sustainability is also increasingly seen to incorporate the more recently developed concept of the creation of shared value. This concept has been 'defined as policies and practices that enhance the competitiveness of a company while simultaneously addressing the economic and social conditions in the communities in which it operates' [4]

This paper will examine the case of the company Bosch, which is focused on packaging optimization for the purpose of sustainable development. Based on the company's 2024 annual report Bosch aims to minimize the environmental impact of its operations through the implementation of a comprehensive, Group-wide environmental management system, supported by clearly defined targets. The company prioritizes climate protection, water conservation—particularly in regions where water is scarce—and the promotion of a circular economy through targeted initiatives. [8]

To achieve these goals, Bosch seeks to ensure that all relevant facilities operate under certified environmental management systems. As of the latest reporting period, 97% of the company's relevant manufacturing and development sites have implemented such systems, with 98% of them certified in accordance with the ISO 14001 standard. Additionally, 90% of the energy management systems in use across the company are aligned with these environmental objectives. [5]

Bosch has clearly defined environmental criteria for the design, planning, and acquisition or construction of facilities, machinery, and manufacturing equipment, for example with regard to energy efficiency and the use of renewable energy sources. These criteria also play a role in the decision-making process when choosing new company locations.[5]

Bosch's sustainability efforts encompass the entire value chain — from the procurement of materials and goods, through production processes at its own facilities, to the use phase of its products and their end-of-life management. This holistic approach ensures that environmental and social considerations are integrated at every stage of the product lifecycle.

The following section presents an overview of all key aspects addressed by Bosch in its pursuit of sustainable development, along with the corresponding activities implemented within each area.

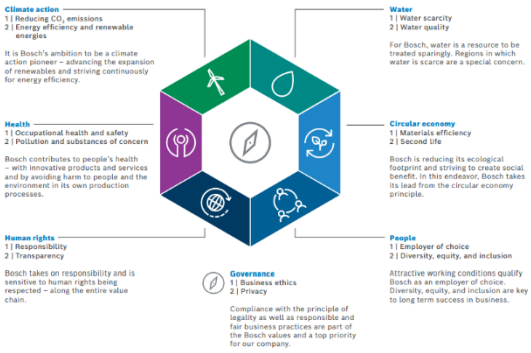

Figure 1. Sustainability strategy

This paper presents a case study of Bosch's successful product *packaging optimization* as part of its sustainable development strategy. The analysis includes an overview of achieved results, relevant key performance indicators (KPIs), and other related metrics.

Explained case study includes segments from both stated Bosch's activities – *climate action* and *circular economy*.

With its more than 450 locations worldwide, the Bosch Group has been carbon-neutral overall since 2020. Four levers were used to achieve carbon neutrality: increasing energy efficiency, generating our own energy from renewable sources (new clean power), purchasing electricity from renewable sources (green electricity), and – as the last resort – offsetting residual CO_2 emissions with carbon credits. In 2024, residual emissions of roughly 531,300 metric tons of CO_2 were offset by carbon credits. This represents a decrease of 8.5 percent on the prior year's level.

Since 2018, Bosch has cut scope 3 emissions by around 27 percent, down to 335 million metric tons of CO_2 in 2023. In this process, company is focusing on the categories that make up around 98 percent of their scope 3 emissions: upstream emissions in the Bosch value chain primarily concern purchased goods and services as well as logistics. Downstream emissions are mainly caused by the use of their products. [7]

For years, materials efficiency has been a fixed criterion in the Bosch product development process, where it is anchored in their Design for Environment (DfE) principle. Company's activities range from reusing products and their components to repairs and right through to remanufacturing – in each case with the objective of extending product and component life cycles. The individual divisions of Bosch each have their own objectives in this regard, depending on market and product-specific framework conditions

Important aspects of sustainable packaging operations involve finding the right balance between cost-efficiency, practical functionality, and environmental responsibility. As more companies aim to adopt greener packaging practices, it becomes crucial to manage these factors thoughtfully to ensure effective results. The main challenge is to choose materials and methods that reduce environmental harm without compromising the performance or affordability needed for regular business activities. [6].

3. CASE STUDY: OPTIMIZATION OF WINDSHIELD WIPER PACKAGING AT BOSCH AS A CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

In line with its commitment to sustainable development and environmental protection, Bosch has implemented a range of initiatives focused on reducing resource consumption and minimizing waste across its value chain. A notable example is the optimization of packaging for windshield wipers—an initiative that significantly contributed to material savings, reduced environmental impact, and increased operational efficiency.

3.1. Initial Packaging Challenges

Prior to the optimization project, Bosch's windshield wipers were packaged in rectangular cardboard boxes that included an internal insert designed to hold the wiper in place. Each package also contained a smaller box with four plastic adapters, even though only one adapter was necessary for the specific vehicle model owned by the customer. This led to the disposal of excess components—three plastic adapters, the insert, and the outer cardboard packaging—

immediately after installation, contributing to unnecessary material waste.

