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Plastic-Free Beverage Distribution:

A Data-Driven Approach to CO_2 Reduction and Environmental Scoring

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ABSTRACT

In response to increasing environmental concerns, our innovative approach targets CO_2 reduction by eliminating the use of plastic containers in the beverage industry. This paper presents a data-driven method for calculating CO_2 savings based on the Ministry of the Environment's CO_2 emission factors. By enabling beverage vendors to sell drinks directly into consumer-provided containers, they significantly cut plastic waste and associated emissions. This method involves the creation of a comprehensive database that tracks and scores environmental impact, providing real-time feedback to businesses on their sustainability efforts. It not only promotes environmental responsibility but also enhances consumer engagement by offering transparent, quantifiable environmental benefits. The methodology and database have been patented, ensuring a robust framework for adoption and scalability across the beverage sector. Initial results indicate a substantial decrease in CO_2 emissions, aligning with global sustainability goals. This paper will describe the design, implementation, and impact assessment of our patented system, demonstrating its potential to shift sustainable practices in the beverage industry. Our findings provide valuable insights into the practical application of CO_2 reduction strategies and offer a scalable model for broader environmental initiatives.

Keywords: CO_2 reduction, plastic-free, beverage industry, sustainability, environmental impact, data-driven

NONMENCLATURE

Abbreviations	
METI	Ministry of Economy, Trade and Industry, Japan
MOE	Ministry of the Environment, Japan

1. INTRODUCTION

1.1 Background

In recent years, Japan has made significant strides in addressing environmental challenges, particularly the reduction of plastic waste. With one of the highest per capita rates of plastic consumption globally, Japan faces considerable pressure to transition towards more sustainable practices. Among the various approaches to mitigate plastic pollution, plastic-free beverage distribution stands out as a promising solution.

Japan's approach to waste management traditionally revolves around meticulous sorting and recycling practices. However, there is growing recognition of the need to complement these efforts with innovative strategies that reduce the overall consumption of single-use plastics. Plastic-free beverage distribution, which includes the adoption of reusable containers and alternative packaging materials, represents a key area of focus.

1.2 Problem Statement

The implementation of economic incentives such as "Pay-As-You-Throw" (PAYT) systems has been explored as a means to drive waste reduction and promote recycling behaviors. PAYT systems impose a direct cost on the disposal of unsorted waste, thereby encouraging individuals and businesses to minimize waste and enhance sorting practices. While PAYT schemes have shown promise in various contexts, their effectiveness in Japan, where high levels of intrinsic motivation for recycling already exist, remains a critical area for investigation. Even the governments actively promote initiatives aimed at encouraging environmentally conscious behavior among consumers. In this context, research has focused on quantifying the environmental impact of used plastic products (Nakanishi et al., 2004). Under this circumstances, this study hypothesizes that similar methods can be applied to model the CO_2 savings associated with these environmentally conscious behaviors within Scope 3 emissions. Specifically, we propose that by following the basic

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guidance on accounting for greenhouse gas (GHG) emissions throughout the supply chain (version 2.4), it is possible to systematically quantify the CO_2 savings resulting from the adoption of sustainable practices. This approach will provide an understanding of the environmental benefits of reducing Scope 3 emissions through targeted consumer and industry actions.

2. SCOPE

2.1 Scope of this Study

In the context of Japan, where societal norms and intrinsic motivations play a crucial role in environmental practices, it is essential to examine how these different incentive structures interact. This paper aims to analyze the impact of various incentives on the adoption of plastic-free distribution methods and their effectiveness in reducing CO_2 emissions.

Corporate branding and product marketing related to decarbonization for consumers. Efforts are being made to appeal to consumers about the CFP of each product, mainly in Europe and the United States, at various levels such as countries, corporate consortia, and individual companies. While some consortiums work on an industry-by-industry basis, there are also cases where retailers and consumer goods manufacturers from various fields collaborate across industries to create rules for calculating and displaying environmental loads.[1]

By employing a data-driven approach, this study will assess how integrating monetary and non-monetary incentives can optimize consumer behavior and enhance the sustainability of beverage distribution in Japan.

This research will also provide insights into how Japan can leverage both economic and motivational strategies to achieve its environmental goals. Understanding these dynamics will be crucial for designing effective policies and interventions that not only reduce plastic waste but also align with Japan's unique cultural and societal context.

