

Ban Ki-moon Foundation + Daejayon

Climate Environmental Leader
Training Course

Proposals from Future Generations for a Net-Zero Future

Foreword

Proposals for the Future: Action Brings Hope

Today, humanity faces unprecedented challenges as a result of the climate crisis.

Indeed, historic heatwaves, wildfires, droughts, and floods are hitting every corner of the world with unprecedented intensity, scale, and frequency. This multifaceted crisis not only impacts our environment, but our economies, societies, and international peace and security.

As such, climate action is no longer a choice, but an obligation, and it has become the most urgent task in order to construct a sustainable future for all.

No single country can solve the climate crisis on its own, and no sustainable future can be expected without elevated solidarity and cooperation within the international community. Guided by this shared conviction, I, as Secretary-General of the United Nations, proudly led the adoption of the Sustainable Development Goals (SDGs) and the signing of the Paris Climate Change Agreement in 2015—historic milestones in humanity's collective commitment to take concrete action.

At the very heart of this journey lies the crucial role of future generations. Universities, above all, must be more than mere spaces for generating new knowledge and technology; they must serve as cradles of social innovation, where the great challenges of our time are identified and solutions are duly proposed.

Students at the center of these institutions must grow into climate leaders who drive a sustainable society through creative thinking and open collaboration.

With this conviction, the Ban Ki-moon Foundation and Daejayon have operated the Youth Climate Environmental Leadership Program since 2022.

The passion and engagement demonstrated by the dynamic students across the past eight cohorts have far exceeded our original expectations.

This publication, 『Outstanding Proposals by Youth Climate Environmental Leaders Vol. 2』, compiles the exemplary proposals selected from the 6th to 8th cohorts, and is presented in both Korean and English.



This volume is far more than a collection of outstanding ideas; it is a testament to how future generations are responding to the climate crisis, and a valuable asset of shared knowledge and experience for our society and global community.

In the face of the climate crisis before us, no one can move forward alone. Governments, businesses, academia, and civil society—together with cities, local communities, and future generations—must build mutual trust and all act in cooperation and partnership.

The solidarity gained as the world's youth share wisdom and experience to act together will be the most powerful force in establishing a sustainable future.

However, a safer, equitable, and more sustainable future will not arrive on its own.

The future is forged by the responsible choices and actions we take today.

I sincerely hope that the wisdom and insights of the climate environmental leaders contained in these proposals will serve as a beacon of hope in overcoming the climate crisis and a force that accelerates a better world for all.

Thank you.

Ban Ki-moon

8th Secretary-General of the United Nations
Chairman, Ban Ki-moon Foundation for a Better Future

Proposals from Future Generations for a Net-Zero Future

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CONTENTS

NO	Keyword	Suggested topic	Proposer	Page
6th	1 Resource Circulation	Eco-friendly Shopping Bags	Ahn Hye-ju / Jeonbuk National University Jeonju Campus	9
	2 Energy	Government-led Consortiums for Hydrogen Transport Technology	Kim Gang-hyeon / POSTECH	21
	3 Green City	Transportation Solutions for Green Cities	Ahn Ye-bin / Sungshin Women's University	37
	4 Green City	Sustainable Ideas for Jeju's Environment and Tourism	Choi Ji-hyeon / Inha University	49
	5 Ecosystem	Carbon Absorption Methods through Blue Carbon and Ocean Forest Creation	Kim Seon-bin / Seoul National University	59
	6 Agriculture	Low Carbon Training for Young Farmers	Hwang Jin-wuk / Kyungpook National University	65
	7 Food	Environmental Protection through Life Cycle Assessment for Food Products	Song Su-min / Mason Korea	77
7th	1 Platform	A Net Zero Journey Starting with a Single Receipt	Go Ha-nim / Kyung Hee University	91
	2 Resource Circulation	A Convenience Store-Based Used Battery Collection and Carbon Point System for Sustainable Development	Kim Tae-gyu / Pusan National University	101
	3 Policy Proposal	Illegal Burning: Heating Rural Communities and the Planet	Kim Ha-eun / Jeonbuk National University	115

NO		Keyword	Suggested topic	Proposer	Page
7th	4	Marketing	Green Marketing 2.0: Rethinking Advertising Language	Yang Ji-min / Hankuk University of Foreign Studies (Seoul)	125
	5	Resource Circulation	Reducing Carbon Emissions through Lower Ink Usage in Cans	Seo Myung-hoon / Kangnam University	135
	6	Platform	A Carbon-Neutral Thermal Platform Utilizing Subway Station Waste Heat	Lee Yeon-woo / University of Seoul	143
	7	International Cooperation	Policy Recommendations for Eco-Tourism Development Cooperation in Southeast Asia	Lee In-hye / Seoul National University	155
8th	1	Policy	Beyond Overconsumption and Carbon Colonialism: A New Model – CPCJ Framework	Park Si-yeon / Sookmyung Women's University	169
	2	Green Campus	Weather Data-Based Campus Energy Demand Forecasting System	Jung Ji-woon / Inha University	177
	3	Energy	Green Shore Power Supply Policy for Eco-Friendly Vessels	Park Ho-jin / Korea Maritime and Ocean University	187
	4	Air Pollution	Eco-Friendly Fleet Rating System for Heavy-Duty Trucks	Shin Min-kyu / Dong-A University	199
	5	Economics	Eco Money Report	Choi Ha-jin / Gachon University	209
	6	Recycling	Phasing Out Thermal Recycling of Plastics	Lee Yeon-seon / Ewha Womans University	217
	7	Policy	Expanding the Emissions Trading System Target to Scope 3	Kim Tae-min / Chonnam National University (Gwangju)	225

Proposals from Future Generations for a Net-Zero Future

6th Cohort Proposal Collection



6th

Resource Circulation	Eco-friendly Shopping Bags	09
	----- Ahn Hye-ju / Jeonbuk National University Jeonju Campus	
Energy	Government-led Consortiums for Hydrogen Transport Technology	21
	----- Kim Gang-hyeon / POSTECH	
Green City	Transportation Solutions for Green Cities	37
	----- Ahn Ye-bin / Sungshin Women's University	
Green City	Sustainable Ideas for Jeju's Environment and Tourism	49
	----- Choi Ji-hyeon / Inha University	
Ecosystem	Carbon Absorption Methods through Blue Carbon and Ocean Forest Creation	59
	----- Kim Seon-bin / Seoul National University	
Agriculture	Low Carbon Training for Young Farmers	65
	----- Hwang Jin-wuk / Kyungpook National University	
Food	Environmental Protection through Life Cycle Assessment for Food Products	77
	----- Song Su-min / Mason Korea	

I Introduction

- a. Recognition of Climate and Environmental Crisis
- b. Increase in Tree Consumption due to Plastic Alternatives
- c. Whether the Issue is Solvable
- d. Problem Recognition and Limitations of Department Store Shopping Bags

I Main Body | Proposal for Achieving Net-Zero for Single-Use Items (Shopping Bags)

- a. Proposal and Targets
- b. Implementation Plan
- c. Implementation Goals
- d. SWOT Analysis

I Conclusion and Recommendations for Future Development

I References and Sources

Resource Circulation

01

Ahn Hye-ju / Jeonbuk National University Jeonju Campus

Eco-friendly Shopping Bags

고가품 판매장으로,
상품에 비해 쇼핑백 단가의 부담 적음



주도적 넷제로의 선행

대기업, 백화점의 주도적 실행
마케팅 전략으로 이용하여 이미지 상승

Abstract

This proposal introduces a "Eco-Circular Shopping Bag" to replace existing shopping bags as a practical measure for carbon neutrality by decreasing paper consumption and reducing deforestation. Made from natural ingredients such as elephant dung, horse manure, and straw, the eco-circular shopping bag serves as an eco-friendly alternative that possesses sufficient durability while minimizing tree consumption. This enables the simultaneous achievement of two core goals: maintaining utility as a shopping bag and practicing carbon neutrality. Furthermore, it yields substantial brand image benefits for corporate and national Net-Zero commitment images.

| Introduction

a. Recognition of Climate and Environmental Crisis

We live in an era of climate and environmental crisis. Even up until the 2010s, awareness was growing around agricultural shifts and food shortages induced by global warming, prompting vigorous "Save the Trees" environmental campaigns. Only 15 years have passed since then; despite a multitude of global initiatives, Earth's rotational axis has tilted further. Scientists point out that we have moved past global warming into global heating, and are now fast approaching an era of "Global Boiling".

In July 2023, UN Secretary-General António Guterres issued a stark warning following analyses indicating that the month would be the hottest in human history, emphasizing that "the era of global warming has ended; the era of global boiling has arrived," and that "it is just the beginning". He added that "G20 nations—responsible for 80 percent of global emissions—must step up for climate action and climate justice". The Earth's tilted axis can be easily conceptualized by imagining a spinning top that has lost its balance. Much like a top that could collapse and cease spinning at any moment, the Earth is tilting to a degree where rotational anomalies would no longer be surprising. What, then, can be done to resolve this?

The international target is Net-Zero, which means carbon neutrality. This means moving beyond merely reducing emissions to achieving a true zero balance in global net emissions by leveraging trees and carbon sinks to secure genuine sustainability. Certain amounts of carbon emissions are inevitable in daily life; vegetation and trees that absorb these emissions serve as the primary solution to achieve neutrality. Therefore, efforts to conserve and plant trees must remain unceasing, and it is vital to source viable alternatives for products that rely on wood.

b. Increase in Tree Consumption due to Plastic Alternatives

In the early 2010s, public restrooms ran campaigns urging citizens to use hand dryers instead of paper towels to protect trees. Alongside this, various campaigns aimed at lowering paper usage—such as saving paper, utilizing scrap paper, and repurposing old newspapers—were actively promoted. Yet at some point, paper towels resurfaced, accompanied by a wave of criticism pointing out the inherent limitations of campaigns single-mindedly focused on paper reduction. For instance, looking at the electricity consumed by hand dryers through the lens of carbon neutrality, one must question whether mechanical dryers are truly the ideal answer. In other words, critics argue that we must weigh the carbon emissions from powering high-wattage hand dryers against those from logging timber and processing pulp.

"내가 친환경적이지 않다?"...트럼프도 등 돌린 '종이빨대'의 해명

머니투데이 | 김성진 기자

2025.02.11 10:44



[MT리포트-무너지는 종이빨대 산업] 보도 후 댓글들/그레픽=이치예

도널드 트럼프 미국 대통령이 10일(현지시간) 플라스틱 빨대로 회귀하는 행정명령에 서명했다. 2035년까지 연방 정부 내 어떤 플라스틱이든 사용을 단계적으로 폐지한다는 바이든 행정부의 계획을 뒤집는 것이다. 트럼프 대통령은 종이빨대가 '말도 안된다', "(친환경) 효과가 없다"고 주장한 다.

머니투데이가 지난 8일 'MT리포트-무너지는 종이빨대 산업' 기획을 보도한 후에도 '종이빨대가 사실 친환경적이지 않다'는 반응이 적지 않았다. 종이를 생산하는 과정에서 나무를 사용하는 등 다양한 측면에선 이런 지적이 사실에 부합하지만, 또 오해의 여지도 있다. 종이빨대를 둘러싼 오해에 대해 자세히 들여다보다.



네 자매, 40년간 같은 사진을 찍다. 마지막 사진을 보면 눈물을 참을 ...
House and Garden

N 네이버에서 머니투데이뉴스 보기

다음언론사홈에서 머니투데이구독

실시간 급상승 3.5초

- ▼ 故서희원 유산 800억, 전 남편 손에...전모 550
- 28 "싸울 힘 없어, 기자가"
- ▼ 2억 집에 냉장고 선택가 '물음찬'...집주인 397
- 2 은 LG '공간' 파는 이유
- ▼ 왜진색은 생황고 왜...박정수 "예능 보고 296
- 65 오해, 연애인 빚 금방 갚았
- ▼ "개학 한 달 미뤄요" 등교 나을 앞 '날레 290
- 26 라"...복싱조에 무슨 일이
- ▼ '옛날 구 마의 보물 지도' "진짜 장난이 제"

Coinciding with this period, microplastics emerged as a dominant environmental slogan, highlighting how microplastic pollution degrades marine ecosystems and ultimately endangers human health through the food chain. The issue of single-use, easily discarded straws became the poster child for the microplastic crisis, drawing intense scrutiny from environmental scientists. Paper straws were proposed as a primary substitute, along with alternatives using hollow plants like barley stalks, which are currently being utilized to a minor degree.

To address the microplastic issue, global initiatives have pushed for paper shopping bags, paper straws, eco-friendly biodegradable bags, and paper packaging as plastic substitutes. It is noteworthy that these products, classified as eco-friendly, are predominantly made of paper. Paper and wood-based materials are widely available alternatives to plastic, represents a natural material, decomposes swiftly, and can be beneficially reintegrated into natural soil. However, opinions remain deeply divided on whether paper is truly an eco-friendly material capable of replacing plastic when taking into account the trees logged for production, water pollution, and intensive energy consumption during the paper manufacturing process. members of the MZ generation

It is based on this very perspective that US President Donald Trump signed an executive order on February 10 to roll back restrictions in favor of plastic straws. President Trump claimed that paper straws are "ridiculous" and "do not work." Domestic scholars also raise

issues regarding their utility, stating that "paper straws cannot be made from recycled waste paper because they would lack sufficient structural strength," and citing a 2022 US Environmental Protection Agency (EPA) report which analyzed that paper manufacturing emits five times more carbon dioxide than producing polypropylene (PP), the raw material for plastic straws. Consequently, while trees are planted on one side to thwart desertification, vast forests are cleared on the other under the banner of environmental eco-friendliness. Bearing in mind our goal to delay the climate crisis and leave a clean environment for future generations, we must look beyond timber and focus greater attention on discovering diverse eco-friendly materials. Simultaneously reducing carbon emissions while conserving natural components that absorb carbon is paramount.

c. Is This a Solvable Issue?

Questions may arise as to whether it is feasible to simultaneously curb paper production while reducing plastic output. We must ponder whether protecting nature is achievable while maintaining our daily lifestyles, and whether production and consumption can proceed sustainably without compromising consumer satisfaction in an advanced modern era. For a genuine Net-Zero framework, looking into the lives of our ancestors reveals the profound wisdom of obtaining materials easily from nature and returning them to nature. Developing fundamental methods that allow modern citizens to embrace and adapt to this wisdom without undue burden is critical.

Even if a solution is engineered, is it realistically executable? It becomes viable if policies and enterprises move in tandem; policy is what dictates the production and consumption patterns of corporations and citizens. When policy introduces actionable, practical measures, businesses and consumers comply—as demonstrated by paper straw legislation. Yet even if bills pass, execution often falls short; while the paper straw mandate drove some plastic straw manufacturers out of business, paper straws failed to firmly settle in the market. Nevertheless, the initiative did launch and gained widespread awareness, with certain franchises continuing its execution. That said, due to unaddressed quality flaws and a lack of support for stable corporate implementation, many establishments are reverting to plastic straws.

Based on this, the primary hurdles to successfully transitioning to novel eco-friendly materials lie in the adoption phase, friction during implementation, and public perception. While law and policy initiate the process, smooth execution and market consolidation remain the responsibility of corporations and citizens. Let us consider one more dimension alongside this. The state likely anticipated the negative impacts on plastic factories, and anyone who has used a paper straw would be familiar with its operational pitfalls. Despite clear financial deficits and legislative complexities, the policy was executed anyway. This was achievable because environmental concerns are now widely felt, and when the

government takes the lead, both businesses and the public tend to follow. Therefore, an effective Net-Zero action plan must be formulated to simultaneously satisfy and engage environment-conscious citizens, the government, and corporations. To transcend these inherent limitations, a concrete proposal is hereby put forward.

d. Problem Recognition and Limitations of Department Store Shopping Bags

Taking the above points into consideration, it is necessary to highlight the Net-Zero limitations arising from logging for paper consumption. A practical method that simultaneously raises international awareness involves converting the materials of single-use department store shopping bags into eco-friendly alternatives. Early adoption by major corporations will catalyze public perception. Bringing personal bags for shopping remains the most desirable approach. However, given that consumers often enter department stores without knowing how much they will purchase or whether they will buy at all, planned shopping trips with personal bags are relatively uncommon. Hence, providing low-cost disposable shopping bags can be considered essential when prioritizing operational efficiency and consumer convenience.

Is there a mechanism that can satisfy corporate interests, consumer satisfaction, and state Net-Zero objectives all at once? Convenience stores have deployed biodegradable plastic bags made from cornstarch, while supermarkets rely on standard prepaid municipal waste bags. Turning to department stores, they routinely hand out thick, plastic-coated shopping bags or large-sized thin paper bags. Many consumers have experienced purchasing a thin, non-coated paper bag for 100 KRW, only for it to rip instantly, forcing them to buy another thick bag for 100 KRW at the next store to repack their items.

To craft a carbon neutrality proposal centered on shopping bags, I focused on two features of current practices. First, shopping bags used by department stores are typically high-quality but coated with vinyl, making recycling impossible and forcing them into landfills as general waste. Second, government policy mandates a flat fee of 100 KRW regardless of bag size or material, which exerts virtually no influence on reducing shopping bag consumption. Although retailers supply bags at prices below cost, product profit margins remain their priority, and they invest heavily in bag aesthetics. From a corporate standpoint, avoiding customer complaints stemming from a thin, uncoated bag tearing and damaging goods naturally takes precedence.

On another note, it is increasingly common to see members of the MZ generation (young consumers in their 20s and 30s in Korea) carrying branded shopping bags as everyday accessories instead of traditional purses. As one youth in their 20s remarked, "Carrying a specific brand's paper bag makes me feel like I am participating in the meaningful, value-

driven activities that the brand pursues," underscoring the strong correlation between corporate branding and shopping bag utility.



| Main Body | Proposal for Achieving Net-Zero for Single-Use Items (Shopping Bags)

We must rethink the automatic assumption that all paper products are inherently eco-friendly, creating an impetus to seek out genuine environmental alternatives. To accomplish this, we must showcase practical products to reshape public awareness and promote change via active public relations. Accordingly, a consumption proposal that minimizes ecological damage is introduced: substituting department store shopping bags with rapidly circulating, highly eco-friendly alternatives.

a. Proposal and Targets

The Eco-Circular Shopping Bag represents an innovative substitute designed to surpass the structural and ecological boundaries of conventional paper bags. To this end, This study proposes the eco-circular shopping bag concept to department stores and the government, outlining the specific bag types for implementation below.

a-1. Specific Options for Department Store Shopping Bags

► Option 1) Elephant Dung Paper Shopping Bag

Elephants consume fiber-rich food for up to 18 hours a day, and because they do not

ruminate, half of their nutrient intake is excreted undigested. Since approximately 20% of their dung consists of pure plant fibers, it can easily serve as raw material for paper pulp. To briefly describe the manufacturing process, the dung is dried, boiled in large cauldrons to form a "pulp slurry," and then flattened and dried. Processing elephant dung into paper in this manner can spare an estimated 240 trees per ton of production according to some statistics. Despite being thoroughly eco-friendly, three primary factors hinder the widespread adoption of elephant dung paper: First, it carries a strong unhygienic connotation due to its source. However, because it undergoes meticulous washing that renders it completely odorless, and only utilizes the undigested straw within the dung, targeted public relations can shift this perception. Second, it is roughly 10 times more expensive than standard A4 paper. Third, due to the negligible elephant population in South Korea, the raw material or paper must be imported. Accounting for these shortcomings, the next option is presented.