Figure 2. Initial Packaging **3.2. Optimized Packaging Solution**

Through a targeted redesign, Bosch introduced a more compact and aerodynamically shaped packaging solution. The new packaging is tailored to fit the wiper blade securely without the need for additional inserts. Moreover, the adapter is now sold separately, enabling customers to purchase only the specific adapter required for their vehicle model. These adapters are distributed in bulk packaging units of 30, 50, or 70 pieces and are available for individual sale.

Figure 3. Optimized Packaging Solution

3.2. Measurable Results and Key Performance Indicators (KPIs)

This packaging optimization yielded measurable environmental and operational benefits. Key performance indicators used to assess the success of the initiative include:

- Material savings: Reduction of plastic usage by up to 35 metric tons per year and cardboard usage by approximately 50 metric tons per year.
- Packaging weight reduction: A single package's weight decreased from 69 grams to 34 grams, representing a 50.7% reduction in material per unit.
- Waste reduction: Fewer surplus components (adapters) are discarded post-purchase.
- Resource efficiency: Improved ratio of packaging weight to product weight and reduction in packaging volume per unit transported.

These KPIs are aligned with Bosch's internal environmental management goals and are regularly monitored as part of the company's ISO 14001-certified environmental management system. The majority of Bosch's manufacturing and development locations operate under this standard, which provides a structured framework for managing environmental responsibilities in a systematic and transparent manner.

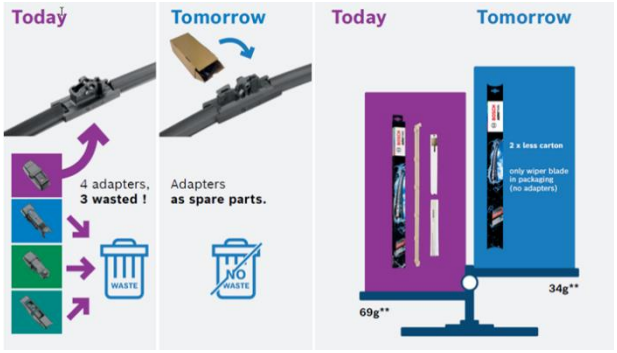

Figure 4. Waste reduction and results

3.3. Alignment with Sustainability Goals and Standards

Bosch is committed to implementing good practices and meeting the requirements of international standards that support the SDGs, and additional procedures have been developed, i.e. calculations in accordance with ISO 14067, and the process of critical review and issuing CO2 reduction signs is ongoing. Independent third party critical review according to ISO 14067 will enable Bosch to communicate results or reduction achievements internally and externally.

The packaging optimization project directly contributes to the United Nations Sustainable Development Goals (SDGs), particularly:

- SDG 12: Responsible Consumption and Production – by reducing material inputs and minimizing waste generation.
- SDG 13: Climate Action – by lowering the environmental footprint associated with packaging materials and logistics.
- SDG 9: Industry, Innovation and Infrastructure – through the application of innovative design for sustainability.

Additionally, the initiative supports Bosch's broader corporate sustainability strategy, which includes objectives related to climate action, circular economy enhancement, and resource efficiency across the product lifecycle.

4. CONCLUSION

The case of Bosch's windshield wiper packaging optimization illustrates how targeted, well-executed design changes can significantly contribute to environmental sustainability while maintaining functionality and economic efficiency. By reducing the use of plastic and cardboard, minimizing surplus components, and improving the weight-to-product ratio, Bosch has demonstrated a strong commitment to sustainable development. The company's alignment with ISO 14001 standards and the broader United Nations Sustainable Development Goals underscores the strategic integration of sustainability into its operations.

Looking to the future, companies like Bosch are expected to further embed sustainability across all levels of their value chains, driven by tightening environmental regulations, evolving consumer expectations, and increasing investor scrutiny. In this context, packaging will remain a key area for innovation and improvement. To sustain momentum, companies should invest in life-cycle thinking, adopt advanced digital tools to monitor and analyze environmental impacts, and foster cross-sector collaboration for circular packaging solutions. Continued focus on eco-design principles, reusable and biodegradable materials, and supply chain optimization will be crucial.

Furthermore, transparency and accountability—achieved through standardized reporting and third-party verification—will play an essential role in validating sustainability claims and building stakeholder trust. As global supply chains become more interconnected and resource constraints more pressing, packaging optimization will no longer be an isolated activity but a central pillar of responsible corporate strategy. By continuously innovating and expanding its sustainability framework, Bosch sets a compelling example for how industrial leaders can balance operational efficiency with environmental responsibility.

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