2.2 Online Scheme

The proposed scoring system for incentivizing beverage shops to promote the use of reusable containers can be effectively illustrated through two distinct but complementary schemes: an Online Scheme and an Offline Scheme. This bifurcated approach allows for a comprehensive evaluation of the system's impact across different platforms and consumer interactions.

The Online Scheme focuses on digital engagement and technology-driven incentives to encourage the use of reusable containers. This scheme is designed to leverage online platforms and digital tools to track, reward, and enhance consumer and shop behaviors related to sustainability.

- Digital Tracking and Scoring: Beverage shops participating in the Online Scheme integrate with a digital platform that tracks the volume of beverages served in reusable containers. This system uses point-of-sale (POS) data, digital receipts, and customer inputs to calculate scores based on the predefined criteria (e.g., volume of beverages served in reusable containers, customer participation rate).
- Customer Engagement: The online platform enables direct engagement with consumers through mobile apps or websites. Customers can register their beverages, receive digital rewards for sustainable practices, and access information on participating shops. The platform also facilitates real-time feedback and educational content about the benefits of using reusable containers.
- Incentive Distribution: Shops and customers receive rewards through digital channels. Shops with high scores may receive the priority to show their shops on the search page of the system. Customers earn digital coupons, discounts, or loyalty points redeemable at participating shops. This approach ensures that incentives are efficiently distributed and easily accessible.

Data Analysis and Reporting: The online system provides comprehensive analytics and reporting tools for beverage shops. Shops can monitor their performance, analyze trends, and adjust strategies based on data insights.

[1] Ministry of Economy, Trade and Industry, Japan, 2023: Retrieved by P8-15,15, 32, https://www.meti.go.jp/shingikai/energy_environment/carbon_footprint/pdf/20230331_2.pdf

2.3. Offline Scheme

The Offline Scheme focuses on in-store and community-based interactions to encourage the use of reusable containers. This scheme emphasizes face-to-face engagement, physical incentives, and community-driven initiatives.

While the Online and Offline Schemes operate independently, their integration offers a holistic approach to promoting the use of reusable containers. The Online Scheme provides a scalable and data-driven method for tracking and rewarding sustainable behaviors, while the Offline Scheme enhances personal engagement and community involvement.