► Option 2) Strawboard (Mabunji) Shopping Bag

The etymology of Mabunji originates from the Hanja characters for horse (馬), dung (糞), and paper (紙), though dictionary definitions classify it as paper manufactured from straw. Historically, it was produced using the undigested fibers left in horse manure as the primary ingredient, mixed with various additives. While not a premium paper grade, its thick texture prevents tearing, making its eco-friendly attributes worthy of attention. Modern strawboard (Mabunji), however, refers to paper made primarily from straw rather than actual horse manure. This demonstrates that high-utility paper can be produced using horse manure and straw.

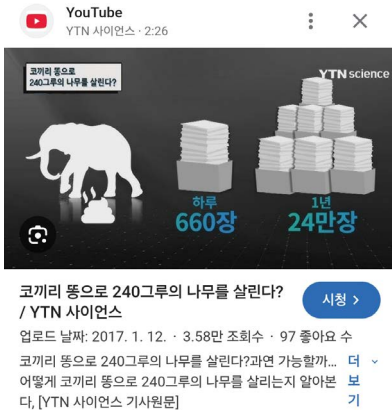
► Final Proposal) "Sangma" Shopping Bag

The final configuration proposes fabricating shopping bags using a blend of straw-based, horse-dung, and elephant-dung papers. I propose naming this collective lineup the "Sangma Shopping Bag," derived from the characters for elephant (Sang) and horse (Ma) to transparently communicate the raw materials and foster market adoption. While the primary components include elephant dung, horse dung, and straw, strawboard-based bags are expected to form the bulk of the volume. On this basis, the Sangma Shopping Bag is proposed to department stores to curb wood pulp consumption.

a-2. Proposal Target Institutions

► Target 1) Department Stores

Because department stores retail relatively high-priced merchandise, they can absorb higher shopping bag unit costs with minimal financial strain. Furthermore, corporate-led Net-Zero initiatives can serve as powerful marketing strategies, generating substantial



positive returns through heightened brand prestige. The exceptional durability of Sangma bags allows for multiple reuses, reinforcing a genuinely green corporate identity. Consumers will also derive a sense of ethical pride by participating directly in environmental conservation through their purchases. Additionally, affluent demographics who frequent department stores are often highly receptive to and proactive about addressing environmental issues. High foot traffic in department stores will also accelerate the evolution of public civic awareness. While

big-box discount supermarkets could be considered, they primarily handle groceries, making it difficult to overcome psychological resistance regarding animal dung. Moreover, demographics aged 10–30, who are highly active on social media and receptive to shifting perceptions, represent a higher proportion of department store shoppers compared to supermarkets. Supermarkets have already consolidated a culture of utilizing multi-use grocery bags or buying prepaid municipal trash bags. Conversely, department stores continue to rely heavily on branded signature bags, making them the optimal target for the Sangma bag rollout.

▶ Target 2) The Government

The government holds the mandate to reshape policy and enforce legislative frameworks. By revising disposable single-use item regulations for large-scale conglomerates, the government can spearhead the adoption of Sangma bags. Additionally, the government can establish granular carbon neutrality benchmarks and award incentives to exemplary enterprises.

b. Implementation Plan

The core implementation plan involves designating the "Sangma Paper Shopping Bag" as the mandatory standard for department stores. To firmly take root in consumer culture, the Sangma bag must be visually distinct from standard packaging and carry informational markers to elevate public awareness. The envisioned design features the integration of a signature Sangma emblem, a QR code, and a natural circulation symbol on the surface of the bag.



Individual retailer logos can be positioned at the center of the bag. Utilizing laser-etching instead of chemical inks would maximize its eco-friendly value.

The Sangma mark, conceptualized via the "Copilot" app, depicts the coexistence of a horse, an elephant, and straw fibers. The horse and elephant facing each other symbolize humanity confronting nature, while the strict black-and-white palette reflects a future that is far from certain. Scanning the QR code directs users to a landing page featuring details on Sangma bags, the environmental impacts of pulp consumption, global desertification metrics, international Net-Zero milestones, logo symbology, and actionable guidelines for eco-friendly daily consumer habits. These visual markers and barcodes will generate robust public relations outcomes. Given their corporate resources, department stores can smoothly manage marketing campaigns and promotional events to solidify the program. Furthermore, limited-edition shopping bags crafted entirely from elephant and horse dung paper can be introduced on World Environment Day to anchor Net-Zero awareness campaigns.

→ **Export Strategy:** Upon commercialization, the product can be positioned as a global standard for export under the English name "hoel bag" (derived from horse and elephant).

c. Implementation Goals

Systematic operational goals must be structured to guarantee the successful deployment of natural circulation bags. As an initial step, a pilot program should be launched across the top three department stores by market share (Lotte, Shinsegae, and Hyundai) before expanding nationwide. This will allow for data-driven adjustments based on consumer feedback and operational metrics before a full-scale rollout. Depending on initial market responses, retailers may offer a choice between standard bags and Sangma bags during the early implementation phase. To lower entry barriers, consumer uptake can be incentivized through point accumulations or additional retail discounts for choosing Sangma bags. Furthermore, reinforcing green marketing campaigns will refine consumer

perceptions and solidify a culture surrounding natural circulation products. The ultimate objective is to achieve comprehensive nationwide integration within 5 years, aligning strictly with international carbon neutrality timelines.

d. SWOT Analysis

The following details the SWOT analysis matrix mapping Strengths, Weaknesses, Opportunities, and Threats:

- **Strengths:** Natural circulation shopping bags are vastly superior in eco-friendliness to standard paper variants and align directly with global Net-Zero benchmarks. They can drastically minimize wood pulp consumption, thereby preserving the carbon sequestration capacity of standing forests. This positions the country favorably as an exemplary leader in international Net-Zero execution. It also offers a turnkey framework for corporations to implement ESG management in line with tightening global green trends. By sparking a critical re-evaluation of disposable manufacturing, this initiative will capture global attention and catalyze an innovation ecosystem dedicated to true Net-Zero solutions.
- **Weaknesses:** Production costs exceed those of standard paper packaging, and initial consumer aversion toward novel organic inputs (manure paper, strawboard) may manifest. Additionally, the current absence of robust, large-scale manufacturing infrastructure poses scaling difficulties during early rollout phases.
- **Opportunities:** The expanding global trend prioritizing green consumables offers fertile ground for the extensive deployment of natural circulation bags. While outright cessation of single-use items is ecologically ideal, outright legal bans restrict consumer freedom and commercial convenience. Therefore, engineering voluntary reductions is critical; adjusting the cost structure of Sangma bags between corporations and consumers can naturally taper demand while fostering long-term carbon neutrality cultures. Legislative frameworks that certify top carbon-neutral firms and award statutory benefits will significantly enhance efficacy. This would serve as an exemplary model for international carbon reduction policy and elevate state environmental standards.
- **Threats:** Developing new manufacturing loops involves high upfront capital investments and faces inevitable friction from entrenched legacy paper manufacturers. Low initial consumer awareness and baseline trust deficiencies could stymie rapid dissemination. Policy backing from the government remains absolutely essential, alongside long-term corporate vision; forging strategic alliances with strawboard manufacturing firms can optimize production integration.

- **Overcoming Weaknesses through Opportunities (WS Strategy):** Higher packaging costs can conversely operate as a structural deterrent that successfully curtails single-use item consumption. Furthermore, rising average living standards have expanded the market for value-driven, conscious consumerism. Imbuing Sangma bags with a premium ethical narrative and adequate durability can fully offset baseline consumer resistance.

| Conclusion and Recommendations for Future Development

While reducing plastic is critical for environmental preservation, we must confront the reality that current paper substitutes are not inherently sustainable. The Sangma natural circulation bag presented in this proposal addresses this by minimizing tree consumption, preserving commercial utility, and seamlessly returning to nature. To catalyze this, the government must enact statutory frameworks that incentivize organic material usage, and enterprises should proactively deploy Sangma bags to foster sustainable consumer ecosystems. Consumers can similarly drive the realization of carbon neutrality by adopting ethical procurement habits. In conclusion, the eco-circular shopping bag transcends mere packaging—it serves as a pivotal inflection point toward a sustainable future. Government, business, and civil society must act in unison to forge a genuinely green consumption paradigm.

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I. Introduction

II. Importance of Hydrogen Storage and Transport Technologies

- i. The Inevitability of Transitioning to Renewable Energy
- ii. Necessity and Potential of Hydrogen Storage and Transport Technologies

III. Technical Aspects of Hydrogen Storage and Transport

- i. Technical Aspects of Hydrogen Storage
- ii. Technical Aspects of Hydrogen Transport
- iii. Current Status of Hydrogen Storage and Transport Technologies

IV. Current Development Status of Hydrogen Storage and Transport Technologies in South Korea

V. Hydrogen Storage and Transport Technology Development Roadmap

- i. Embodiment of the Technology Development Roadmap
- ii. Structural Organization of the Technology Development Roadmap
- iii. Empirical Case Studies of Structural Organization

VI. Conclusion

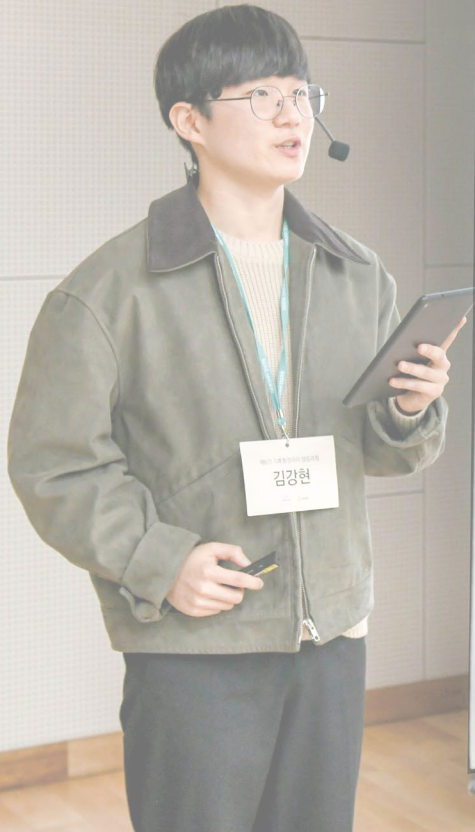
VII. References and Materials

Energy

02

Kim Gang-hyeon / POSTECH

Government-led Consortia for Hydrogen Transport Technology



수소 운반
기술의 중요성

Importance of H₂ tr
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명백한 기

기후 위기는 경
증명되었으며, 기후
로그 위기감

| Introduction

The climate crisis has arrived as an undeniable reality. Extreme weather events—such as torrential rains, heatwaves, heavy snowfalls, and typhoons—along with rising sea levels, are now directly threatening several nations. Despite this, global greenhouse gas emissions are not being drastically reduced. In fact, even pre-existing frameworks for transnational cooperation, such as the Paris Climate Change Agreement, are facing severe jeopardy.

The recent withdrawal of the United States from the Paris Climate Change Agreement demonstrates how the gravity of environmental crises is being overshadowed by nationalistic egoism. It further suggests that if the status quo persists, the probability of resolving the climate crisis through transnational cooperation remains low. However, the climate crisis, though currently obscured, will grow exponentially. By the time climate change becomes visible enough to pierce through nationalistic egoism, it will have escalated to an unmanageable level.

In a global climate where sacrifices or decisive commitments from individual nations can no longer be expected, the only viable solution to resolve the climate crisis is a fundamental transition of energy sources. Given that the inevitability of this transition is universally recognized, we must pursue transnational cooperation while establishing a clear vision for South Korea to spearhead the future of energy transition. Ultimately, transitioning energy sources will necessitate storage and transport in the form of green hydrogen. As detailed below, South Korea must strategically focus on hydrogen storage and transport technologies to lead the coming future.

| Importance of Hydrogen Storage and Transport Technologies

i. The Inevitability of Transitioning to Renewable Energy

When considering energy transition, the most readily apparent solution is the expansion of nuclear energy. Nuclear power is often cited as a compelling alternative because it offers a stable power supply with minimal greenhouse gas emissions. Indeed, efforts to expand nuclear power generation are visible in many countries, including the United States. South Korea has likewise refocused on nuclear energy, prompting a shift toward CF100 (Carbon Free 100) rather than RE100(Renewable Energy 100). However, when analyzed from the perspective of high-level radioactive waste management, whether nuclear fission can serve as a permanent solution remains highly questionable. Currently, used nuclear fuel is

only temporarily stored within nuclear power plants. Even in "nuclear-advanced nations" such as the U.S., France, and Japan, permanent underground disposal facilities have not even entered the site-selection phase. For South Korea, temporary storage facilities are projected to reach full capacity starting with the Hanbit Nuclear Power Plant in 2030. Given this timeline, the current surge of interest in nuclear power should be understood as a transitional phenomenon—a stopgap measure while renewable energy technologies mature to a commercially viable level.

Another factor reinforcing the inevitability of transitioning to renewable energy is the variation in national capacity for renewable energy production. Because renewable energy relies heavily on geographic factors such as solar irradiance and hydrology, inherent advantages and disadvantages exist by country. Looking at solar power, a representative renewable energy source, it is evident that European nations, South Korea, and Japan are at a severe geographical disadvantage. <Refer to Figure 1> When incorporating hydropower capacities—where countries like Canada and Northern Europe excel—and factoring in the total land area available for renewable power generation, South Korea and Japan emerge as among the most geographically disadvantaged nations in the world. .

While green policies and energy transitions are superficially framed as altruistic global efforts toward sustainable development, a fierce undercurrent of geopolitical hegemony for the post-energy-transition era is actively at play. Ultimately, the mandatory nature of renewable energy will manifest as an economic reality through trade barriers. We must recognize that if a renewable energy-based industrial structure were strictly enforced today, South Korea would be among the hardest-hit nations on Earth.

In contrast, many Western European countries recognized their geographical limitations early on and have established mechanisms to import hydrogen produced via renewable energy by land. In fact, they are currently executing a plan to upgrade and partially expand existing natural gas pipelines by 2040 to complete a comprehensive hydrogen import infrastructure. This global trajectory further proves that immediate preparation for the renewable energy transition is imperative.

ii. Necessity and Potential of Hydrogen Storage and Transport Technologies

To minimize these latent trade barriers, increasing generation efficiency through renewable energy production technology is important. However, as a means to overcome inherent domestic limitations, we must place a concentrated focus on hydrogen storage and transport technologies.

According to the global consulting firm McKinsey & Company, if South Korea and Japan utilize green hydrogen produced from renewable energy, importing it from overseas is overwhelmingly more cost-effective. <Refer to Figure 2> Importing green hydrogen

inherently hinges on a seamless sequence of storing and transporting hydrogen, highlighting why we must prioritize these technologies. Here, the scope of hydrogen procurement will include both importing green hydrogen produced overseas by foreign enterprises and securing green hydrogen produced abroad by domestic companies.

On a positive note for South Korea, the country possesses substantial competitive advantages in hydrogen utilization within the broader context of a hydrogen economy. If South Korea pairs its world-class hydrogen utilization technologies and existing infrastructure with advanced storage and transport capabilities, a stable hydrogen value chain can be successfully established. This will, in turn, stimulate private investment and accelerate the transition toward a genuine hydrogen economy.

Technical Aspects of Hydrogen Storage and Transport

i. Technical Aspects of Hydrogen Storage

Hydrogen storage technologies can be broadly categorized into physical and chemical methods. Physical methods store hydrogen molecules in their native state, encompassing liquid hydrogen storage via phase change (cryogenic liquefaction) and compressed gaseous hydrogen storage. Chemical methods do not store hydrogen molecules directly; instead, they store hydrogen through chemical bonding with a carrier substance. Depending on the type of carrier used, chemical methods are sub-divided into organic and inorganic carrier systems.

The most representative inorganic method utilizes ammonia as the carrier, while organic methods collectively fall under the category of LOHC (Liquid Organic Hydrogen Carriers). Deciding which substance is optimal for hydrogen storage and transport involves evaluating multiple trade-offs. For instance, ammonia holds a distinct advantage in terms of energy storage density per unit volume and weight. On the other hand, LOHCs excel because they can be stored and transported under ambient temperature and pressure conditions.

While physical storage methods offer numerous advantages regarding energy density and storage/transport efficiency, they require significant technological refinement and further research. Therefore, chemical storage methods currently stand closer to widespread commercialization.

ii. Technical Aspects of Hydrogen Transport

Hydrogen transport technology is intrinsically linked to storage methods. Storing hydrogen physically requires cryogenic temperatures or ultra-high pressures, necessitating entirely new types of vessels compared to conventional petroleum or natural gas tankers. Considering the boil-off gas management and thermal dynamics involved, transporting liquefied hydrogen at cryogenic temperatures could introduce a new paradigm to the shipbuilding industry. A similar specialized shipping technology will be required when utilizing ammonia as a hydrogen carrier. However, when deploying LOHC as the carrier, it can be transported under conditions close to ambient temperature and pressure, allowing the utilization of existing oil and chemical tankers without modification. This is why the economic evaluation of hydrogen carriers must comprehensively factor in the transport infrastructure alongside energy density.

iii. Current Status of Hydrogen Storage and Transport Technologies

There is a widespread perception that hydrogen storage and transport technologies are not entirely eco-friendly. This skepticism stems primarily from the fact that current carbon dioxide emissions associated with these processes are higher than those of direct renewable energy generation or nuclear fission. Indeed, there are valid grounds for such criticism.

Discussions on what constitutes "clean hydrogen" have been ongoing, with various boundary standards established. Representative metrics include:

- Well-to-Wheel: From power generation to final utilization.
- Well-to-Port: From power generation to the receiving terminal at the destination.
- Well-to-Gate: From power generation to the storage phase.

When evaluated under the Well-to-Port standard, carbon dioxide emissions for hydrogen storage and transport generally exceed the clean hydrogen threshold of 4kg/kgH₂, though variations exist depending on vessel fuel types and transport distances. <Refer to Figure 3> Consequently, the argument that current storage and transport technologies are not entirely green is rational.

However, the critical question is whether these contemporary drawbacks represent insurmountable, inherent limitations or temporary hurdles that can be resolved through technological innovation. Data on emissions across the chemical storage value chain reveals that the vast majority of carbon dioxide emissions and energy consumption occur during two distinct phases: the loading/unloading (hydrogenation/dehydrogenation) of the carrier, and the maritime transport of the carrier itself.

