

# Study on Sustainability and Application of Smart Package Design for Circular Economy

Yuan Liu

Liaoning Communication University, Shenyang 110136, China

**Abstract.** Today, the garbage problem of packaging materials is a direct disaster to mankind such as environmental pollution and weather change. Therefore, this research proposes sustainable technology and utilization strategies for smart package design throughout the life cycle, where package design is an environmental problem, and tries to contribute to the realization of a recycling economy. Therefore, multi-dimensional ecological innovation such as people, environment, and profit are needed, and the circular economy is realized through intelligent packaging design. The use of intelligent packaging design has its impact, which will change our way of life from a macro perspective and ultimately affect the symbiotic relationship between our quality of life and our values.

**Keywords:** Circular Economy Package; Smart Package Design; Sustainability.

## 1. Theoretical Background

### 1.1. Trends in the Circular Economy

The focal point of an economic system that emphasizes resource recycling is the reutilization of trash as a novel ecological design objective. This system regards waste as a remarkably sustainable and recyclable resource, while concurrently striving to minimize resource consumption. The use of production technology has the potential to decrease the expenses associated with resource extraction and processing. Additionally, the utilization of such technology can lead to the generation of by-products and pollutants during the waste stage, which can help mitigate the environmental issues arising from resource utilization. The utilization of resources as fundamental inputs for organizations may contribute to both economic development and environmental preservation, while also ensuring optimal resource utilization. In order to attain sustainable development, it is imperative to engage in the practice of recycling resources, hence enabling their reuse and minimizing waste generation [1]. The circular economy governs the utilization of resources.

### 1.2. Intelligent Packaging Design

This approach involves the integration of scientific and technological advancements, as well as the consideration of economic strategies and commercial aspects, inside a circular framework rooted on the principles of industrial ecology. The primary objective is to optimize the product life cycle. The sustainability of smart packaging design lies in its adoption of shared use practices and consideration of economic strategies. This is achieved by integrating numerous functions throughout the product life cycle, therefore reducing the environmental effect of equipment and commercial transactions. By doing so, smart packaging design not only benefits human life but also contributes to the optimization of a sustainable future [2].

### 1.3. Sustainable Design Methodology

The circular economy incorporates the principle of environmental responsibility, which is included into the package design process even prior to its life cycle assessment. The implementation of sustainable design is of utmost importance in addressing global demand by means of design. One may argue that this activity involves the use of established methodologies within the framework of a linear economy. This notion diverges from the broader framework of structural ecological design. Transitioning from a conventional technology to a circular economy is not a straightforward process

for a product designer or designer. It is important to consider the concepts of sustainable development and institutional innovation.

## 2. Sustainability Analysis and Application of Smart Packaging Design

### 2.1. Environmentally-friendly Materials

An orbital economy Innovative packaging intelligence technology In the consumer era, packaging design is of the utmost importance; however, the issues of mass production, brief product life cycles, and increased waste are inextricably linked to a variety of environmental pollutants and affect the environment throughout the product life cycle [3]. Intelligent packaging comprised of biomaterials has demonstrated promise as a sustainable alternative to plastics, not only in terms of reducing waste and the strain on landfills, but also in substitution for petroleum resources. Natural substances, processed biodegradable substances, soluble substances, and edible substances are all biomaterials. All of these materials are of natural origin, devoid of any toxic or chemical components. Moreover, they are biodegradable and recyclable by nature, and do not emanate any hazardous substances. The ecologically sustainable water container developed by university students in London, England, and featured in Figure 1. It represents a novel and inventive substitute for conventional plastic vessels. It is designed to decrease container pollution. It comprises ingestible "spherical" water encased in an edible film, which decomposes without producing any residue. It is capable of entirely resolving the critical issue pertaining to bottled water and eliminating packaging pollution.



**Figure 1.** Ooho's new edible water ball

### 2.2. Minimize and Optimize

The consideration of social, economic, and environmental factors across the whole life cycle of a product is crucial in determining its sustainability within a circular economy framework. Thus, the original design of the product plays a pivotal role in this determination. The enhancement of environmental performance through design strategies may be achieved by focusing on the structure or form of package design, which has the potential to influence consumer behavior. As seen in Figure 2, a convenience food container composed entirely of organic material may undergo compression and expansion, achieving a size comparable to that of a bowl by the application of heat via the addition of hot water. This innovative packaging design, characterized by its clever structure and form, has the potential to enhance energy efficiency while utilizing less resources. The implementation of an optimal design has the potential to mitigate the issue of excessive packaging, resulting in a reduction of packaging materials by two to three times. This reduction in packaging not only conserves valuable resources and minimizes transportation costs, but also plays a crucial role in mitigating greenhouse gas emissions throughout the circulation process. Furthermore, the adoption of an optimal design contributes to energy conservation. The container depicted in Figure 3 is constructed in a square shape, which is specifically optimized for transportation purposes. This design choice allows for optimum utilization of loading space, resulting in energy savings during transportation and facilitating an effective circulation process [4].