2.5 Combined Benefits:

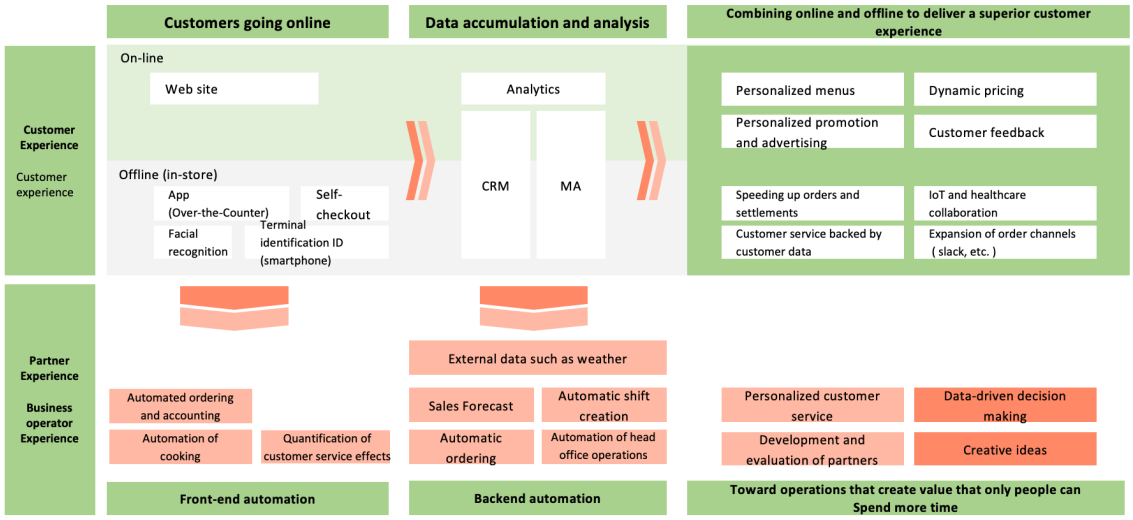

Fig.1 Online to Offline Scheme

- Customer Incentives: Shops implement physical incentive mechanisms such as loyalty point schemes. Customers who bring their own containers or participate in sustainable practices receive immediate rewards at the point of sale.
- Community Engagement: Offline initiatives include in-store promotions, educational workshops, and community events that highlight the benefits of reusable containers. Beverage shops collaborate with local organizations to promote sustainability and foster a culture of environmental responsibility.
- Feedback and Improvement: Beverage shops receive feedback through customer interactions, in-store surveys, and community forums. This feedback helps shops refine their practices and address any challenges encountered. The offline scheme also includes periodic reviews and audits to ensure compliance and measure effectiveness.

2.4 Integration and Synergies

- **Enhanced Reach**: The Online Scheme broadens the scope of engagement through digital channels, while the Offline Scheme strengthens local connections and direct interactions with customers.
- **Comprehensive Data**: The integration of online and offline data provides a more complete picture of the impact of the scoring system, facilitating better decision-making and policy adjustments.
- **Increased Motivation**: Combining digital rewards with physical incentives maximizes motivation for both beverage shops and customers, leading to more significant behavior changes and environmental benefits.

3. METHODOLOGY

3.1 Platform Mechanism

This sales support system consists of user terminals and a server device. The user terminal displays store information for multiple locations where beverages can

be purchased and has the function of sending purchase requests based on the user's operation. The server device is responsible for receiving purchase requests, processing payments, and assigning environmental scores （Japan, Patent #7280601).

In the context of this study, Scope 3 emissions are considered within the framework of carbon credit trading and emissions trading schemes involving tokens. The focus is specifically on the boundary defined in Table 1. This study does not address Scope 3 emissions beyond this boundary but explores how emissions within this scope can be managed and potentially offset through carbon credits and token-based trading mechanisms.

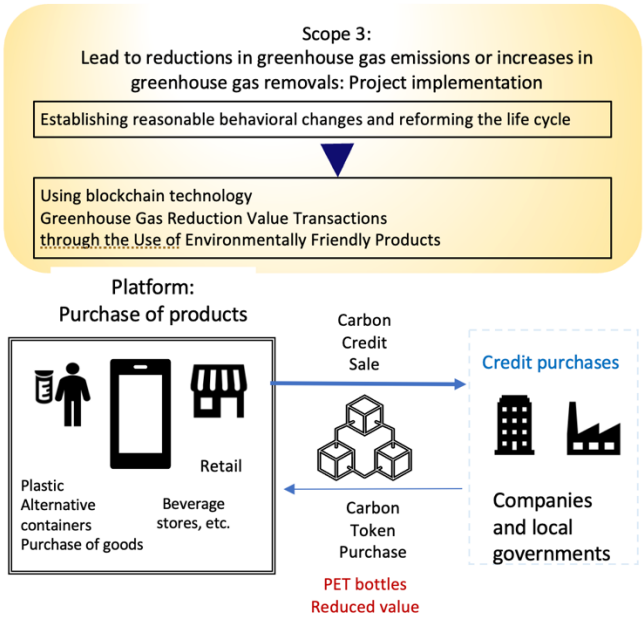

Fig.2 Use Case Boundary

3.2 Store Display Method

The store display method of the user terminal shows nearby store information in either a map or list format. The displayed information includes the store's location, operating hours, types of beverages available, and prices. Furthermore, the store display method has a mechanism that adjusts the display frequency and ranking according to the environmental score, prioritizing the display of eco-friendly stores. This allows environmentally conscious users to easily choose eco-friendly stores, thereby contributing to global warming prevention efforts.

[2]

Fig.3 User Interface

3.3 Purchase Request Transmission and Reception Methods

When a user sends a request to purchase a beverage from a specific store, the purchase request transmission method on the user terminal sends this information to the server device. The purchase request reception method of the server device processes the received request and notifies the corresponding store.

3.4 Payment Execution Method

The payment execution method on the server device processes the payment based on the user's payment information upon receiving a purchase request. Once the payment is completed, a notification is sent to the user terminal, and the user can then pick up the beverage at the store.

3.5 Scoring Method

The server device assigns an environmental score based on the number, volume, and type of beverages sold by each store. The environmental score is an indicator that reflects the use of reusable containers and the effectiveness of recycling activities, thereby evaluating environmentally conscious stores. By increasing their environmental score, a store's display priority is enhanced, leading to a higher evaluation of stores that actively engage in global warming prevention efforts.