The potential to reduce carbon emissions during the hydrogenation and dehydrogenation processes can be inferred from the evolution of hydrogen carriers. For instance, MCH (Methylcyclohexane), a prominent LOHC candidate, minimizes irreversible reactions by controlling the chemical equilibrium during hydrogenation and dehydrogenation. This increases the carrier recycling rate, thereby minimizing carbon emissions. Furthermore, ongoing global R&D to identify optimal compounds among biphenyl-based and various other materials demonstrates that minimizing energy losses during the storage and extraction phases is an entirely achievable goal.

For maritime transport, carbon emissions can be minimized by transitioning ship fuels. Technologies utilizing ammonia as a marine fuel are being broadly researched, ranging from 100% ammonia-fueled engines to dual-fuel systems co-firing ammonia and natural gas. For vessels transporting ammonia, utilizing the cargo itself as fuel creates strong synergies for the hydrogen economy. Research is also actively underway on green methanol as a marine fuel. Since methanol production can leverage both biomass and green hydrogen, this creates a virtuous cycle wherein green hydrogen is both produced and utilized to power its own transport.

| Current Development Status of Hydrogen Storage and Transport Technologies in South Korea

As previously noted, South Korea possesses substantial strengths in hydrogen utilization. In particular, Korean enterprises lead the global market in sectors like hydrogen fuel cell vehicles, meaning that once a hydrogen economy takes hold, explosive synergies can be realized.

However, the situation is vastly different for hydrogen storage and transport technologies. Compared to global benchmarks, South Korea is classified as a fast follower in high-pressure compressed hydrogen storage, hydrogen pipeline networks, hydrogen refueling stations, and ammonia storage/hydrogen extraction technologies. Furthermore, South Korea is categorized as a "laggard" in solid-state hydrogen storage and cryogenic liquid hydrogen storage technologies. This indicates a clear lag not only in the chemical storage and transport methods highlighted earlier but also in liquefied hydrogen storage technologies, which are poised to play a central role in the mid-to-long-term energy cycle. <Refer to Figure 4>

Contrasting sharply with this technological gap, an examination of national budget allocations for the hydrogen economy reveals that storage and transport technologies receive a disproportionately small share. Between 2016 and 2020, only 12% of the

cumulative investment in the hydrogen economy was allocated to storage and transport. In the 2022 hydrogen economy transition budget, this figure dropped to a mere 4%. Given that the completion of a hydrogen economy ultimately depends on building an uninterrupted value chain via storage and transport technologies, the efficiency of current national investments remains highly questionable. Therefore, the most urgent priority is to expand state-led R&D investment across the entire spectrum of hydrogen storage and transport technologies. <Refer to Figure 5>

To bridge this technological divide, it is crucial to accurately categorize these technologies and formulate systematic initiatives. The Hydrogen Technology Development Roadmap, which laid out short-term plans up to 2025, serves as the existing blueprint. According to this roadmap, hydrogen storage and transport are divided into physical storage, chemical storage, and transport, with each further subdivided into three to four detailed technologies. <Refer to Figure 6> However, this framework is insufficient as a comprehensive guideline and national blueprint for South Korea's strategic direction. Consequently, there is an urgent need to restructure and refine the roadmap into a "Hydrogen Storage and Transport Technology Development Roadmap 2.0," as proposed below.

| Hydrogen Storage and Transport Technology Development Roadmap

i. Embodiment of the Technology Development Roadmap

First, the technical objectives must be granularly detailed to foster multi-faceted development in hydrogen transport. For example, if a roadmap lumps hydrogen carriers into broad organic and inorganic categories without specific targets, private corporations will focus exclusively on short-term economic viability, while public research institutes will only pursue low-risk, high-probability materials. Because the leading candidates for hydrogen carriers shift constantly, detailing the roadmap is essential to remain agile amid rapid technological trends. A holistic understanding and targeted research are required across all related technologies, structured as follows:

- **High-Pressure Gaseous Transport:** Developing advanced lightweight materials for high-pressure tanks and improving thermal engine efficiency are mandatory.
- **Liquid Hydrogen Storage & Transport:** Technologies to enhance tank insulation and minimize boil-off gas (BOG) losses are vital. This includes passive methods (re-liquefying evaporated hydrogen) and active methods (preventing evaporation altogether), along with tank lightweighting.

- Ammonia Carrier Systems: Requires optimizing the traditional Haber-Bosch process for green applications and maximizing the thermal efficiency of ammonia cracking (dehydrogenation).
- LOHC Systems: The focus must shift to discovering novel candidate materials and optimizing the underlying hydrogenation/dehydrogenation reaction mechanisms.
- Maritime Transport & Marine Propulsion: Integrating thermoelectric systems requires improving the thermoelectric figure of merit (ZT) of materials, alongside large-scale empirical testing for commercial vessels. To implement eco-friendly marine fuels, development must be bifurcated into the three primary production pathways for green methanol and dedicated ammonia-fueled propulsion systems.

By segmenting and detailing these pathways, national R&D budgets can be deployed with high efficiency, and private-sector accessibility to hydrogen transport technologies will significantly improve. <Refer to Figure 7>

ii. Structural Organization of the Technology Development Roadmap

Second, we must transition toward government-led, highly organized collaborative research. We must establish a Phase 1 cooperation network where entities dealing with hydrogen storage, thermal decomposition, and transport technologies can directly share data and collaborate. Expanding on this, a Phase 2 cooperation network must be formed to encompass these foundational networks while managing international collaborations—forming a comprehensive Korean Hydrogen Storage and Transport Consortium. <Refer to Figure 8>

This structure will lay the groundwork for robust industry-academia-research cooperation and maximize research efficiency. Crucially, experiencing the full operation of an independent, domestic hydrogen value chain will allow South Korea to clearly chart its future technological trajectory. While domestic collaborations have historically occurred between individual production-storage companies or transport-reforming companies, an overarching consortium integrating all these nodes is virtually unprecedented.

Essentially, the final consortium requires sustained government backing. As diverse institutions participate, public oversight is necessary to coordinate conflicting interests. Furthermore, should geopolitical dependencies arise in securing hydrogen production overseas, the state must resolve them through strategic diplomacy. Therefore, the realization of this Korean Hydrogen Consortium necessitates the active participation of public entities, such as the Ministry of Science and ICT.

As aforementioned, the specific details of this detailing and structural organization may appear somewhat ambitious or decoupled from immediate industrial frontlines. However,

the core of this proposal lies in the systemic concepts of detailing and organization for the roadmap—an urgent and entirely viable task.

iii. Empirical Case Studies of Structural Organization

A clear precedent can be found in Japan. In 2020, Japan's AHEAD Consortium successfully completed a full hydrogen supply chain: producing hydrogen in Brunei, storing it using LOHC technology, shipping it to Japan, extracting the hydrogen from the carrier, and delivering it to end-users. The AHEAD Consortium brought together diverse stakeholders: the Japanese government facilitated diplomacy with Brunei, Chiyoda Corporation provided the hydrogen carrier technology, and NYK Line managed maritime transport. This initiative served as a vital catalyst, expanding into a subsequent consortium involving Kawasaki Heavy Industries, Shell Japan, Sumitomo Corporation, and Iwatani Corporation to transport liquefied hydrogen from Australia.

In South Korea, the collaboration between Samsung Engineering and Lotte Chemical on ammonia-based hydrogenation/dehydrogenation technology can be classified as a Phase 1 cooperation network under this framework. Additionally, joint ventures like POSCO Holdings and Samsung Engineering cooperating on green hydrogen production projects in Oman demonstrate that corporate-level collaborations are beginning to take shape.

| Conclusion

Admittedly, this proposal remains somewhat conceptual, as it lacks quantitative impact assessments or a fully finalized execution blueprint. However, the climate crisis cannot be resolved without a fundamental re-evaluation of energy. While eco-friendly policies or voluntary campaigns can yield meaningful environmental benefits within existing energy frameworks, they are ultimately constrained by relying on individual or institutional goodwill.

Furthermore, carbon reduction through such efficiency gains inevitably plateaus. Certain carbon-emitting elements are indispensable to human survival; thus, while conventional energy optimization may reduce emissions in the short term, the trajectory will inevitably converge toward a baseline plateau. The only breakthrough capable of breaking through this inherent limitation is a complete transition of the energy source itself. Shifting the baseline and lowering the convergence floor can only be guaranteed by an energy source transition, which must be our core posture toward the climate crisis.

To truly achieve this transition, we must not fixate solely on the storage and transport

technologies proposed today. As renewable energy generation should function as the bedrock, continuous research into improving the efficiency of solar, wind, and hydro power is vital, alongside sustained attention toward nuclear fusion, which is the ultimate energy source. Furthermore, to build a seamless hydrogen economy, sustained investment must accompany hydrogen utilization and consumer-facing infrastructure so that the public can consume energy conveniently.

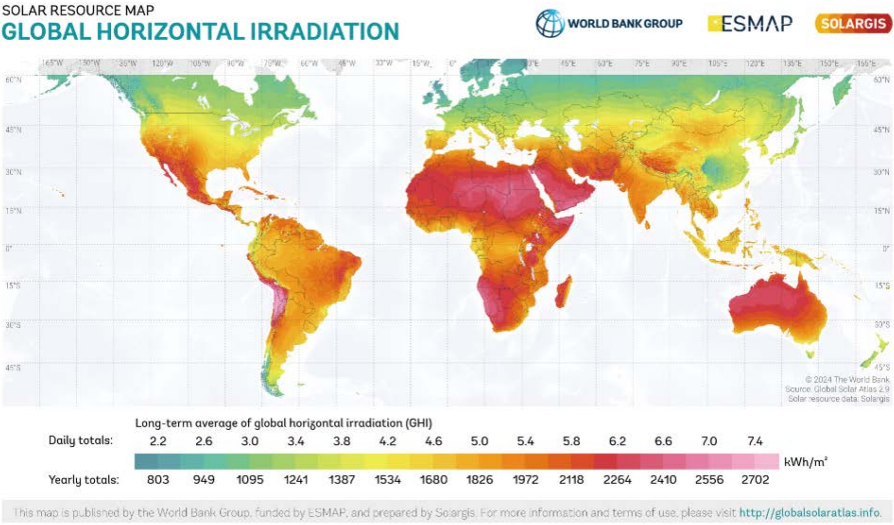
While this proposal focused specifically on storage and transport because it represents South Korea's most critical vulnerability, true energy transition can only be realized through comprehensive attention and investment across the entire green hydrogen value chain.

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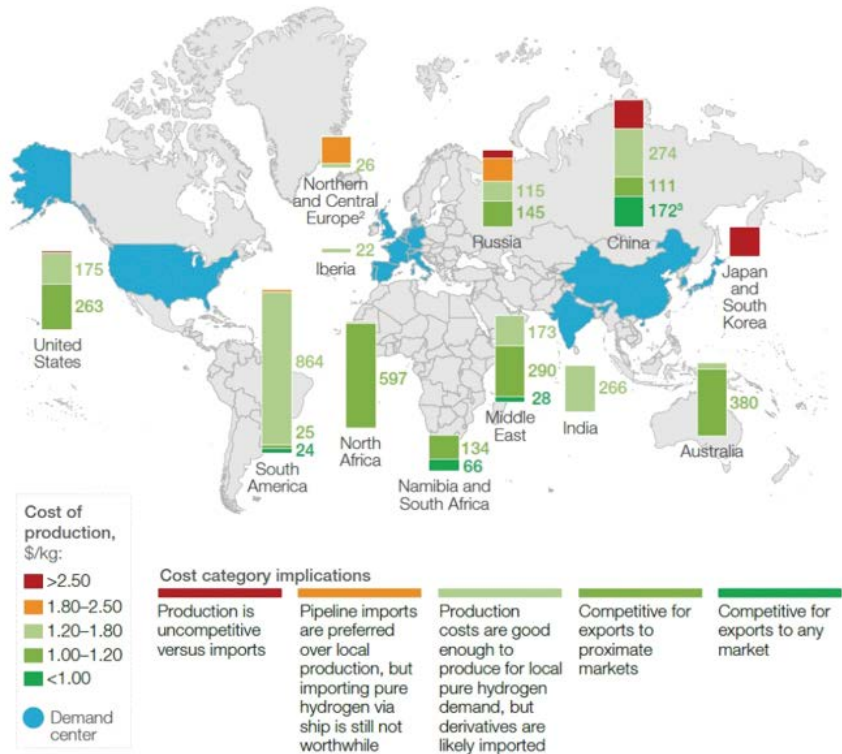
Materials

<Figure 1> Validation report for global solar radiation model, World Bank, 2019.

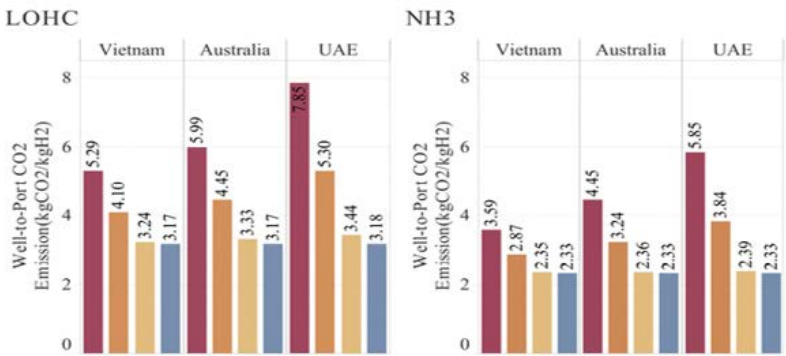


<Figure 2> Global hydrogen flows, Hydrogen Council, Mckinsey&Company, 2022.

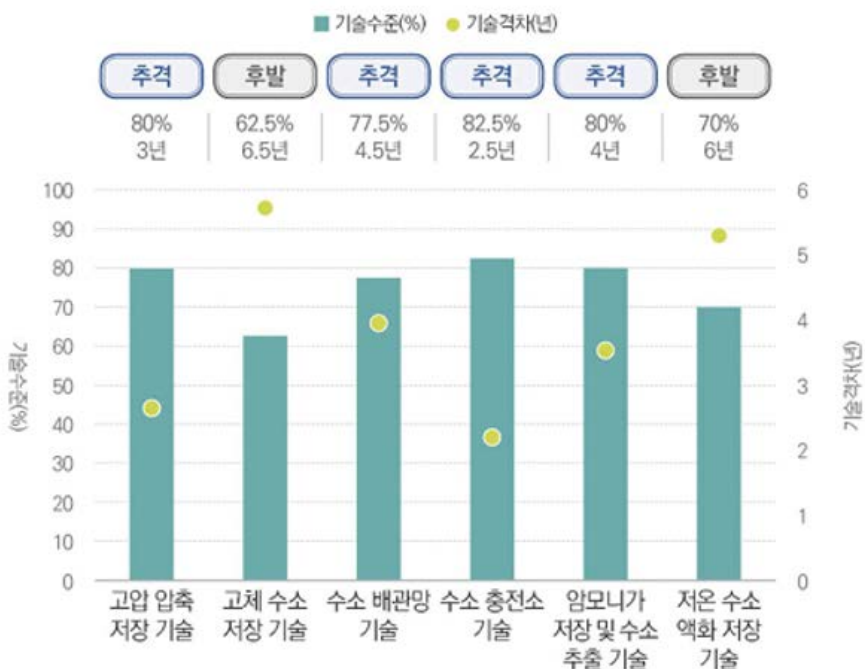
Hydrogen production potential,¹ 2050, million tons per annum



<Figure 3> Technology Level Assessment of the Hydrogen Sector for Major Countries and Its Implications, National Institute of Green Technology(NIGC)



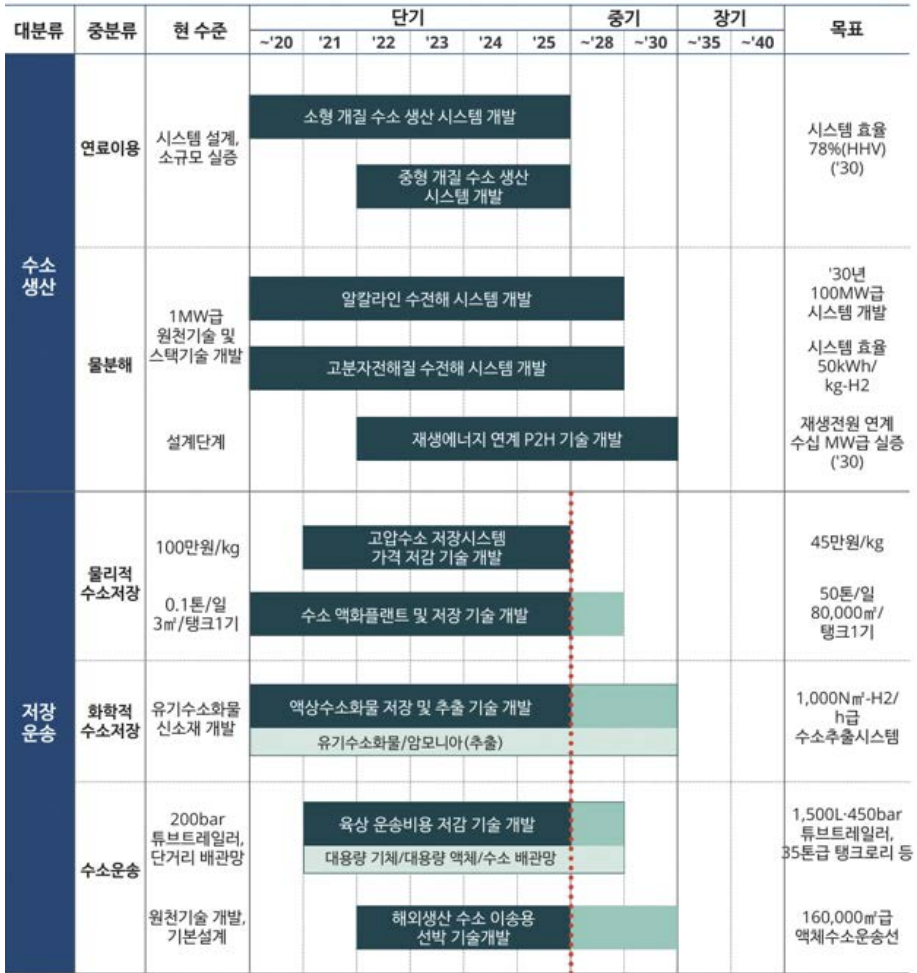
<Figure 4> Status of Hydrogen Technological Innovation and Development in Major Countries, Lee Jung-hun, 2022



<Figure 5> The Expanding Global Hydrogen Supply Chain War... South Korea's Transport and Storage Budget Accounts for a Mere 4%, Seoul Shinmun, 2023.