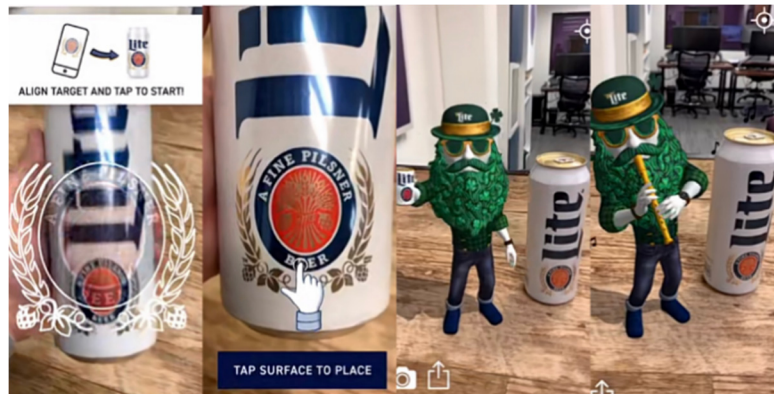
**Figure 2.** 100% organic instant food container



**Figure 3.** Square Coca Cola design

### 2.3. Dematerialization

Augmented reality (AR) is a sophisticated technological innovation that offers authentic, engaging, and engrossing encounters. The diagram depicted in Figure 4. The subject of inquiry is to the packaging of Miller Lite brand canned beer. Consumers have the ability to utilize their mobile phones to scan the brand logo, therefore facilitating the opportunity to engage with a musician for a shared drinking experience. This interaction serves to enhance consumers' interest in consumption while also enabling them to share this experience with their social network on various online platforms. In order to foster an emotional interactive experience, it is imperative to enhance customers' intuitive tactile engagement with products[5].



**Figure 4.** AR (augmented reality) canned beer packaging design

### 3. Use of Smart Packaging at Every Stage of the Cycle

To facilitate the establishment of a circular economy, the implementation of a comprehensive and structured response strategy is needed. In order to achieve this objective, it is imperative to take into account social, economic, and environmental issues in all package design endeavors. Furthermore, it is essential to use the subsequent intelligent packaging design methods in a flexible manner, aligning them with the many stages of the product's life cycle. In the first phase of production, it is important to employ environmentally conscious materials that mitigate harm to the ecosystem. Additionally, the implementation of intelligent packaging, utilizing renewable resources, is recommended. By using these strategies, it becomes feasible to mitigate the occurrence of air, soil, and marine pollution that arises from landfills, while also facilitating the recycling of valuable materials over their entire life cycle. Furthermore, throughout the design phase, including a simple and optimal structure can effectively eliminate the need for superfluous industrial procedures. The implementation of this intelligent packaging system effectively streamlines production processes while also facilitating convenient transportation and storage. Moreover, the enhancement of energy efficiency during distribution and storage is achieved by the reduction of weight and size of packaging. Thirdly, throughout the production phase, it is important to ensure the preservation of product quality over an extended period and minimize the wastage of products to the furthest degree feasible. Specifically,

the use of intelligent packaging systems capable of maintaining the integrity of enclosed items has the potential to prolong their shelf life, minimize the quantity of packaging materials required for redistribution and replication, and diminish reliance on synthetic preservatives. In the distribution phase, the utilization of smart packaging enables the monitoring of items throughout their storage, transit, and delivery processes. The intelligent packaging systems has the capacity to effectively handle products in various chemical and physical exterior conditions, hence enhancing their resilience and longevity. Furthermore, during the use phase, tangible stuff is substituted by intangible matter. The smart package offers a wider range of content and minimizes the production of environmental pollutants by integrating Internet of Things (IoT) technology and substituting physical items with equivalent digital services. Furthermore, the negative aspects of the circular economy lie in consumers' perception and the dearth of information available to them. In order to achieve this objective, it is imperative for designers to take into account social, economic, and environmental considerations throughout the entirety of the packaging design processes. Consequently, designers should use the subsequent intelligent packaging design methods in accordance with the various stages of the product's life cycle.

#### **4. Conclusion**

There is a growing global focus on the utilization of natural resources, with a collective recognition of the necessity for a circular economy. In order to foster the circular economy, it is imperative that individuals, producers, sellers, consumers, and designers alike assume a feeling of accountability and actively engage in the necessary behaviors associated with their respective roles. In essence, it is imperative to prioritize the pursuit of mutually beneficial values and enhance the quality of human existence through the dissemination of sustainable intelligent technology among relevant parties. This may be achieved by adopting appropriate legislation, executing strategies for brand ecological marketing, and fostering a culture of environmentally conscious consumerism. Furthermore, it is crucial to analyze the environmental implications of packaging. This involves developing innovative package designs that prioritize sustainability, utilizing eco-friendly materials, implementing energy-efficient practices, and promoting resource regeneration. These efforts are essential for fostering a circular economy. Furthermore, the pursuit of financial gain is a crucial aspect to consider. The circular economy is a novel business model that prioritizes the pursuit of environmental value, while acknowledging the significance of profit generation in entrepreneurial endeavors. To elucidate, the pursuit of monetization in the context of the circular economy is driven by the future potential and value associated with enabling the recycling of trash in packaging as a novel resource, establishing a financially viable business model, and fostering the emergence of fresh prospects. From a macroscopic viewpoint, the sustainable examination and implementation of intelligent package design has beyond just novel technological methodologies, so progressively mitigating waste and resource depletion while also diminishing environmental contamination. The field of packaging design has evolved from being considered waste to being recognized as a valuable resource. The emerging cultural paradigm of the circular economy is exerting a transformative influence on individuals' lifestyles, with intelligent package design poised to serve as a pivotal catalyst for the advancement of the circular economy in the future.

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