4. Formulas and Parameters for CO_2 Quantification

4.1 Method for Calculating CO_2 Emissions

[2] Ministry of Economy, Trade and Industry, Japan, 2023: Retrieved by P8-15,15, 32, https://www.meti.go.jp/shingikai/energy_environment/carbon_footprint/pdf/20230331_2.pdf

To quantify CO_2 emissions, the following basic formula is used:

$$\text{CO2 Emissions} = \sum_{i=1}^{n} (E_i \times A_i)$$

- E_i the CO_2 emission rate for beverage i, which represents the amount of CO_2 emitted per unit (e.g., per bottle) of that beverage due to production and transportation.
- A_i is the number of units of beverage i sold.

The total CO_2 emissions for each beverage type are calculated by multiplying the CO_2 emission rate E_i by the quantity sold A_i. Summing this across all beverages gives the total CO_2 emissions for the system or platform in question.

This approach allows for a detailed breakdown of how different beverages contribute to overall CO_2 emissions, making it easier to identify where reductions can be made or how the environmental impact can be improved by adjusting the production, transportation, or sales of specific beverages.

4.2 Nudge Approach

The concept of this distribution systems to develop a transaction system using information dissemination (nudges) and conduct technical investigations by utilizing a transaction platform that has been socially implemented and commercially used to verify the promotion of voluntary countermeasures. The study aggregates detailed data on the alternative value of consumers using their own containers instead of the PET bottles or plastic cups they have traditionally used to carry beverages. In this context, the system visualizes transaction information for products that did not use plastic, such as when customers use their own containers (bottles or tumblers) instead of disposable cups at coffee shops. It also assumes an environmental score. By setting this environmental score, it becomes possible to add environmental awareness to loyalty program points and integrate them into a database. Furthermore, by collecting, analyzing, and personalizing transaction information, the system can provide feedback, which not only supports customer promotions but also encourages sustained behavior. This approach promotes voluntary carbon-reducing behavioral changes.

The development will be carried out by referring to and considering checklist-type frameworks such as the Behavioral Insights Team's "MINDSPACE" and Thaler and Sunstein's "NUDGES."[3]

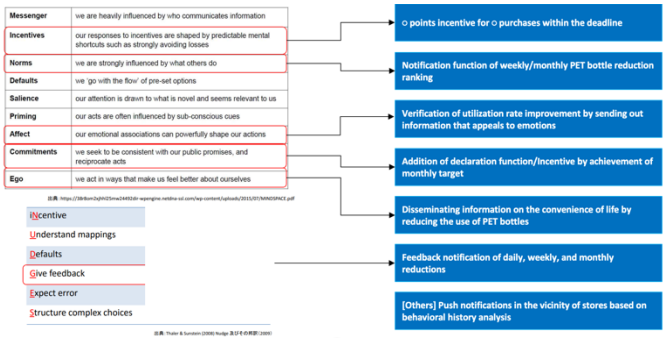

Fig.4 Nudge-based Model

5. EXPERIMENTS

5.1 Basic Concept for Calculating Base Unit of CO_2

Since this scoring system can be utilized in actual stores, we tested the system's effectiveness in real stores and observed its impact on *CO_2* reduction and user behavior. The focus here is to consider a model that specifically demonstrates how much the use of reusable containers contributes to climate change mitigation.

The reduction in carbon dioxide emissions was estimated using the base unit provided by the Japanese Ministry of the Environment and its underlying principles. This estimation considers the reduction achieved when beverages are served in bottles or containers brought by consumers instead of using plastic cups at the store.

Basic Concept for Calculating Base Unit (Ministry of the Environment Waste Management and Recycling Department Planning Division, Office for the Promotion of a Circular Society)

- The 3R (Reduce, Reuse, Recycle) effect per beverage sale in a consumer's reusable bottle is calculated.