**<Figure 6> Hydrogen Technology Development Roadmap, Jointly published
by relevant government ministries, 2019.**



기술개발 현황/보급 실적/경제성·환경성 분석 이후 국가수소공급 전략 수립 및 기술개발 재정비

<Figure 7>



<Figure 8>



I Introduction

- a. Urbanization of South Korea
- b. Urban Heat Islands Caused by Transportation
- c. Current Status and Problems of Public Bicycles

I Main Body: Measures to Activate Public Bicycles

- a. Creating Eco-Friendly Wind Corridors
- b. Building an Integrated Transfer System with Public Transportation
- c. Supporting the Installation and Maintenance of Bicycle Parking Lots
- d. Provision of Climate Companion Allowances
- e. Helmet Wear Certification Campaign for Creating a Culture of Safety

I Conclusion and Suggestions for Future Development

I References and Sources

Green City

03

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Transportation Solutions for Green Cities

Abstract

This proposal presents specific measures to activate public bicycle systems to address urban heat islands and climate change. It analyzes the potential of public bicycles to resolve urban transportation challenges and contribute to achieving Net-Zero targets, while highlighting current operational shortcomings. To address these issues, it proposes concrete blueprints to the Ministry of Land, Infrastructure and Transport (MOLIT) and the Ministry of Environment (ME), including eco-friendly bicycle path design, the establishment of an integrated transfer system with public transit, improvements to bicycle parking facilities, and the introduction of a Climate Companion Allowance. If these proposals are realized, Seoul can move beyond merely activating public bicycles and leap forward as a genuine "Green City" anchored in eco-friendly transportation.

Cut Your Net Zero Future

한강공원

서울숲

청계천
일대

| Introduction

a. Urbanization of South Korea

Since the 1960s, South Korea has experienced rapid urbanization alongside fast-paced industrialization. Urbanization gives rise to an artificial climate phenomenon shaped by human activity, resulting from the complex interplay of anthropogenic heat release, increased atmospheric pollutants, and changes in land cover. Cities are predominantly characterized by dry surfaces paved with concrete or asphalt, featuring land cover conditions deficient in soil and vegetation.

The paved, dry surfaces of urban areas restrict rainwater infiltration into the soil. Furthermore, the heavy use of fossil fuels across industrial, transportation, and residential sectors in cities leads to an increase in greenhouse gas emissions. This concentrated discharge of anthropogenic heat and greenhouse gases raises urban temperatures.

In cities densely populated with industrial facilities and vehicles, atmospheric pollutants such as sulfur dioxide, nitrogen oxides, and aerosols emitted during fossil fuel combustion multiply. These pollutants act as condensation nuclei, increasing the formation of clouds and fog. Vehicles on the road burn fossil fuels, releasing greenhouse gases and atmospheric pollutants that further exacerbate the urban heat island effect.

It is now time for an eco-friendly transition to take place not only in industry but also within transportation systems. In particular, rising traffic volume in urban areas is increasing the concentration of fine particulate matter (PM_{2.5}), which causes respiratory illnesses and poses a direct threat to public health. Therefore, introducing eco-friendly modes of transport to improve air quality, alongside continuous policy support, is essential.

b. Urban Heat Island Caused by Transportation

Amid ongoing global warming, urban areas are exhibiting a sharper temperature upward trend than the global average due to the urban heat island (UHI) effect. In South Korea as well, the annual average temperature has risen by 0.2°C every 10 years over the past 109 years (1912–2020), indicating more pronounced warming than the global benchmark, with temperatures in urban areas showing an exceptionally steep rise. An Urban Heat Island refers to a phenomenon where temperatures inside a city are higher than in surrounding non-urban areas, caused by the accumulation of atmospheric pollutants and anthropogenic heat generated by human activities. Due to urban heat islands, peak temperatures occur in downtown centers, whereas suburban areas surrounding the city exhibit lower temperatures than the urban core.

In cities, atmospheric pollutants manifest as smog. Recently, photochemical smog has become increasingly common in urban areas; this happens when nitrogen oxides or Volatile Organic Compounds (VOCs) emitted primarily from vehicle exhaust, undergo photochemical reactions triggered by ultraviolet radiation, producing compounds harmful to living organisms, such as ozone or peroxyacetyl nitrates (PANs).

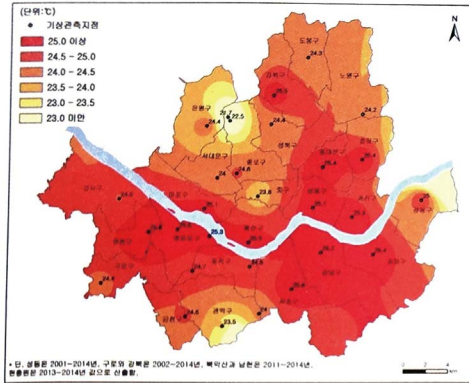
Major cities in South Korea (with populations over 1 million) include Seoul, Busan, Incheon, Daegu, Daejeon, Gwangju, Suwon, and Ulsan. Among these, Seoul, which has the largest population, exhibits a highly pronounced urban heat island effect, as evidenced by the distribution of summer average temperatures in Seoul. High-density urban districts with heavy vehicle traffic and substantial atmospheric pollutant emissions—such as Gangnam, Seocho, Songpa, Yeongdeungpo, Yangcheon, Dongdaemun, and Seongdong—

can be seen to have higher temperatures than their surroundings. Conversely, areas surrounding forested mountains, such as Bukhansan (northeastern Eunpyeong, northern Jongno), Gwanaksan (southern Gwanak), and Namsan (southern Jung-gu), show relatively lower temperatures than their vicinity.

To mitigate Seoul's urban heat island effect and achieve Net-Zero targets, the city's climate environment must be improved through sustainable transportation policies. To this end, expanding the deployment of electric and hydrogen vehicles, transitioning public transit into eco-friendly modes, and activating low-carbon mobility options like bicycles are emerging as key policy priorities.

c. Current Status and Problems of Public Bicycles

"To resolve urban transport issues, the Seoul Metropolitan Government introduced the public bicycle sharing service "Ttareungi" in 2015, with approximately 25,000 bicycles in operation as of 2023.



Distribution of Average Summer Temperatures in Seoul (1998–2014)



Seoul's Public Bicycle Sharing System, 'Ttareungyi'

Ttareungyi offers the advantages of simple, IT-based rentals and convenient data collection. Bicycles help ease downtown traffic congestion, ultimately contributing to mitigate the urban heat island effect. Furthermore, as a zero-emission mode of transport, public bicycles are recognized as a key asset for achieving Net-Zero targets. . However, several operational issues are hindering convenience for citizens.

- **Insufficient Eco-Friendly Bicycle Paths and Parking Infrastructure:** The first problem facing public bicycles is the lack of eco-friendly bicycle paths and parking facilities. Environmentally conscious dedicated bicycle paths are insufficient, and poorly managed bicycle parking facilities are frequently observed. Although Seoul's bicycle paths currently span a total length of approximately 1,200 km, many segments remain disconnected within a vehicle-centric road infrastructure. In some areas, they operate as shared spaces with pedestrians, continuously raising safety concerns. Moreover, when bicycle users do not wear helmets on roads shared by pedestrians and vehicles, the risk of safety accidents escalates significantly.
- **Weak Integration with Public Transit Transfers:** The second issue is the weak integration with public transit transfers. Public bicycles lack a seamless transfer system with subways and buses, which somewhat compromises transit efficiency. It has been observed that Seoul's public bicycles offer benefits only when transferring to public transit within 30 minutes, and outside of regions like Seoul or Sejong, transfer systems are largely underdeveloped. In other words, public bicycles currently face limitations when serving as a standalone mode of travel; unless an efficient transfer system linked to public transportation is established, it will be difficult for them to become a viable option for long-distance commuting.
- **Civic Accessibility Barriers:** The third issue pertains to accessibility for citizens. For some citizens, the cost of using public bicycles can be financially burdensome, and there are cases where geographical placement creates a disadvantageous barrier to access. Public bicycle rental stations are occasionally concentrated in specific areas, meaning some individuals face long distances between stations, which diminishes convenience. Therefore, policies are required to distribute public bicycle stations more equitably and enhance accessibility in transport-disadvantaged areas.

| Main Body: Measures to Promote Public Bicycle Use

Due to the aforementioned problems, the full potential of public bicycles is currently not being realized. The role of public bicycles is deemed crucial for resolving urban traffic congestion and mitigating urban heat islands over the long term. In this section, specific measures to promote public bicycle use will be proposed to the Ministry of Land, Infrastructure and Transport (MOLIT) and the Ministry of Environment (ME).

a. Creating Eco-Friendly Wind Corridors

First, the Ministry of Land, Infrastructure and Transport(MOLIT) must consider creating eco-friendly bicycle paths. This is because the reckless expansion of bicycle paths can conversely lead to environmental degradation. Destroying existing green pathways to increase roads paved with concrete and asphalt would cause the road surfaces to absorb and radiate solar heat, thereby raising surrounding temperatures further.



‘Hangang Park’ acting as a Wind Corridor

Accordingly, the Road Safety & Operation Division of MOLIT should design bicycle paths along wind corridors to ensure that the urban heat island effect is mitigated.

Following the urban heat island circulation loop, a wind known as a country breeze blows along the ground surface from the surrounding suburban areas—where temperatures are relatively lower and air pressure is higher—toward the urban center, where temperatures are higher and pressure is lower.

Although a country breeze generally has low wind speeds, it plays a key role in circulating and replacing urban air by moving clean air from the surrounding green belts into the heart of the city. Therefore, securing and maintaining "wind corridors"—which serve as channels for fresh country breezes to migrate into the urban interior—can substantially improve urban air quality.

Bicycle path networks that follow green spaces and rivers within downtown areas can facilitate air circulation, thereby contributing to lowering fine dust concentrations. Wind corridors generally manifest along waterways like rivers or hills covered with forests. Currently, large-scale green spaces such as Seoul Forest, Hangang Park, and the Cheonggyecheon stream area form wind corridors that help alleviate the heat island effect.

However, urban expansion and road construction driven by urbanization are severing these wind corridors, meaning that development must be executed in a manner that preserves them. Consequently, the Ministry of Land, Infrastructure and Transport must incorporate infrastructure designs that account for wind corridors right from the urban planning stage, and collaborate with the Ministry of Environment to draft measures for preserving and expanding them.

b. Building an Integrated Transfer System with Public Transportation



GTX Lines

Secondly, the Metropolitan Transit Transfer Division of MOLIT should prioritize building an "Integrated Transfer System" in major cities where public bicycle and public transit transfers are currently disconnected.

The Integrated Transfer System is a scheme that applies public transportation transfer discounts to subways or buses when using public bicycles. Currently, some cities, including Seoul and Sejong, operate discount systems for transfers made within 30 minutes of using a public bicycle. However, the 30-minute time limit can feel rushed to some citizens. There may be insufficient time to return the bicycle, catch one's breath, and walk to the next transfer point. Therefore, Seoul's public bicycle system should expand

and apply transfer benefits from within 30 minutes to within 1 hour.

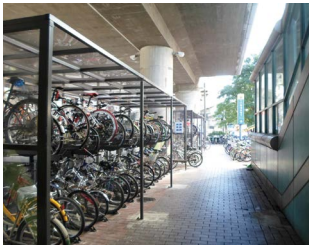
A transportation innovation took place in 2024 with the partial opening of GTX-A. The Great Train eXpress (GTX) is a metropolitan express railway network constructed to maximize accessibility between the Seoul metropolitan area and downtown Seoul; its utilization is expected to grow further once all lines open in the future. Therefore, public bicycles should be deployed at major GTX stations to support convenient transfers for citizens. In terms of information provision, real-time bicycle rental availability, transfer routes, and transfer time limits can be guided through smartphone applications and in-station kiosks.

Because the "Integrated Transfer System" is a policy capable of significantly activating public bicycle use, it should be successfully implemented in cities beyond Seoul as well. Strengthening the link between regional transport networks like the GTX and public

bicycles can bring positive shifts to commuting patterns within the Seoul metropolitan area. For instance, encouraging citizens commuting from the outer rims of the metropolitan area to combine public bicycles and public transit instead of driving personal cars would help ease downtown traffic congestion and alleviate the shortage of parking spaces.

Additionally, there is a need to apply public bicycle transfer discounts in small and medium-sized cities, not just the capital region. Since small and medium-sized cities have relatively scarce public transit grids, public bicycles can serve as a substantive alternative mode of travel. Accordingly, it is vital for the Ministry of Land, Infrastructure and Transport to cooperate with local governments to introduce tailored local transfer policies and reinforce linkages between public bicycles, buses, and subways.

c. Supporting the Installation and Maintenance of Bicycle Parking Lots



Double-Decker Bicycle Racks



Underground Mechanical Parking System in Tokyo, Japan

Thirdly, the Ministry of Land, Infrastructure and Transport needs to strengthen support for installing and maintaining bicycle parking lots.

Walking along the streets, one often notices that parking facilities for public bicycles or electric scooters are untidy, or that these vehicles are left lying on sidewalks, obstructing pedestrian traffic. Installing bicycle parking infrastructure at major public transportation hubs would help organize bicycles while simultaneously supporting convenient transit transfers for citizens. In areas near subway stations where parking spaces are scarce, an additional option is to install "double-decker bicycle racks".

Another example of parking facilities is Tokyo's "Eco Cycle," an underground mechanical bicycle parking system. This parking facility can accommodate both public bicycles and privately owned bicycles, offering excellent convenience to citizens who ride their own bikes. Furthermore, being stored in a sealed underground space, it minimizes concerns over theft and is highly efficient in terms of space utilization. Above all, it is expected to minimize disruptions to the urban landscape and avoid significantly hindering pedestrian passage.



Jamsil Bicycle Parking Tower

Similarly, a mechanical bicycle parking facility has been installed in Jamsil. However, a news report previously revealed that it had been left abandoned in a broken state for three years; this case highlights how a lack of a maintenance system can leave facilities unutilized for prolonged periods.

This instance caused substantial inconvenience to users and eroded public trust in civic infrastructure. To rectify such problems, the Ministry of Land, Infrastructure and Transport should connect with the Seoul Metro to reinforce regular inspection systems and introduce a "report button" allowing citizens to immediately notify the operator when a malfunction occurs. Furthermore, developing a system that enables citizens to check the real-time availability of nearby bicycle parking via smartphone apps will reduce unnecessary travel and facilitate more efficient parking operations.

If bicycle parking spaces within cities are systematically organized, pedestrian safety will be secured and the urban landscape will improve. Furthermore, efficient operation of parking facilities will boost bicycle utilization rates and strengthen connectivity with public transit, bringing anticipated carbon emission reduction benefits. Consequently, properly establishing bicycle parking infrastructure is not merely about expanding facilities, but rather a vital process toward creating a sustainable urban transportation framework.

d. Provision of Climate Mobility Incentive

Moving forward, public bicycle activation measures are proposed to the Ministry of Environment. The Ministry of Environment can provide allowances to public bicycle users. While policies supporting public transit costs do exist, they remain somewhat lacking when it comes to directly driving up public bicycle usage. Currently, Seoul's Ttareungi operates on a daily pass basis at 1,000 KRW for a 1-hour pass and 2,000 KRW for a 2-hour pass. Although satisfaction with the cost may vary individually, citizens might choose not to opt for bicycles due to accessibility and convenience disadvantages compared to buses or subways.

관종	가격	비고
30일권(따릉이 포함)  +  + 	65,000원	- 청년(만 19~39세)할인 : 58,000원 ※ '티머니 카드&페이' 참고
30일권(따릉이 미포함)  + 	62,000원	- 청년(만 19~39세)할인 : 55,000원 ※ '티머니 카드&페이' 참고

Climate Card Pricing

The Climate Card (기후동행카드) is an initiative officially launched on July 1, 2024, designed to improve urban air quality and reduce traffic congestion by boosting the usage of public transit and Ttareungi. On a monthly basis, the Climate Card options including Ttareungi cost 65,000 KRW, which is 3,000 KRW more expensive than the option excluding Ttareungi.

Under these conditions, it appears difficult to expect an increase in public bicycle utilization rates.

Accordingly, the Climate Adaptation Division or the Transport Policy Division of the Ministry of Environment could establish an allowance or refund scheme targeting individuals who use public bicycles 15 times or more per month.

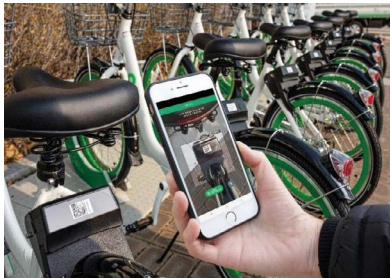
Specifically, the allocation of a "Climate Companion Allowance" is proposed. This approach involves paying an allowance based on the number of bicycle riding days to Climate Card users who ride Ttareungi at least 15 times a month. For example, if a user rides for 20 days in a month, multiplying this by 200 KRW would grant a total allowance of 4,000 KRW. This proposal can mitigate the financial burden on citizens and encourage public bicycle riding, taking inspiration from Gyeonggi Province's "Climate Action Opportunity Income".

On the Climate Action Opportunity Income app, rewards accumulate when users participate in various sustainable practices, such as walking, cycling, and using public transit. For cycling, users can accumulate a maximum reward of 600 KRW per day, which can later be redeemed as Gyeonggi Local Currency. Such reward systems have the effect of providing continuous motivation to users and fostering voluntary participation. However, considering the government budget, duplicate benefits between the Climate Companion Allowance and the Climate Action Opportunity Income should be prevented.

Given that the Climate Companion Allowance proposal relies on the national budget, securing diversified funding sources is necessary for its effective operation. First, funding can be raised through a joint budget allocation between the Ministry of Land, Infrastructure and Transport and the Ministry of Environment. Alternatively, it can be

linked with the Emissions Trading Scheme (ETS) to induce voluntary donations from corporations. Corporate donations can be encouraged as a channel for fulfilling Corporate Social Responsibility (CSR), contributing to easing the fiscal burden. Over the long term, another strategy involves establishing quantitative data on the carbon reduction achievements of public bicycle riders to capture additional financing from the international carbon credit market.

e. Helmet Wear Certification Campaign for Creating a Culture of Safety



Ttareungi with QR Codes



Helmets and Public Bicycles



Climate Card Poster

Lastly, the Ministry of Environment needs to build a culture of safety in alignment with the Ministry of the Interior and Safety (MOIS).

Because bicycle safety accidents occur quite frequently, the system has struggled to gain full public confidence. If a secure transit environment is guaranteed, citizens will

confidently increase their bicycle use, allowing public bicycles to ultimately establish themselves as a sustainable mode of transportation.

To cultivate a safe bicycling culture, a helmet wear certification campaign is proposed. The helmet wear certification campaign involves attaching QR codes to both public bicycles and helmets, and extending mileage points or fare discounts to users who successfully complete the wear verification. For example, offering incentives such as one free rental for every 10 certifications can drive civic participation and propagate a safety-first culture.

| Conclusion and Suggestions for Future Development

In conclusion, public bicycles play a central role in mitigating urban heat islands and realizing a sustainable Green City. To achieve this, the Ministry of Land, Infrastructure and Transport must center its focus on building environmentally sustainable bicycle paths, developing public transit transfer frameworks, and upgrading parking facilities. The Ministry of Environment should subsidize public bicycle use and drive user base growth by fostering a culture of safety. If cooperation between the two agencies successfully activates public bicycles beyond Seoul and across other cities, it will serve as the foundation for manifesting a green city alongside reaching Net-Zero goals.

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I Introduction

- Growth of the Tourism Industry and Environmental Challenges
- Current Status of Waste Generation in Jeju's Tourism Sector
- Excellent Policies of Overseas Tourist Destinations

II Body | Proposals for Sustainable Tourism in Jeju

- Eco-Friendly Mobility Support Policy
- Sustainable Lodging Certification System
- Eco-Friendly Travel Platform Development

III Conclusion and Future Directions

IV References and Sources

Green City

04

Choi Ji-hyeon / Inha University

Sustainable Ideas for Jeju's Environment and Tourism



Abstract

Jeju Island, recognized by UNESCO as both a tourism resource and an environmental asset, holds the distinction of ranking first nationwide in municipal solid waste generation per capita. Along with the increase in tourists, the volume of municipal solid waste is skyrocketing, and due to indiscriminate waste discharge and a lack of management, Jeju Island's natural environment is gradually being damaged. A vicious cycle continues where the environment is being discarded for the sake of people who came to see the beautiful natural environment. This paper aims to propose appropriate measures for sustainable tourism regarding waste management emitted from the tourism industry within Jeju, as well as the preservation of the natural environment.

| Introduction

a. Growth of the Tourism Industry and Environmental Challenges

Globally, the tourism industry is developing rapidly, establishing itself as a major driver of economic growth. Every year, billions of tourists travel domestically and internationally to experience diverse cultures and nature, which acts as an important factor contributing to the economic revitalization of each country. In particular, the development of air transportation and the proliferation of digital technology have increased the accessibility of tourism, allowing more people to enjoy travel. However, this revitalization of the tourism industry is having a serious negative impact on the environment. In areas where tourists congregate, the natural environment is damaged, resources are excessively consumed, and cases of ecosystem destruction due to reckless development occur frequently. Furthermore, the large volume of waste and increasing carbon emissions at tourist destinations are directly linked to climate change, making the balance between long-term environmental sustainability and tourism development an increasingly urgent challenge. Accordingly, national governments and related organizations are introducing eco-friendly tourism policies and seeking various measures for sustainable tourism development, and the need for tourists to raise their awareness of environmental protection is also being raised.

b. Current Status of Waste Generation in Jeju's Tourism Sector

Jeju Special Self-Governing Province is the largest volcanic island in South Korea, located in the southwestern part of the country, and is one of South Korea's most popular tourist destinations, to the extent that it has exceeded 13 million visitors for the past three consecutive years. There is no doubt that Jeju Island holds precious environmental value as unique and beautiful natural landscapes such as Seongsan Ilchulbong, lava tubes, and columnar joints can be seen across the entire island. In 2002, it was designated as a Biosphere Reserve; in 2007, it was listed as a World Natural Heritage; and in 2010, it received Global Geopark certification, becoming the only island in the world to have earned UNESCO's Triple Crown in the field of natural sciences.

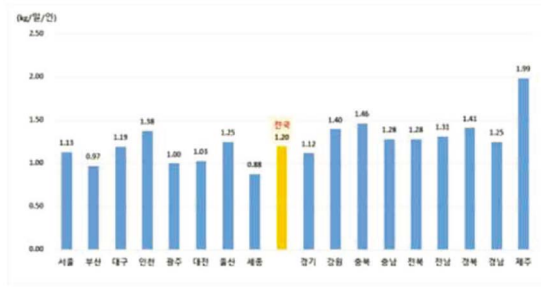
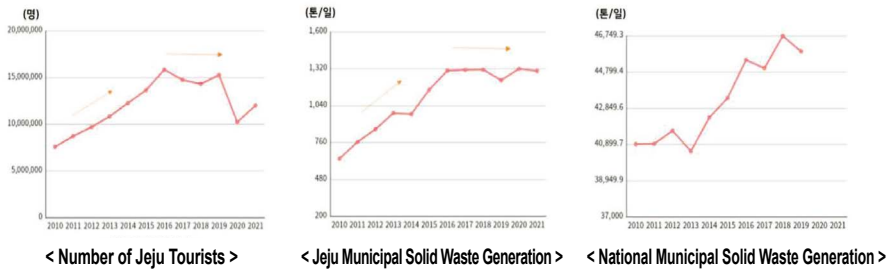


Figure 7. Daily Municipal Solid Waste Generation Per Capita by Region

Source | 2022 Current Status of National Waste Generation and Treatment (Ministry of Environment, Korea Environment Corporation)



Source | KOSIS National Statistical Portal / Jeju Statistical Portal

As such, when thinking of Jeju Island, many people first associate it with a clean and environmental image. However, not many people know the fact that Jeju Island ranks first in municipal solid waste generation per capita nationwide. Jeju's per capita municipal solid waste generation is the highest in the nation, at nearly double the national average. This is because, although Jeju has a larger transient population than other regions and correspondingly a higher volume of waste discharge, the statistics are calculated using only the permanent resident population . This implies that the influence of the tourism industry on Jeju Island is substantial, suggesting the need to discuss the resulting environmental problems more deeply and prepare solutions.

To secure additional evidence, public data was used to compare the trends of Jeju Island's annual municipal solid waste volume and the number of tourists. The data show that both graphs show a similar trend, gradually increasing from 2010 and then stagnating after 2016. When comparing this with the national waste volume graph, there was a clear difference, from which it can be inferred that the number of tourists affected the volume of municipal solid waste.

Jeju Province has officially conducted a fact-finding survey regarding this issue, and in 2022, it conducted the nation's first 'Fact-Finding Survey on Waste Generation in the Tourism Sector.' According to the survey results, the amount of waste generated from the tourism industry was estimated at approximately 67,670 tons, which corresponds to one-seventh of the total generation. Looking by industry sector, the lodging industry was overwhelmingly the highest at 85.3%, followed by the utilization/amusement/convenience casino industry at 5.3%, and the tourism transportation and rental car industry at 4.1%. Since this first-conducted survey had a limitation where the subjects were restricted to large-scale businesses, it is predicted that the proportion of waste in the tourism sector would be much larger if the impacts of restaurants and cafes were also investigated.

Meanwhile, in relation to this, Jeju Province has announced the 'Carbon Free Island Jeju 2030' aiming for the reduction of plastic use and the harmony between the natural environment and people. This policy sets forth four major goals, and in particular, is actively promoting renewable energy and eco-friendly electric vehicle plans. However, concerns regarding the feasibility of achieving the goals are continuously being raised. Accordingly, the importance of policies that can bring Jeju Island one step closer to a 'carbon-zero island' while providing tourists visiting Jeju with a satisfying eco-friendly travel experience is becoming greater.

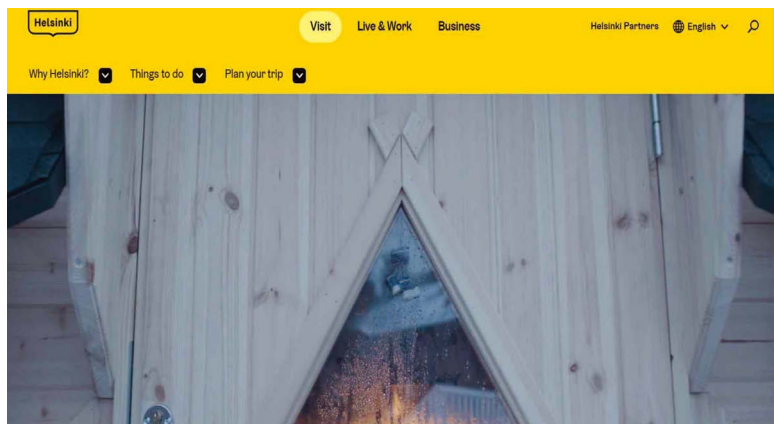
c. Excellent Policies of Overseas Tourist Destinations

The problem of tourism waste is a common issue appearing not only in Jeju Island but also in world-class tourist destinations. Overtourism, meaning the phenomenon of excessive tourism, refers to the problem where conflicts occur socially and environmentally with local residents due to an excessive number of tourists. Regarding this, an investigation was conducted on how overseas tourist destinations have responded.

Mallorca Island, often described as the Jeju Island of Spain, is causing residents to suffer great damage due to the overtourism phenomenon to the extent that protests have occurred. As hotels and other infrastructures were built to accommodate the increasing number of tourists, problems such as damage to natural landscapes, increased waste, resource shortages, and rising real estate prices occurred. Accordingly, Mallorca has introduced an environmental tax system, which is being implemented with the intention for tourists to share the responsibility for the environment together. The collected funds are used for environmental protection, such as the creation of artificial rivers, as well as for museums and convenience facilities according to transparent procedures.

Helsinki, Finland, operates a platform that supports eco-friendly travel called "Think Sustainably." Through this site, tourists can easily obtain information on eco-friendly accommodations, vegan restaurants, and environment-friendly tourist destinations. In

addition, It is home to many hotels that have received 'Green Key,' an international eco-friendly tourism certification, and the 'Nordic Swan Ecolabel,' a Nordic eco-friendly certification system, demonstrating interest in eco-friendly construction and lodging. In particular, in the Viikki district, an eco-friendly ecological residential complex is established as a renewable energy town utilizing solar and wind energy systems.



<https://www.myhelsinki.fi/visit/>

Copenhagen, Denmark, pilot-introduced 'CopenPay,' which induces eco-friendly habits among tourists. 'CopenPay' is a reward system that converts green actions into currency for cultural experiences. If someone helps clean by picking up trash at Copenhagen's tourist attractions, they can get a free kayaking experience, and if they use a bicycle or walk to a museum, they can receive benefits such as a free meal. Through this, tourists can naturally gain motivation to practice eco-friendly actions during the travel process and obtain the effect of saving travel expenses. Along with this, the local community gains advantages in tourist destination management and environmental protection, making it a policy from which positive effects can be expected for both sides.

| Body | Proposals for Sustainable Tourism in Jeju

a. Eco-Friendly Mobility Support

As of September 2024, Jeju Island has the highest proportion of rental cars relative to registered vehicles in the country at 46.33%, and rental cars are most preferred as the primary mode of transportation among visitors. In particular, due to the characteristics of Jeju Island, which has an environment where building public transportation infrastructure

is difficult, tourists show a strong tendency to select rental cars for convenient mobility. In this regard, a plan to actively expand the use of electric rental cars is necessary for eco-friendly mobility support sustainable tourism in Jeju.

Jeju Island is the region that started the distribution of electric vehicles earliest in the nation, and its electric vehicle infrastructure is relatively well-established compared to other places, giving it an environment suitable for electric vehicle use. Utilizing these advantages, providing practical and diverse benefits is necessary to increase the rate at which tourists select electric vehicles as rental cars. By implementing a system that provides benefits such as free use of public parking lots and discounts on charging fees for tourists when using electric rental cars, the economic advantages can be emphasized, and tourists' choices for eco-friendly mobility can be encouraged. In addition, improving charging infrastructure is essential to enhance the convenience of using electric vehicles. In fact, tourists who have used electric rental cars point out frequent charging station malfunctions and the insufficient number of stations as the main drawbacks. Therefore, the maintenance and repair system for charging stations must be strengthened, and the proportion of rapid chargers must be increased further at each tourist destination for tourists for whom time management is important.

Another proposal for eco-friendly mobility is hosting the Jeju Fantasy Bicycle Competition. Jeju Island's Fantasy Bicycle Path provides an optimal environment for riding a bicycle in harmony with beautiful natural landscapes, and is constructed to pass through major tourist attractions such as Soesokkak and Yongduam. This Fantasy Bicycle Path is formed as a course that takes one lap around the circumference of Jeju Island, and it is gaining popularity among many bicycle riders as they can enjoy riding along with the natural scenery spread out along coastal roads with low traffic volume. However, its public awareness is not high yet, and more active public relations and vitalization strategies are required.

Accordingly, the ultimate goal of this proposal is to establish hosting a bicycle competition centered on the Fantasy Bicycle Path as a recurring festival. There is also a plan to subdivide the categories so that not only professional bicycle riders but also beginners and general tourists can participate and enjoy. If souvenirs symbolizing Jeju Island are provided to competition participants, or if various events linked with local commercial districts are operated, it can also contribute to the vitalization of the local economy. Through competitions held regularly like this, the Jeju Fantasy Bicycle Path can be effectively promoted, attracting visits from tourists, and positive effects can be expected in spreading the culture of using bicycles, which are an eco-friendly means of transportation. Furthermore, reinforcing the management and accessibility of public bicycle rental stations is essential so that tourists can easily rent bicycles even if they do not bring them directly. The condition of the bicycles must be checked frequently, the

number of branches must be increased, and return convenience must be augmented. In addition, the markings for the bicycle path must be made clear, and crackdowns on illegally parked vehicles must be strengthened so that the Fantasy Bicycle Path can be further vitalized.



Source: Bicycle Happiness Sharing (<https://www.bike.go.kr>)

If efforts to support tourists' eco-friendly mobility are continuously pursued in Jeju Island, the air pollution problem caused by exhaust fumes can be alleviated, and it will serve as an opportunity for Jeju Island to further strengthen its image as an eco-friendly tourist destination.

b. Sustainable Lodging Certification System

According to the results of the 'Fact-Finding Survey on Waste Generation in the Tourism Sector,' it can be seen that most of Jeju Island's municipal solid waste comes from the lodging industry. This means that disposables used in lodging facilities, waste discharge, and energy consumption have a large impact on the environment. Therefore, raising lodging businesses' interest in environmental protection and inducing eco-friendly operations can be a core approach to solving the problem.

In addition, consumers' interest in eco-friendly travel products has been on an increasing trend recently. According to a survey conducted by 'Yeogiotte,' 78.8% of respondents indicated growing favorability toward eco-friendly travel products. And according to a report released by 'Trip.com,' which introduced a sustainability-certified lodging label, it can be seen that Koreans are showing high interest in sustainability and want options for sustainable travel to be clearly displayed. As the demand for eco-friendly lodging increases like this, a policy to encourage lodging businesses within Jeju Island to adopt eco-friendly operation methods is necessary.

To this end, if a "Sustainable Lodging Certification System" is implemented, an environment can be created where tourists can confirm that a business is an eco-friendly lodging business and consider it as an option. Although there is an existing international certification program called "Green Key," it has limited reach among Jeju's diverse range of accommodation businesses, making a separate domestic certification system necessary. . Therefore, a method of establishing a separate certification system within Jeju Island and granting eco-friendly certification to lodging businesses that meet certain criteria would be effective. In particular, providing reusable amenities, utilizing solar energy and introducing energy-saving systems, and utilizing local food ingredients are representative activities that lodging businesses can practice for eco-friendly operations. Certified businesses can receive subsidies related to the introduction of eco-friendly facilities and gain additional advantages through promotion. In addition, to allow tourists to easily check businesses that have received eco-friendly lodging certification, the certification mark can be displayed in connection with tourism information platforms or lodging reservation sites, and additional benefits can be provided to customers using eco-friendly lodging, thereby inducing consumer participation.

The criteria for granting the certification mark were selected in three areas as follows:

1. Facility Field: Whether energy consumption is being made efficient, whether facilities are composed of eco-friendly materials, whether eco-friendly information is being provided to guests, etc.
2. Product Field: Whether eco-friendly or fair-trade products are being used, whether savings are well practiced for waste minimization, whether recycling systems are well equipped, etc.
3. Transportation Field: Whether the surroundings are created in an environment-friendly manner, whether bicycle parking spaces or electric vehicle charging facilities are well equipped, etc.

c. Eco-Friendly Travel Platform Development

As can be seen from the previous data, people generally have a positive perception of eco-friendly products and services not only in daily life but also during the travel process. This shows that eco-friendly consumption is not just a trend but is establishing itself as an essential value for a sustainable life. 'CopenPay' implemented in Copenhagen could also be executed based on this perception and received good evaluations worldwide. Going beyond a simple campaign for an eco-friendly travel culture, it could provide practical benefits and induce active participation from tourists. In Jeju Island, there is a necessity to prepare a program for the coexistence and harmony of the local community and tourists, and by introducing this concept, a system is needed to induce tourists to naturally practice eco-friendly actions within the travel process itself. For example,

there are activities in which anyone can easily participate even during travel, such as using a tumbler at a cafe, using public transportation such as a bicycle or a bus, and voluntarily collecting trash generated during the trip. If a system is established where the province systematically rewards this instead of leaving it as an individual practice, tourist destinations will be managed more eco-friendly.

An online app or website dedicated to eco-friendly travel can be developed so that tourists can practice eco-friendly activities and verify them on the relevant platform or social media

If a tourist performs more than a certain number of eco-friendly missions, benefits such as Jeju Island limited-edition souvenirs, local store coupons, or discounts and free admission to major tourist attractions are provided. On the platform, various additional elements such as Jeju travel destination and restaurant recommendation guides, eco-friendly mission events, tourist communities, and real-time rankings can be added to induce tourists' interest and increase the participation rate.

| Conclusion and Future Directions

Jeju Island is currently facing a severe tourism waste problem, and an ironic vicious cycle continues where the environment is rather damaged by the people who come to admire the beautiful natural environment. The positive impact of the tourism industry on the Jeju economy is clear, but it is important to build a balanced tourism model that achieves harmony so that the opposing tasks of tourism vitalization and environmental protection do not clash.

To solve these problems, active interest and practice regarding sustainable tourism are required. Rather than a simple one-off policy, establishing an eco-friendly tourism system and changing tourists' awareness are important. Practical and effective policies in the mobility and lodging sectors, which are handled as the largest industries in the Jeju tourism industry, must be continuously pursued, and not only tourists but also local residents, businesses, and local governments must cooperate together to participate in protecting Jeju Island's nature. Beyond the dimension of simple environmental protection, these efforts will make a great contribution to continuously maintaining Jeju Island's unique charm and, furthermore, establishing it as a world-class eco-friendly travel destination.

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Ecosystem

05

Kim Seon-bin / Seoul National University

Carbon Absorption Methods through Blue Carbon and Ocean Forest Creation



"갯벌이 탄소 흡수원으로 인정받기 위한 노

하지만 갯벌은 (온실가스 배출·흡수량의 국제적
준이 되는) 현행 IPCC(기후변화에 관한 정부
국제) 지침에서 해당 부문 탄소흡수원으로
는 불투과성의 포함돼 있지 않다.