[3] R. Thaler, C. Sunstein, Yale University Press, 2008, Nudge: Improving Decisions about Health, Wealth, and Happiness

- The disposable container that was not used due to the use of a reusable bottle is assumed to be a 350ml paper cup (with a lid), with a weight of 15.3g, based on literature values.
- Since the reusable bottle can be used repeatedly, the environmental impact during its production is not considered, but the environmental impact during washing is considered.
- The amount of natural resources saved is assumed to be equal to the weight of the disposable container that was not used.
- The amount of waste generated is assumed to be reduced by the weight of the disposable container that was not used.
- It is assumed that all disposable containers that are discarded are incinerated.
- The amount of carbon dioxide emissions reduced is assumed to be equal to the emissions that would have been generated from the extraction of raw materials, manufacturing, transportation, and waste disposal of the disposable containers that were not used.
- The weight of the unused disposable container can be adjusted at the discretion of the inputter.

	Plastic Cup (iced)	Paper Cup (hot)	Difference
Reduction in natural resources (crude oil equivalent) (g)	7.34	5.10	2.25
Reduction in waste generation (g)	6.22	1.81	4.41
CO2 reduction (g-CO2)	32.83	14.26	18.58

Tab.1 CO_2 Saving per Type of Cups

(Source: Ministry of Environment, Japan: 3R (reuse, reduce, recycle) Standard Rate)

5.2 Purpose of Modeling

General environmental behavior points are typically aimed at marketing purposes, where the focus is on reward programs with monetary value targeting individual purchases. However, this scoring system offers a more refined approach by allocating points based on the quantity of beverage (ml) provided by stores in containers brought by consumers, thereby aligning the CO_2 reduction metrics with the standards set by the Ministry of the Environment. This allows for a more detailed database at the retail level.

Typically, when selling iced takeout beverages, stores provide plastic cups with straws and lids, while hot drinks are served in paper cups with lids. The author noted that the 3R unit standards set by the Ministry of the Environment clearly distinguish the CO2 reduction potential between these different types of cups. The reductions are as follows:

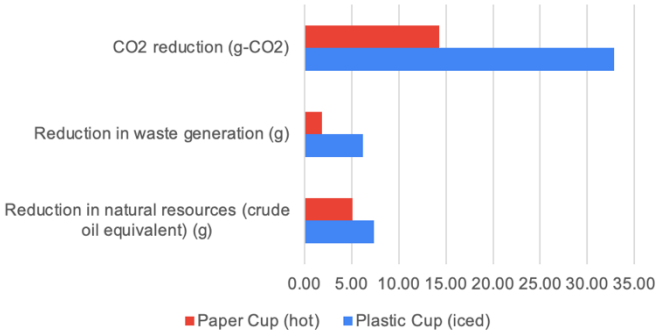

Fig.5 Social Impact Volume

(Source: Ministry of Environment, Japan: 3R (reuse, reduce, recycle) Standard Rate)

As shown, even the choice of disposable containers used for beverages can lead to differences in CO_2 emissions. By using the system developed in this study, beverage sellers can not only promote "bring your bottle" campaigns but also gain insights into the CO_2 emissions associated with different types of disposable containers based on the volume of beverages served.

According to a private survey, the most common frequency for people to purchase coffee from shops (in this case, convenience stores) is 2-3 times per week. If we simulate a scenario with 10,000 people, 3,000 of them would buy coffee using disposable cups three times a week. Over a year, this amounts to 144 times, and we can also calculate the total volume assuming 250 ml per cup.

	Plastic Cup (iced)	Paper Cup (hot)	Difference
Reduction in natural resources (crude oil equivalent) (g)	7344000	5097600	2246400
Reduction in waste generation (g)	6220800	1814400	4406400
CO2 reduction (g-CO2)	32832000	14256000	18576000
Ton Conversion	32.832	14.256	18.576

Tab.2 CO2 Saving per Type of Cups (Ton)

(Source: Ministry of Environment, Japan: 3R (reuse, reduce, recycle) Standard Rate)

Furthermore, if 9,000 people start using their own containers to buy coffee over the course of a year, it

would contribute to a reduction of 32 tons of CO_2. Considering that there are approximately 7,600 convenience stores, even if we consider half of them to be in urban areas of Tokyo, the CO_2 reduction effect would be 243,200 tons (3,600 stores × 32 tons).

5.3 Proof of Concept Model

When considering the CO_2 emissions per PET bottle on an LCA basis, the following settings can be considered.

- Target Area: Minato-ku, Tokyo, Japan (office district)
- Target Stores**:** beverage shop (café) exclusively for reusable bottles
- Evaluation Indicators: CO_2 reduction amount based on the Ministry of the Environment's 3R base unit, amount of reusable container usage

In designing this scoring system, hypothetical calculations were conducted to achieve certain benchmark values based on the Ministry of the Environment's 3R base unit.[4]

Conditions

1. Two takeout-only coffee shops that allow customers to bring their own bottles.
2. Central business district.

Demonstration Period: 4 months including a 1-month incentive campaign

Incentive: one (1) additional beverage per purchase and free reusable container for the first purchase

Results: Reduction from the base unit: 3,708 kg/CO_2

During a four-month trial period, a one-month campaign was conducted, but due to the closure of the store for one week due to the tenant building's circumstances, the actual trial period was just over three months. This trial was carried out at two locations in Minato Ward, a neighboring area. These stores were in office districts with high convenience, directly connected to the train station. The locations were particularly favorable for office workers to easily stop by in the mornings and afternoons with their own containers.

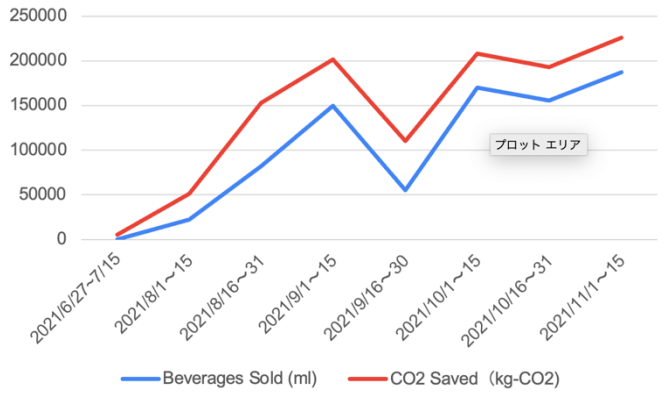

Fig.6 CO_2 Saved (kg-CO_2) for Shop A

The results show a reduction from the base unit: 3,708 kg/CO_2, allowing the shop owners to quantitatively understand how much CO_2 was reduced based on the store's sales volume. Furthermore, the effectiveness of the campaign as a consumer-targeted appeal was clearly demonstrated. As seen in the data, there was a noticeable drop in usage after the campaign, indicating that continuous promotion is necessary to balance environmental impact and consumer engagement.

6. CONCLUSIONS

The escalating environmental impact of single-use plastics, particularly in beverage distribution, has prompted significant interest in developing and implementing sustainable alternatives. Plastic-free solutions, such as reusable containers and innovative packaging, have emerged as crucial components in the quest to reduce plastic waste and mitigate CO_2 emissions. However, the effectiveness of these solutions can be influenced by a variety of factors, including behavioral incentives and economic considerations.

One effective strategy to promote environmental sustainability is the implementation of "Pay-As-You-Throw" (PAYT) systems, which impose financial costs on the disposal of unsorted waste. PAYT schemes aim to encourage waste reduction and sorting by directly

[4] (Reference: Ministry of the Environment 3R Base Calculation, p. 83-87, 2004 Report on Life Cycle Assessment for Containers and Packaging, Ministry of the Environment, Contractor: Policy Research Institute Foundation, p. 62)

linking waste generation to cost. Conversely, non-monetary incentives, such as "Don't throw away" (DtD) campaigns, focus on fostering intrinsic motivation and behavioral changes through environmental awareness and education.

In the context of plastic-free beverage distribution, understanding this dynamic is essential for designing interventions that not only reduce plastic usage but also align with consumers' intrinsic motivations. This paper seeks to explore how various incentives - both monetary and non-monetary - affect the adoption and effectiveness of plastic-free distribution methods. By leveraging data-driven insights, this research aims to assess the impact of different incentive structures on consumer behavior and environmental outcomes, ultimately contributing to more effective and sustainable strategies for beverage distribution.

In summary, this study aims to bridge the gap between economic theories and practical applications in the context of environmental sustainability, with a particular emphasis on Scope 3 emissions. It will provide valuable insights into how integrated incentive systems can be optimized to promote the adoption of plastic-free alternatives and enhance the overall effectiveness of environmental policies. By focusing on Scope 3 emissions within the framework of carbon credit trading and token-based emissions trading schemes, this study proposes a targeted system to address these specific elements and drive more sustainable practices.

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