Decades of continuous development, land reclamation, and rising greenhouse gas emissions from growing fossil fuel consumption have accelerated global warming. Consequently, the frequency and intensity of extreme weather events—such as heatwaves, heavy rainfall, droughts, and sea-level rise—are steadily escalating, causing severe socio-economic damage worldwide. The climate crisis is no longer perceived as a challenge isolated to specific nations or regions, but rather as a collective task that humanity must address together; accordingly, carbon neutrality has emerged as one of the most critical environmental policy objectives globally.

To counter climate change, countries around the world have committed to reducing greenhouse gas emissions through international frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC, 1992), the Kyoto Protocol (1997), and the Paris Climate Change Agreement (2015), based on which they are executing diverse carbon neutrality policies. South Korea is also participating in these international efforts, having announced its 2030 National Greenhouse Gas Reduction Roadmap (2016) and the 2050 Carbon Neutrality Strategy (2020). Recently, interest has surged in carbon sequestration strategies leveraging natural ecosystems, beyond simply reducing carbon emissions.

The initial focus for carbon sequestration centered on green infrastructure and green carbon. Green carbon refers to the carbon captured and stored by terrestrial ecosystems, where carbon sequestration in nature primarily occurs through plant photosynthesis. The sequestered carbon is stored within the plant biomass or deposited into the soil in the form of litter, branches, and roots, where it is stored over long periods.

However, interest in blue carbon grew sharply following a joint report by the United Nations Environment Programme (UNEP), the Food and Agriculture Organization (FAO), and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), which revealed that approximately 55% of the carbon sequestered in nature is stored within marine ecosystems. Since then, the significance of blue carbon has garnered global attention, and related research and policy discussions have steadily accelerated since 2018.

Blue carbon denotes the carbon captured and sequestered by marine and coastal ecosystems. In particular, coastal wetlands such as mangroves, salt marshes, and seagrass meadows are known to store more than half of all blue carbon, with studies reporting that their carbon sequestration capacity per unit area is three to five times greater than that of terrestrial forests. Consequently, blue carbon is recognized as a core Nature-based Solution (NbS) for climate change mitigation, and countries worldwide are actively pursuing carbon neutrality strategies through the restoration and conservation of coastal wetlands.

Therefore, this project aims to focus on blue carbon—which has not yet received sufficient attention domestically—to explore methods that simultaneously achieve marine ecosystem conservation and the enhancement of carbon sequestration.

South Korea possesses tidal flats rich in blue carbon. Korean tidal flats (Getbol) are recognized as among the world's five most significant tidal flat ecosystems, representing highly valuable ecosystems characterized by outstanding biodiversity and rich habitats for diverse marine organisms. Domestic tidal flats store approximately 13 million tons of carbon and are known to absorb a minimum of 260,000 tons to a maximum of 490,000 tons of carbon dioxide (CO₂) annually. This is equivalent to the annual CO₂ emissions of approximately 200,000 passenger vehicles, and on a maximum estimated basis, it aligns with the annual carbon absorption volume of roughly 73.4 million 30-year-old pine trees.

The total area of South Korea's tidal flats spans approximately 2,482km², accounting for about 2.5% of the national land mass. Beyond functioning as simple carbon sinks, tidal flats provide multifaceted ecosystem services. They serve as habitats for marine organisms while simultaneously providing water purification, disaster mitigation, fisheries production enhancement, and cultural and tourism resources. According to research, the economic value of the ecosystem services provided by Korean tidal flats is estimated at approximately 18 trillion KRW annually.

Despite this immense value, tidal flats are not yet officially recognized as distinct carbon sinks under the Intergovernmental Panel on Climate Change (IPCC) guidelines. Because of this limitation, they are not actively integrated into national carbon sequestration policies, imposing constraints on securing budgets and policy support for conservation and management initiatives.

First, continuous land reclamation and infill projects for development have led to a steady decline in tidal flat acreage. According to the National Tidal Flat Area Survey conducted by the Ministry of Oceans and Fisheries (MOF), the domestic tidal flat area stood at 2,482 km² as of 2018, representing a decrease of 5.2km² compared to 2013. This reduction is approximately 1.79 times the size of Yeouido, indicating that the rate of decline has accelerated compared to previous survey periods. Once degraded, tidal flats require a substantial amount of time to recover their original ecological functions; hence, area reduction can lead to severe environmental issues.

Second, despite the critical timing that mandates the expansion of blue carbon research, the related budget has conversely been reduced. According to the 2024 budget proposal submitted by the MOF, the budget for tidal flat ecosystem restoration projects decreased by approximately 18.5% compared to the previous year. At a juncture where expanding scientific research and restoration projects is imperative, this fiscal reduction could negatively impact the vitalization of blue carbon initiatives.

Third, although the government has consistently pushed forward marine forest creation projects to increase carbon sequestration, persistent concerns have been raised regarding the insufficient post-project management.

A survey by the Korea Fisheries Resources Agency (FIRA) revealed that post-management was deficient in approximately 22% of the established marine forest sites. This underscores that constructing a continuous, long-term management framework is far more critical than simple initial creation.

Consequently, this project proposes a practically applicable promotion of blue carbon model targeted at Incheon Metropolitan City, the Korea Marine Environment Management Corporation (KOEM), and the Ministry of Environment (ME). The target site selected for this initiative is the Songdo tidal flat area in Incheon. Incheon City is currently developing a basic framework to designate this area as a National Urban Park, and the site is highly evaluated for its ecological value and strategic policy impact.

The Songdo tidal flat possesses the nation's largest blue carbon potential, featuring a total tidal flat area of 743km², an organic carbon stock of 4,923,784 tons, and an organic carbon accumulation rate of 34,425 tons per year. Furthermore, it exhibits high ecological value as a designated Ramsar wetland, hosting diverse wildlife that includes 10 natural monument species and 15 endangered species.

However, due to ongoing reclamation projects in the Songdo area, the acreage of tidal flats and salt marshes has been shrinking, which has precipitated a downward trend in the populations of benthos and migratory birds. As additional development plans exist for the future, proactive intervention for ecosystem conservation and restoration is strictly required.

To address this, the project proposes a primary strategy focused on ecological restoration utilizing tetrapods, which are pre-existing coastal structures. By reinforcing these existing structures with recycled materials such as oyster shells, the project aims to expand marine habitats and enhance ecological functions. Additionally, the introduction of *Salix subfragilis* (red-veined willow) will strengthen carbon sequestration and water purification capabilities while providing spawning grounds and shelters for fish and invertebrates.

The second strategy involves the deployment of artificial floating islands. Artificial floating islands provide new ecological spaces where aquatic macrophytes and diverse organisms can coexist, simultaneously performing water purification and carbon storage functions. Furthermore, they can contribute to enhancing biodiversity by expanding vegetative spaces that are otherwise deficient in urban coastal zones.

The third strategy centers on constructing an advanced management framework leveraging smart technologies. Periodic drone monitoring will enable continuous tracking

of changes in tidal flat area, vegetation distribution, and the generation status of marine debris. Furthermore, data-driven decision-making will enable the execution of more efficient and systematic restoration initiatives.

The fourth strategy is the establishment of citizen participation-based governance. To secure the long-term sustainability of climate change responses, infrastructure development must be accompanied by sustainable management frameworks. Therefore, the project aims to build a cooperative system involving public agencies, private corporations, civil society organizations, and local residents.

Prior to creation, public interest will be cultivated through blue carbon educational programs, student idea competitions, and tidal flat promotional ambassador programs. After creation, continuous engagement will be sustained by operating citizen monitoring teams, ecological experience programs, volunteer corps, and regular public hearings.

The vitalization of blue carbon holds the promise of a future that simultaneously achieves carbon neutrality and marine ecosystem conservation. This project has proposed four core strategies for the Songdo tidal flat: tetrapod utilization, artificial floating island deployment, smart technology-based management, and the establishment of citizen-participatory governance. Through these measures, multifaceted positive outcomes are expected, including an increase in blue carbon sequestration, the recovery of marine ecosystems, and mutual prosperity with local communities.

In terms of future development trajectories, the short-term focus will involve establishing pollution source management systems and implementing physical restoration projects. In the mid-term, focus will drive the founding of dedicated research institutes and the expansion of civic education programs. Over the long term, a more sophisticated management architecture will be realized by introducing autonomous surface vessels (ASVs) for marine debris collection and underwater robotics for marine ecosystem restoration.

In conclusion, blue carbon vitalization represents an effective strategy that enhances carbon sequestration capacity while simultaneously achieving marine environmental restoration and the sustainable development of local communities. If sustained scientific research and policy support are secured moving forward, blue carbon can become a core resource for South Korea's path to carbon neutrality, ultimately making a substantial contribution to building healthy marine ecosystems and a sustainable future society.

I Introduction

- Climate Crisis and Agriculture
- Low-Carbon Agricultural Technology Policy
- Problems and Limitations of Current Policies

I Body | Proposals for a Training Course for Carbon-Reducing Young Farmers

- Necessity of the Proposal (2050 Carbon Neutrality Scenario)
- Specific Solutions and Strategy
- Current Status of Related Systems and Case Studies

I Conclusion and Recommendations

I References and Sources

Agriculture

06

Hwang Jin-wuk / Kyungpook National University

Low Carbon Training for Young Farmers

Abstract

This paper was written from the perspective of a student studying agricultural science, highlighting the vital importance of cultivating carbon-reducing young farmers in the era of climate crisis. It provides a multi-faceted analysis of the processes through which young farmers practice eco-friendly agriculture and learn methodologies for greenhouse gas mitigation, thereby presenting pathways to contribute to the achievement of net-zero emissions targets. It proposes policy improvements such as specialized education for practicing carbon-reducing agriculture, government subsidy frameworks, and the implementation of innovative agritech, while emphasizing strategic directions for sustainable agriculture. Ultimately, this text underscores the significance of this training course as an essential paradigm shift for the future of the environment and agriculture by incentivizing the active participation of the youth.

| Introduction

a. Climate Crisis and Agriculture

Agriculture itself is identified as one of the key contributors to the climate crisis. Conventional high-input, productivity-oriented agricultural practices accelerate the application of synthetic fertilizers and chemical pesticides, precipitating a vicious cycle that contaminates soil and water resources while increasing greenhouse gas (GHG) emissions. As climate change intensifies, the agricultural ecosystem becomes increasingly vulnerable, threatening national food self-sufficiency targets.

Agriculture must now transcend simple primary production and establish itself as a core pillar of climate change mitigation. To achieve net-zero emissions and build a sustainable agricultural sector, the paradigm must shift away from conventional high-input, intensive agriculture toward a low-carbon structural framework. In this context, precision agriculture leveraging Information and Communications Technology (ICT) is emerging as a viable alternative. For instance, a farm in the Netherlands successfully utilized precision agriculture to increase productivity by 30% while reducing fertilizer application by 26% and water consumption by 18%.

The domestic agricultural sector must actively incorporate Data, Network, and Artificial Intelligence (D.N.A.) technologies to reduce agricultural inputs and mitigate environmental degradation. Concurrently, efforts must be driven to scale up eco-friendly farming practices and enhance the carbon sequestration capacity of soil and water resources. If contemporary agricultural practices do not transform, the climate crisis will inevitably accelerate. For a sustainable future, agriculture must pioneer this transformation.

b. Low-Carbon Agricultural Technology Policy in South Korea

The Rural Development Administration (RDA) is scaling up field-level implementation of digital technology-driven paddy water management techniques and establishing optimal fertilizer application standards to curb the use of synthetic fertilizers. Furthermore, the RDA is actively promoting the commercialization of low-carbon organic technologies, analyzing the mitigating efficacy of extending the mid-season drainage period from the conventional 1–2 weeks to over 2 weeks, and expanding shallow intermittent irrigation practices across farming sectors. Consequently, methane mitigation driven by paddy water management technology is projected to increase from 100,000 tons in 2021 to 240,000 tons in 2025, and reach up to 540,000 tons after 2030. An automated water gate system designed to effectively regulate paddy water levels is also scheduled for development by the end of this year.

In parallel, the optimization standards for fertilizer application aimed at reducing nitrogen fertilizer consumption will expand to cover 246 crops by 2025. Concurrently, the development and distribution of 'Green Rice'—a rice cultivar bred to maintain crop yields while reducing chemical fertilizer requirements—is accelerating the expansion of environmentally sound agriculture.

In the livestock sector, resource-recirculating technologies for livestock manure are being developed and deployed to minimize carbon footprints. This includes the development of domestic methane-mitigating feed additives, low-protein feed formulation technologies, and the introduction of precision livestock farming (PLF) utilizing ICT. Furthermore, the development of agricultural heating and cooling systems utilizing integrated thermal sources, such as solar photovoltaic (PV) and geothermal energy, is expanding the agricultural deployment of renewable energy. The commercialization of high-efficiency energy technologies to optimize energy efficiency is also steadily progressing.



2050 Targets by Core Task for Carbon Neutrality

Meanwhile, to address climate change in the agricultural sector, the RDA developed a carbon sequestration technology utilizing biochar pellets in 2018. Biochar is a carbon-rich material produced through the pyrolysis of livestock manure and agricultural byproducts. When incorporated into soil, it mitigates carbon emissions and improves the soil ecosystem, garnering significant attention as a greenhouse gas sink. Accordingly, field utilization across agricultural lands is expanding as studies verify biochar's soil-amendment effects and establish optimized application standards. Following the registration of the methodology under the voluntary emission reduction project last year, empirical validation was conducted from 2022 to 2023, and field-level distribution has been actively driven since 2024.

Research is also underway to evaluate the carbon sequestration capacity as well as the economic and environmental values of various low-carbon farming methods, including soil organic matter management, no-tillage (zero-tillage) practices, and winter cover cropping. Based on these findings, a practical field manual for agricultural soil carbon sequestration was compiled to support seamless execution by local governments and farming communities. Furthermore, the Ministry of Agriculture, Food and Rural Affairs (MAFRA) is jointly developing incentive frameworks, such as carbon credits, for agricultural households actively participating in GHG mitigation.



**Rural Development Administration
Carbon Neutrality Pilot Campaign**

To propagate carbon mitigation technologies across agricultural fields, institutional collaboration among central governments, local authorities, and the private sector is being reinforced. The RDA is expanding field verification projects by linking pre-established mitigation technologies, such as paddy water management and biochar application, with national pilot initiatives, thereby strengthening the cooperative framework between the Korea Agriculture Technology Promotion Agency (KOAT) and local agricultural research and extension services. In coordination with MAFRA, the commercialization of superior private-sector technologies is being driven forward, alongside the launch of the '3-Go Practice Campaign' (Increase value, Decrease emissions, Maintain sustainability) in partnership with local governments and agricultural organizations. This initiative provides

technical data to farmers and cultivates specialized personnel within city and county agricultural technology centers and extension officers, accelerating the mainstream adoption of low-carbon agricultural technologies.

The RDA secured a budget allocation of 26.8 billion KRW in 2022 for the research, development, and deployment of carbon-neutral agritech. By continuously expanding its R&D personnel dedicated to carbon neutrality, the administration is fully committed to realizing net-zero emissions across the agricultural and livestock sectors.

As such, while carbon neutrality represents a challenging task requiring a structural macroeconomic transformation across the entire agricultural sector, it has become an urgent imperative for agricultural sustainability. Driven by robust coordination and communication among the RDA, agricultural research institutes, farming communities, and consumers, efforts to realize carbon neutrality remain ongoing.

c. Problems and Limitations of Current Policies

The RDA conducted a survey targeting conventional farmers to assess their awareness and adoption willingness regarding climate change adaptation and greenhouse gas mitigation technologies. The scope of the survey encompassed farm management characteristics, climate change perceptions, current utilization status of GHG mitigation technologies, and willingness for adoption.

[Table 4-7] Farm Adoption Willingness by Technology

Category	Technology	Utilization (Willingness) Rate	Primary Reason for Utilization (Reason for Non-Adoption)
Rice Paddy	Intermittent Irrigation	82.4%	Lack of technical understanding (32.8%), Fear of yield reduction (32.8%)
	No-Tillage / Minimum Tillage	29.1%	Fear of yield reduction (47.4%), Lack of technical understanding (22.8%)
	Green Manure Cover Cropping	20.1%	Yield reduction (30.3%), Concerns over increased production costs (25.6%)
	Biochar Application	56.8%	Uncertainty regarding soil-amendment efficacy (45.5%), Lack of technical understanding of biochar-driven soil amendment (19.1%)
	Government Effort		Subsidies for initial capital expenditure (30.4%), Support for securing market channels (23.1%)
Protected Cultivation Facilities	Geothermal Heat Pump	9.9%	High burden of initial installation costs (70.0%)
	Multi-layer Insulating Curtains	23.3%	High burden of initial installation costs (65.2%)
	Circulating Water-Jacket Cultivation	28.6%	High burden of initial installation costs (58.6%)
	Government Effort		Subsidies for initial capital expenditure (35.5%), Support for securing market channels (22.9%)
Livestock	Composting/Liquefaction Co-utilization Facilities	51.4%	High cost of livestock manure treatment (37.3%), Lack of local co-utilization facilities (24.1%)
	Bioenergy Co-utilization Facilities	18.3%	High cost of livestock manure treatment (37.9%), Lack of local co-utilization facilities (30.0%)
	High-Quality Forage	64.0%	High price relative to quality (46.2%), Lack of understanding of what constitutes high-quality forage (38.5%)
	Methane-Reducing Feed Additives	69.7%	Among ruminant livestock farms unwilling to use: Concerns over rising operational costs (feed costs) (52.9%), Lack of understanding of methane-reducing feed additives (17.6%)
	Optimized Protein Feed Formulation	80.0%	Concerns over rising operational costs (feed costs) (47.4%), Lack of understanding of optimized protein feed or fear of productivity decline (15.8%)
	Government Effort		Direct incentives such as direct payments (27.6%), Public relations and education (23.8%), Subsidies for initial capital expenditure (23.4%)

The survey results revealed that the percentage of farmers acknowledging the necessity of GHG mitigation efforts was high, standing at 76.1% for rice paddy farmers, 77.6% for protected cultivation farmers, and 87.6% for livestock farmers. However, the recognition rate regarding specific carbon neutrality targets was relatively low, exhibiting particularly deficient levels among rice paddy farmers (31.0%) and protected cultivation farmers (38.6%). Regarding awareness of greenhouse gas emissions from agriculture and livestock industries, the proportion of respondents who answered 'somewhat knowledgeable' was also low, at 32.5% for rice paddy farmers, 39.5% for protected cultivation farmers, and 48.6% for livestock farmers.

When analyzing adoption willingness by mitigation technology, rice paddy farmers showed the highest receptivity toward intermittent irrigation (82.4%), protected cultivation farmers toward circulating water-jacket systems (28.6%), and livestock farmers toward optimized protein feed formulation (80.0%). However, the overall utilization rate of mitigation technologies remained depressed. The primary barriers cited by rice paddy farmers were 'concerns over yield reduction and increased production costs,' while protected cultivation farmers pointed to the 'burden of initial installation costs,' and livestock farmers highlighted 'concerns over rising operational costs' and 'expensive treatment costs.'

In particular, the data underscores that farming households exhibit exceedingly low participation rates in low-carbon agricultural support policies. This stagnation is primarily driven by the burden of initial capital expenditure (CapEx), a deficit of technical information, and a lack of tangible economic benefits. Consequently, to scale up the field integration of mitigation technologies, it is essential to expand CapEx subsidies, provide direct financial incentives, secure market channels, and reinforce public relations and training programs. Furthermore, the government must incentivize participation by formulating customized policies tailored to specific agricultural commodities and regional characteristics, developing and distributing novel mitigation technologies, and providing fiscal benefits such as tax exemptions.

Eligibility and Requirements

- Target: Farmers or agricultural corporations that were eligible for the basic direct payment in the immediate preceding year, are engaged in paddy farming, and can achieve economies of scale of 50 hectares or more including owned (or leased) flatlands.
- Note: "Agricultural Corporation" refers to corporations pursuant to Article 2, Item 2 of the Act on Fostering and Supporting Agricultural and Fisheries Business Entities. "Producer Organization" refers to organizations pursuant to Article 4 of the Framework Act on Agriculture, Rural Community and Food Industry.

To enhance the institutional efficacy of low-carbon agricultural policies, the active participation of diverse demographic cohorts of farmers is indispensable; however, the current policy framework presents high barriers to entry for young agricultural professionals. An examination of the eligibility criteria reveals that financial support is strictly restricted to agricultural corporations or producer organizations capable of consolidating paddy farming operations to a scale of 50 hectares or more, while also having qualified for the basic direct payment in the immediate preceding year.

For young farmers, however, accumulating initial capital and securing arable land is exceptionally difficult, and establishing a large-scale operational infrastructure requires significant time. Furthermore, young entrepreneurs launching agricultural startups or small-scale eco-friendly farms face practical hurdles in establishing corporate entities or gaining admission into established producer organizations. Consequently, these stringent requirements concentrate state support primarily around pre-existing large-scale farms and corporate agricultural entities, effectively blocking entry and participation opportunities for incoming young farmers.

To secure the long-term sustainability of low-carbon agriculture, flexible policy adjustments are required, such as lowering initial barriers to entry and introducing transitional buffers for land-scaling requirements, thereby ensuring that young farmers can access policy support. This structural flexibility will empower a diverse array of agricultural stakeholders to participate in the low-carbon agricultural transition.

| Body | Proposals for a Training Course for Carbon-Reducing Young Farmers

Therefore, to achieve the targets set forth in the agricultural sector's 2050 Carbon Neutrality Scenario and to establish a sustainable agri-food system, we formally propose the implementation of a Training Course for Carbon-Reducing Young Farmers to relevant ministries, including the Ministry of Environment and the Ministry of Agriculture, Food and Rural Affairs, as outlined below.

a. Necessity of the Proposal (2050 Carbon Neutrality Scenario)

Using net-zero mandates as a catalyst, the domestic agricultural sector is driving a transition into a low-carbon, eco-friendly industry. To achieve this, Phase 1 (by 2030) focuses on establishing low-carbon agricultural transitions and verified mitigation technologies; Phase 2 (by 2040) aims to improve the agricultural environment and expand the scale of GHG mitigation; and Phase 3 (by 2050) seeks to fully realize carbon neutrality

and sustainable agriculture.

To execute this roadmap, major GHG emission sources such as synthetic fertilizers, livestock manure, and coal energy are being systematically mitigated, while the expansion of renewable energy drives net-zero targets within the agricultural sector. Concurrently, high-input farming methods are being converted into low-input systems through the propagation of precision agriculture and the introduction of eco-friendly and ecological agricultural models. Ongoing initiatives include reducing chemical fertilizer and pesticide application, introducing low-carbon husbandry management such as low-methane feed formulation, and expanding the non-agricultural utilization of livestock manure. Furthermore, greenhouse gas mitigation is being driven by shortening food miles within the agri-food supply chain, improving dietary habits, and scaling up alternative food markets, while energy transitions are facilitated by deploying renewable energy via rural spatial planning frameworks.

At the policy level, the public-interest direct payment system is leveraged to provide financial compensation for GHG reduction activities. The government is also developing diverse business models linked to farm income generation, such as expanding mutually beneficial cooperation between farms and corporations and activating external transactions for carbon offset credits. Additionally, regional policies are being deployed to eliminate free-rider problems, establishing space-partitioned regional net-zero models capable of local resource recirculation. Furthermore, alongside the development of GHG mitigation technologies, the scientific foundation is being reinforced by sophisticated statistical and estimation methods for agricultural GHG generation, mitigation, and verification.

However, compared to the targets established in the 2050 Carbon Neutrality Scenario, the contemporary agricultural sector faces several critical limitations:

- First, the expansion of eco-friendly agriculture is delayed. Despite policy-driven nurturing of eco-friendly agriculture since the 2000s, as of 2020, eco-friendly cultivation acreage accounted for a meager 5.2% of the total arable land, which is severely depressed compared to advanced economies. Despite aggressive government support, chemical fertilizer consumption per unit area remains high due to farmers' conventional fertilization habits.
- Second, soil environment remediation is insufficient. Domestic agricultural soils face risks of acidification due to nutrient leaching from rainfall and heavy chemical fertilizer application, maintaining a highly elevated nitrogen balance. To remediate this, fertilization prescriptions based on soil testing results are issued to farmers to encourage optimized application rates; however, the land actually tested accounts for only 4% of total agricultural land, undermining the policy's efficacy.
- Third, mitigating food waste driven by shifting dietary habits is difficult. Structural

limitations exist in reducing food waste due to the rise in dining out and traditional culinary habits that favor lavish table settings. While food waste mitigation is a critical component for achieving carbon neutrality targets, substantive reductions have not materialized due to insufficient shifts in consumer patterns and public awareness.

- Fourth, the energy transition within the agricultural sector is lagging. Petroleum fuels account for 81.6% of the heating energy used in protected horticulture facilities, whereas renewable energy utilization stands at a deeply deficient 5.2%. In particular, despite systemic thermal loss occurring due to degraded cladding and insulation materials, efforts to optimize energy utilization efficiency remain insufficient.
- Fifth, the conversion of agricultural byproducts into bioenergy is deficient. Due to limitations on eligible biomass commodities, regional fragmentation, and surging collection and transportation costs, bioenergy conversion projects suffer from low economic viability. This economic stagnation acts as a structural impediment to lowering carbon emissions in the agricultural sector.

These multi-faceted limitations represent significant barriers to achieving the milestones set in the 2050 Carbon Neutrality Scenario, dictating a critical need for more aggressive policy optimization and field-level integration. Under these systemic constraints, the vast majority of currently active projects are tailored exclusively for established professional farmers. The most critical vulnerability is identified as the profound deficit of entry-level initiatives and experimentation channels for the youth—the future generation of agriculture.

b. Specific Solutions and Strategy

To propagate low-carbon agricultural technologies and cultivate specialized human capital, we propose the implementation of an open education program accessible to all. Previously, entry pathways into low-carbon agriculture were highly restricted. This program will expand educational access and enhance practical feasibility by recruiting specialized educators, including state-trained low-carbon agricultural technology certification auditors, relevant university professors, and senior researchers.



**Low-Carbon Agricultural Products
Certification Auditor**

The curriculum is structured into a three-phase system:

1. The Experiential Phase, focused on mastering the foundational concepts of low-carbon agriculture.
2. The Educational Phase, featuring advanced coursework designed to train individuals to propagate agritech.
3. The Settlement Phase, providing direct assistance to help participants grow into independent farmers through actual farming operations.

This phased approach ensures institutional sustainability by helping graduates establish themselves in agriculture while providing substantive employment and entrepreneurial opportunities. In particular, this initiative will connect with youth agricultural support projects operated by local governments to build educational infrastructure utilizing state-owned lands. By driving an influx of young professionals, it will simultaneously contribute to stimulating local commercial districts and mitigating rural depopulation.



Smart Farm Youth Startup Incubating Center

Furthermore, this program benchmarks the Smart Farm Youth Startup Incubating Center curriculum to deliver a structured timeline: short-term initiatives will provide agricultural high school and university students with opportunities to experience low-carbon farming; medium-term phases will build practical technical mastery through hands-on field training; and long-term tracks will deliver employment and startup support to cultivate specialized low-carbon agricultural experts.

The government will encourage enrollment by issuing official certificates or qualifications to students who complete this training course, while providing career incentives such as bonus points during corporate and public sector hiring processes. To expand public awareness of low-carbon agriculture, aggressive promotional strategies will be deployed via youth advisory councils and student ambassador programs.

Concurrently, to maximize the educational efficacy of the curriculum, hands-on field training synchronized with dynamic agricultural ecosystem shifts will be provided. The program will review methodologies to develop state-of-the-art low-carbon agricultural models by integrating smart agritech and precision farming systems. As climate change mitigation establishes itself as a critical international mandate, building innovative agritech distribution systems and educational frameworks for sustainable agriculture is imperative. Therefore, this program will expand youth entrepreneurship and employment leverage based on low-carbon agriculture, while reinforcing strategic coordination among the

federal government, local authorities, and the private sector to substantively contribute to carbon neutrality goals.

To execute this, the central government will oversee the curriculum and fully subsidize educational expenses; local governments will provide training facilities and infrastructure; and young agricultural professionals will acquire low-carbon agritech to participate in sustainable farming operations. Furthermore, this curriculum will transcend simple technical instruction, operating as a comprehensive training framework encompassing agribusiness management and supply chain logistics to ensure that the youth can achieve long-term economic stability in the agricultural sector. Ultimately, cultivating a next-generation farming cohort equipped with climate change mitigation capabilities will strengthen the structural sustainability of Korean agriculture and establish a pioneering model for carbon neutrality.

c. Current Status of Related Systems and Case Studies

To achieve South Korea's carbon neutrality goals, multi-sector policies are being implemented to accelerate low-carbon agriculture and sustainable rural revitalization.

- First, the Low-Carbon Agricultural Products Certification Auditor Training Course is an educational and licensing system administered by the Korea Livestock Environmental Management Institute (KLEMI), targeting specialists in livestock management and climate change response. The curriculum covers greenhouse gas mitigation and low-carbon agricultural technologies. Upon completion, participants can operate as certified auditors via a professional qualification exam, aiming to stimulate the low-carbon agricultural and livestock products certification system and accelerate the transition toward eco-friendly livestock industries.
- Second, the Smart Farm Youth Startup Incubating Center is an intensive program providing 20 months of field-centric training for young individuals aspiring to launch smart farms. Trainees master agricultural operations leveraging smart agritech. Upon graduation, they receive institutional benefits, including priority leasing rights for state-managed smart farms and startup capital subsidies, thereby supporting youth entry into agriculture and fostering sustainable agribusiness management.
- Third, the Carbon Neutrality Pilot District Initiative aims to establish resource-recirculating systems driven by local communities. In a joint venture, Chungnam Province and Korea Western Power Co., Ltd. will select five villages to install recycling assistance centers and operate community-driven action programs. This initiative is designed to induce municipal solid waste mitigation and stimulate local recycling practices, building a sustainable community model for carbon neutrality.

These integrated initiatives play a crucial institutional role in distributing low-carbon

agricultural technologies, expanding youth participation in farming sectors, and reinforcing the foundational infrastructure for community-level carbon neutrality.

| Conclusion and Recommendations

To realize carbon neutrality, the propagation of low-carbon agricultural technologies and the cultivation of young agricultural professionals are indispensable. To achieve this, open educational frameworks must be operated, delivering substantive employment and startup support through a 3-phase curriculum spanning experiential, educational, and settlement phases. In alignment with the Smart Farm Youth Startup Incubating Center, these initiatives must stimulate local commercial districts, supported by systematic frameworks driven by central-local-private coordination. Graduates must be granted official certifications alongside employment and entrepreneurial incentives to induce stable settlement in sustainable agriculture. Through a comprehensive curriculum and the integration of cutting-edge agritech, this initiative will contribute to the targets of the 2050 Carbon Neutrality Scenario while cultivating a next-generation farming cohort equipped with climate response capabilities. In solving the contemporary climate crisis, the youth are the ultimate key.

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I Introduction

- A. The Climate and Environmental Crisis Context
- B. Environmental Impact and Social Responsibility of the Food Industry
- C. The Necessity of Life Cycle Assessment (LCA) Analysis

II Body: Proposals for Achieving Net Zero in the Food Industry Based on LCA Evaluation

- A. Strengthening Eco-Friendly Food Certification Systems
- B. Promoting Local Food and Low-Carbon Diets
- C. Hosting Seminars on Food Waste Management

III Conclusion and Future Directions

IV References and Sources

Food

07

Song Su-min / Mason Korea

Environmental Protection through Life Cycle Assessment for Food Products

Abstract

This text analyzes the environmental impact of the food industry in a situation where the severity of the climate and environmental crisis is growing, and proposes solutions for sustainable development. It reveals that the food industry is a major industry causing problems such as greenhouse gas emissions, resource consumption, and food waste, and emphasizes the necessity of LCA (Life Cycle Assessment) analysis to solve these issues. Based on this, it proposes plans to achieve NET ZERO in the food industry. It suggests ① strengthening eco-friendly food certification systems, ② encouraging local food and low-carbon diets, and ③ hosting food waste management seminars. Through these strategies, it emphasizes that the environmental impact must be minimized throughout the entire process of the food industry, and a foundation for a sustainable future must be established.

| Introduction

a. Current Status of the Climate and Environmental Crisis

The issue of environmental degradation driven by industrial development is not a phenomenon that has emerged only recently. Discourse emphasizing the importance of environmental protection has consistently developed since the early stages of industrialization. As industrialization intensified, environmental pollution worsened, giving rise to visible international movements. In the late 19th century, the Nature Conservation Movement was conceived in the United Kingdom and the United States. In 1972, the United Nations Conference on the Human Environment (UNCHE) was convened in Stockholm, guiding international discussions on environmental protection into a formal institutional framework. Subsequently, the Kyoto Protocol in 1997 established legally binding targets for greenhouse gas (GHG) reduction, and the signing of the Paris Climate Change Agreement in 2015 further consolidated the international cooperative framework to mitigate global warming.

Recently, however, the severity and urgency of environmental problems have been highlighted at a qualitatively different level compared to the past. This shift occurs because the impacts of climate change and environmental pollution have progressed beyond the realm of scientific prediction and have materialized into visible, empirical phenomena. The climate science community warns that the global average temperature has already risen by approximately 1.1°C compared to pre-industrial levels, and an additional increase of 3~4°C is projected by 2100 if current GHG emission trends persist (IPCC, 2021). While environmental pollution was previously perceived as a localized issue confined to specific regions, the severity has intensified today to the extent that the impacts of climate change are felt on a global scale. Therefore, environmental pollution and climate change must no longer be defined as abstract warnings for the future, but rather as existential crises currently confronting humanity.



Figure 1. LA Wildfire (Source: Sports Donga)

Indeed, on the Korean Peninsula, an increasing trend in monsoon precipitation and a rising frequency of floods have been observed over the past five years due to the effects of climate change driven by global warming. In the United States, a massive wildfire that occurred in Los Angeles in January 2025 caused five fatalities, displaced more than 180,000 residents, and destroyed over 12,000 homes and buildings, resulting in catastrophic damage. Chronic drought and high temperatures induced by climate change were identified as the primary causes of this wildfire. The increasing frequency of these extreme weather events is being scientifically linked to anthropogenic GHG emissions. According to research in the field of climate attribution science, the probability of such extreme weather events occurring has increased several-fold to dozens of times due to climate change (Diffenbaugh & Barnes, 2023).

Confronting this reality, sustainable development and carbon neutrality are emerging as core policy agendas in the international community. The European Union (EU) has established a regulatory framework by introducing the Carbon Border Adjustment Mechanism (CBAM), which imposes tariffs based on the carbon emissions of imported products. Concurrently, the Republic of Korea announced the '2050 Carbon Neutrality Scenario,' presenting a concrete implementation pathway to achieve net-zero emissions. In parallel, global demand for Environmental, Social, and Governance (ESG) management has surged rapidly. Both institutional investors and consumers explicitly express their preference for eco-friendly companies, positioning ESG as a strategic variable directly linked to a firm's long-term competitiveness and market value (Friede et al., 2015).

b. Environmental Impacts and Social Responsibility of the Food Industry

While resolving environmental issues is recognized as an urgent task on a global scale, deriving and implementing concrete, effective solutions entails substantial difficulties due to the diversity of their causes and the complexity of their impacts. The food industry is classified as a representative sector that causes various environmental issues, including GHG emissions, resource consumption, and food waste generation. According to a large-scale meta-analysis by Poore & Nemecek (2018), which evaluated data from 38,700 farms, approximately 26% of global GHG emissions originate from the food system.

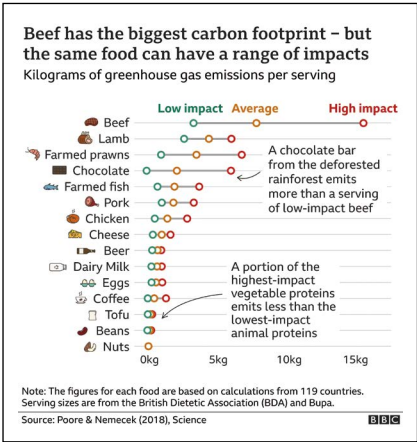


Figure 2. Carbon Emissions by Food Product (Source: BBC)

A subsequent study by Crippa et al. (2021) reported that this figure reaches as high as 34%. Such empirical evidence implies that the transformation of the food industry is an indispensable element in establishing a sustainable environmental framework.

Examining the environmental impacts across the entire life cycle of food—from production and consumption to disposal—through empirical examples reveals that the production of 1 kg of beef emits approximately 60 kg of carbon dioxide equivalent (CO₂e). Furthermore, animal-based foods account for approximately 57% of GHG emissions within the food system, whereas plant-based foods account for only 29% (Poore & Nemecek, 2018). This indicates that substantial carbon reductions can be achieved simply by changing dietary patterns. In addition, according to the Food and Agriculture Organization (FAO), approximately one-third of the food produced globally is wasted. A domestic survey conducted by Greenpeace also revealed that 78.1% of household plastic waste originates from food-related waste.

As such, the environmental impacts generated by the food industry are closely linked to our daily lives through various pathways. In particular, the food industry is a consumption sector in which the entire global population directly participates. Therefore, changes in consumption patterns possess the potential to generate more extensive and rapid environmental ripple effects than other industries. The EAT-Lancet report by Willett et al. (2019) demonstrated that a transition toward a sustainable and healthy food system could prevent 10.6 million premature deaths annually while ensuring sustainability within planetary boundaries. Furthermore, this transition can universally contribute regardless of economic development or national income levels, indicating that the normative and practical value of improving the food industry is immensely significant.

c. The Necessity of Life Cycle Assessment (LCA) Analysis

It is self-evident that the food industry can play a pivotal role in environmental protection; however, responding fragmentarily to individual issues makes it difficult to achieve fundamental solutions. As previously stated, the environmental problems induced by the food industry occur throughout the entire process, encompassing raw material production, processing, distribution, consumption, and disposal. Therefore, without a systematic approach that comprehensively considers these stages, it is difficult to derive effective solutions. Consequently, applying the Life Cycle Assessment (LCA) methodology is required to systematically quantify the environmental impacts of the food industry and to explore sustainable alternatives.

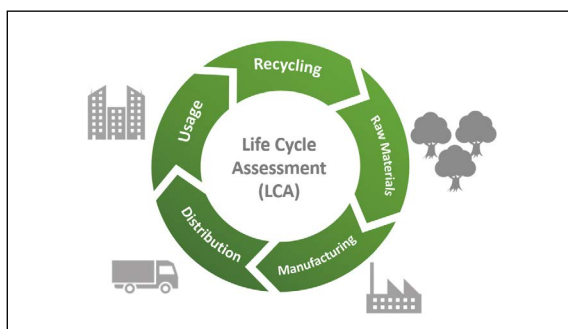


Figure 3. Life Cycle Assessment (LCA)

LCA is a methodology that quantitatively analyzes the environmental impacts occurring throughout the entire life cycle of a product or service. According to the ISO 14040 and ISO 14044 standards of the International Organization for Standardization (ISO), it is systematized into four stages: Goal and Scope Definition, Life Cycle Inventory (LCI) analysis, Life Cycle Impact Assessment (LCIA), and Interpretation. Through this process, specific stages where GHGs are excessively emitted or points where intense resource consumption is concentrated can be identified and improved, and the results can be utilized as scientific evidence for deriving eco-friendly alternatives. According to a study by Notarnicola et al. (2017), LCA has been discussed as the most reliable methodology for identifying environmental hotspots and establishing sustainability strategies in the agri-food sector.

Ultimately, by applying the LCA methodology to the food industry, the environmental impacts of individual food products can be evaluated based on quantified evidence, enabling the formulation of more systematic and effective environmental protection strategies. To achieve Net Zero, it is essential to secure the circularity and sustainability of the entire system beyond simple emission reductions. By integrating LCA with circular economy principles, an integrated food system transformation strategy can be established to simultaneously pursue waste minimization and resource efficiency (Ingrao et al., 2025).

| Main Body: Proposals for Achieving Net Zero in the Food Industry Based on LCA Evaluation

To realize universal and sustainable environmental protection, a structural transition across the entire industry is required beyond individual-level practices. Particularly in the

food industry, which imposes a profound burden on the environment, a paradigm shift toward a more sustainable approach must be implemented urgently. Accordingly, the three measures proposed in this section correspond to different stages of LCA analysis—namely production, distribution/consumption, and disposal/recycling—and should be designed to encourage the participation of multi-layered actors, including policymakers, corporations, and consumers.

a. Strengthening the Eco-Friendly Food Certification System

Although eco-friendly food certification systems are already operational domestically, the establishment of clearer and more intuitive evaluation criteria based on LCA evaluations must be pursued concurrently to promote the diffusion of sustainable production methods. In particular, as evidence-based regulatory frameworks, such as the EU's Carbon Border Adjustment Mechanism (CBAM), are introduced by various countries, the reform and advancement of relevant domestic systems are required.

The current 'Eco-Friendly Agricultural Product Certification System' managed by the Ministry of Agriculture, Food and Rural Affairs is structured to grant certification to products that satisfy production method criteria, such as pesticide-free or organic farming. A low-carbon agricultural product certification system is also in operation to induce carbon emission reductions. However, these certification systems focus primarily on production methods rather than quantitatively evaluating carbon emissions throughout the life cycle, which imposes structural limitations on consumers' ability to intuitively perceive the environmental impacts of products.



Figure 4. The Currently Implemented 'Eco-Friendly Agricultural Products Certification Scheme'

To resolve these issues, the introduction of an LCA-based eco-friendly food certification system should be actively considered. The Eco-Score label system, which is being pilot-operated in EU countries such as France and Belgium, displays the environmental impacts of products using an A–F color-coded rating method, and empirical evidence has reported that it exerts a significant influence on consumers' eco-friendly purchasing behavior (Grasso & Asioli, 2021). Similarly, this proposal suggests the introduction of a traffic-light environmental labeling system that indicates high carbon emissions in red, medium levels in yellow, and low-carbon products in green.

Concurrently, an institutional support system must be implemented to enhance the effectiveness of the certification system. According to a literature review by Rondoni & Grasso (2021), carbon footprint labels exert a more significant effect on purchasing behavior when integrated with consumer education programs than when applied in isolation. Furthermore, a systematic review by Potter et al. (2021) empirically confirmed that environmental sustainability labels have a statistically significant effect on consumer product selection. Therefore, tax incentives and research and development (R&D) support should be provided to corporations that obtain eco-friendly certifications, while systematically operating eco-friendly food education programs for consumers to enhance the social acceptance and policy effectiveness of the certification system.

b. Promoting Local Food and Low-Carbon Diets

The current food industry emits substantial amounts of carbon not only during the production stage but also throughout the distribution and consumption processes. In addressing these problems structurally, policies related to local food can function as crucial policy instruments. Existing domestic policies regarding local food include the operation of direct local food stores, support for eco-friendly school meals, and the low-carbon agricultural product certification system. However, the current low-carbon certification has a methodological limitation, as its scope of analysis is restricted to the agricultural production stage, meaning that carbon emissions generated during distribution and consumption are not sufficiently reflected. According to a domestic empirical study by Kim et al. (2024), expanding local food consumption in South Korea could reduce transportation-sector GHG emissions by approximately 2.5%, which is estimated to be equivalent to an economic value of approximately 54.23 million USD (approx. 70.5 billion KRW).

Beyond domestic cases, 'Oisix ra daichi' in Japan operates an upcycled subscription service utilizing local food, achieving a reduction of 3.5 tons of food loss within approximately 2.5 months of its launch. In the Netherlands, the EET program supports both eco-friendly agricultural cultivation and the economic profitability of farmers, thereby inducing voluntary participation. As demonstrated, successful local food policies yield

significant policy implications in that they generate multidimensional benefits beyond merely shortening distribution distances, such as vitalizing regional economies, reducing food waste, and raising consumer awareness (Mistry et al., 2016).



Figure 5-6. Oisix ra daichi Products (Source: Oisix ra daichi Official Website)

Along with improvements in the production stage, promoting low-carbon diets within consumers' daily eating habits must be pursued concurrently. According to a study by Springmann et al. (2018), transitioning to a Mediterranean or vegetarian-oriented diet can reduce food-related GHG emissions by up to 70%. Clark et al. (2019) identified that increasing the proportion of plant-based protein intake is the most effective single action for reducing an individual's carbon footprint. Notably, Tilman & Clark (2014) emphasized that transitioning to plant-based diets is indispensable to satisfy the increasing global food demand by 2050 while simultaneously mitigating environmental impacts.

Accordingly, the following concrete policy measures are proposed:

- Mandate LCA-based carbon emission evaluations for local food distribution to quantitatively reflect the carbon contribution of the distribution process.
- Provide differential carbon reduction subsidies to restaurant businesses and distributors that utilize local foods with low carbon emissions.
- Provide differential regional currency reward points to consumers who purchase local food evaluated via LCA, and grant additional reward points when purchasing visually imperfect ("ugly") produce that would otherwise be discarded due to low marketability, thereby aiming to simultaneously reduce food waste and carbon emissions.
- Promote public-private partnership projects that propagate low-carbon diet recipes utilizing seasonal local produce through social media, targeting youth engagement

c. Hosting Food Waste Management Seminars

Waste management and environmental protection represent crucial policy challenges

worldwide; however, the effective management of food-related waste remains insufficient in many countries. According to FAO (2023) statistics, the annual global generation of food waste reaches approximately 60.85 million tons. The fact that the gap in waste generation between developed nations (approx. 804 million tons) and developing nations (approx. 768.6 million tons) is not substantial implies that the waste issue is a universal, structural challenge independent of economic development levels (Rahman et al., 2024). In this context, South Korea has established itself as an international model in waste management through its strict separate discharge regulations and advanced recycling systems.

Therefore, this proposal suggests hosting policy seminars to share South Korea's successful waste management experiences with the international community. Through a literature review, Wang et al. (2023) verified that the food waste policy experiences of developed countries provide substantial contributions to policy formulation in developing countries. Carmona-García et al. (2024) also emphasized that international knowledge sharing and cooperation contribute to achieving the Sustainable Development Goals (SDGs) through a comparison of eco-innovation policies related to food waste between the EU and ASEAN countries.

The core agendas that should be addressed through the seminar are as follows:

- **Presentation of South Korea's Separate Discharge and Recycling Policies:** This includes analyzing the roles of the central and local governments, the structure of support policies, and the effectiveness of separate discharge regulations.
- **Discussion on LCA-Based International Waste Management Standards:** Discuss policy directions for LCA-based waste management applicable worldwide and develop a common international standard framework.
- **Development of Tailored Separate Discharge Guidelines for Participating Countries:** Korean experts and policymakers from participating countries will jointly establish implementation guidelines aligned with the specific conditions of each nation.
- **Field Inspections and Technological Exchange:** Promote practical technology transfers by visiting recycling processing facilities and food waste resource recovery facilities.

Furthermore, regarding the selection of participating countries, it is desirable to prioritize



Figure 7. Recycling Guidelines
(Source: Ministry of Environment)

inviting developing nations with weak waste management infrastructure to support the enhancement of their policy capacities. This will raise international recognition of South Korea's environmental technologies and policies while establishing an independent Green ODA model that links Official Development Assistance (ODA) with environmental diplomacy. In addition, the outcomes of the seminar must be actively connected with international agreements, such as the global food waste reduction initiative '10×20×30,' to guarantee policy continuity and sustainability.

Conclusion and Proposals for Future Development Directions

Environmental protection must no longer be defined as an optional consideration but as a civilizational imperative, and securing the sustainability of the food industry must establish itself firmly as a core pillar of climate change response strategies. To achieve this, the LCA methodology must be actively utilized to systematically quantify the environmental impacts occurring across the entire life cycle of the food industry, and effective policy interventions must be implemented based on these data.

The three measures presented in this proposal—▲ strengthening the eco-friendly food certification system, ▲ promoting local food and low-carbon diets, and ▲ hosting food waste management seminars—are organically linked to the major stages of LCA analysis and are based on policy instruments with realistic applicability. While these three measures are effective individually, their synergy in reducing carbon emissions across the food system can be maximized when they are implemented in a complementary manner.

In the future, academic research and policy development for a sustainable food industry must be further vitalized, and governments, corporations, and consumers must cooperate to expand actions for environmental protection. In particular, to enable data-driven policy design, a national infrastructure must be constructed to establish and regularly update an LCA database spanning the entire supply chain of the domestic food industry. Furthermore, market transparency and corporate environmental accountability should be strengthened by institutionalizing a mandate for food corporations to disclose LCA analysis results as part of their ESG management (Friede et al., 2015). To realize this, systematic datasets regarding the resources used and carbon emissions generated throughout the entire production, consumption, and disposal processes must be established for each food category. Along with this, operating tailored education programs for each life cycle stage is essential to raise consumer awareness and enhance practical capacities. Through this comprehensive approach, realizing Net Zero targets and constructing a sustainable food system will become possible, ultimately leading to

a substantive transition toward a sustainable future where humanity and ecosystems coexist.

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Proposals from Future Generations for a Net-Zero Future

7th Cohort Proposal Collection



7th

Platform	A Net Zero Journey Starting with a Single Receipt	91
	----- Go Ha-nim / Kyung Hee University	
Resource Circulation	A Convenience Store-Based Used Battery Collection and Carbon Point System for Sustainable Development	101
	----- Kim Tae-gyu / Pusan National University	
Policy Proposal	Illegal Burning: Heating Rural Communities and the Planet	115
	----- Kim Ha-eun / Jeonbuk National University	
Marketing	Green Marketing 2.0: Rethinking Advertising Language	125
	----- Yang Ji-min / Hankuk University of Foreign Studies (Seoul)	
Resource Circulation	Reducing Carbon Emissions through Lower Ink Usage in Cans	135
	----- Seo Myung-hoon / Kangnam University	
Platform	A Carbon-Neutral Thermal Platform Utilizing Subway Station Waste Heat	143
	----- Lee Yeon-woo / University of Seoul	
International Cooperation	Policy Recommendations for Eco-Tourism Development Cooperation in Southeast Asia	155
	----- Lee In-hye / Seoul National University	

I Introduction

- Growing climate and environmental crisis and the need for action
- Recognizing the Problem of Paper Receipts
- The Need for Electronic Receipts and Limitations

I Body

- Development of a Government-Led Integrated E-Receipt Platform
- Introducing the K-Ecolog Initiative
- Encouraging Participation of Digitally Vulnerable Groups
- Carbon Point Donations and Social Dissemination
- Collaboration with Public Institutions

I Conclusion

I References and Sources

Platform

01

Go Ha-nim/ Kyung Hee University

A Net Zero Journey Starting with a Single Receipt

Abstract

This paper, written from the perspective of a future generation living in the climate crisis, examines the environmental problems caused by paper receipts and proposes K-Ecolog, an integrated electronic receipt platform, as a solution. This explores the limitations and challenges of the current electronic receipt system and discusses the need for a new platform that includes participation ideas for digitally vulnerable groups and a carbon-point donation system. Then it introduces the objectives and key features of K-Ecolog, emphasizing that effective operation requires close cooperation among public institutions. Ultimately, it argues that the widespread adoption of electronic receipts is a crucial step toward reducing carbon emissions and fostering a sustainable consumption culture.

| Introduction

a. Growing climate and environmental crisis and the need for action

Climate change is a global issue that transcends national borders, and its impacts are becoming increasingly severe. The summer of 2025 was recorded as the hottest summer in the Republic of Korea. The monsoon season brought unprecedented rainfall that caused widespread flooding and significant damage. As such, the climate crisis is not a problem unique to the Republic of Korea, but a common challenge faced by the entire world.

The climate crisis will continue to affect both current and future generations. Rising food insecurity, risks to human health, and residential flooding are already becoming everyday realities. Scientists have also warned that if the global average temperature rises by more than 2°C above pre-industrial levels, the consequences could exceed humanity's capacity to adapt. To prevent this, the international community has been strengthening its efforts to work together. For example, at the 2022 G7 Summit in Germany, leaders launched the Climate Club to support the goals of the Paris Agreement and accelerate industrial decarbonization. It reflects a shared determination among countries to reduce greenhouse gas emissions.

The Republic of Korea has also pledged to achieve carbon neutrality by 2050 and is implementing a wide range of policies. Ultimately, the climate crisis is a reality that we must confront together, and proactive action to address it is the only way to safeguard both the present and the future.

b. Recognizing the Problem of Paper Receipts



무의미하게 폐기되는 종이 영수증

Even as digital transformation accelerates, paper receipts continue to be printed in large volumes. In everyday transactions at convenience stores, supermarkets, cafés, and other retail establishments, receipts are often printed automatically and discarded without even being checked. However, many of these receipts ultimately become unnecessary waste, reflecting a consumption habit with little lasting value.

The issue with paper receipts extends beyond simply generating unnecessary waste. First, paper receipts pose a significant environmental burden as they cannot be recycled.

Receipt thermal paper contains endocrine-disrupting substances such as bisphenol A (BPA) due to its special coating process. In addition, they are often disposed of as general waste and subsequently incinerated or landfilled. Therefore, municipal wastes increase and could further aggravate the waste disposal crisis.

Second, the disposal process generates greenhouse gases and harmful pollutants. According to data from the Ministry of Environment, approximately 12.9 billion paper receipts were issued in 2018 alone, generating nearly 10,000 tons of waste. The carbon footprint of a single receipt is estimated at approximately 1.8 grams of CO₂, resulting in an annual domestic total of around 22,000 tons of carbon emissions in 2018. Incinerating paper receipts releases carbon dioxide into the atmosphere. In addition, endocrine-disrupting chemicals can leach into soil and water when paper receipts are landfilled. Therefore, paper receipts are more than just a small piece of waste, representing a significant environmental concern.

Third, the production of paper receipts requires significant resources and contributes to deforestation. Producing paper receipts required the felling of approximately 128,000 trees in 2018. Trees are a vital resource for mitigating climate change by absorbing carbon dioxide. Unsustainable logging diminishes this capacity, contributing to a faster buildup of greenhouse gases in the atmosphere. Ultimately, paper receipts not only generate carbon emissions throughout their issuance and disposal processes, but also reduce the planet's carbon sinks, creating a vicious cycle, worsening the climate crisis.

Finally, paper receipts carry both economic and social costs. According to 2018 data, the 12 retailers that signed an agreement with the Ministry of Environment in 2019 to expand the use of electronic receipts accounted for 11% of all paper receipts issued in the Republic of Korea, totaling approximately 12.8 billion receipts annually. When accounting for, printer maintenance, and operating costs, this amounted to hundreds of billions of won in social costs every year. Small business owners must bear the costs of printer maintenance and thermal paper replacement, while large corporations and retailers are also unable to avoid substantial expenses. Despite this, sufficient institutional measures and efforts to raise consumer awareness aimed at reducing receipt issuance have yet to be implemented.

Therefore, the issue of paper receipts goes beyond a mere consumer habit. It is a structural challenge that must be addressed during the transition to a resource-circulating society in the face of the climate crisis. Expanding the use of electronic receipts can become a key solution that not only enhances convenience but also reduces environmental impacts, carbon emissions, and social costs at the same time.

c. The Need for Electronic Receipts and Limitations

To address paper receipt waste, the Republic of Korea has actively promoted electronic receipts. Electronic receipts offer economic and administrative benefits, including lower printing and storage costs, reducing risk of loss or damage, and digital data storage, while improving the convenience of record keeping and verification. They are also gaining attention as a way to reduce the environmental impacts associated with the thermal paper, ink, and disposal processes required for paper receipts. In fact, the Ministry of Environment and the Korea Environment Corporation are promoting the adoption of electronic receipts through the Carbon Neutrality Points Program. In addition, the “100 won incentive per electronic receipt” has been widely adopted by major retailers and food service companies, including Starbucks Korea, E-Mart, and S-OIL.

Above all, electronic receipt programs are well justified from both institutional and environmental perspectives. First, the revised Seoul Ordinance on Carbon Neutrality and Green Growth (May 2025) provides a legal basis for promoting electronic receipts by authorizing financial and administrative support, as well as education and awareness campaigns to reduce paper receipt use.

Second, it can directly contribute to achieving the Republic of Korea’s 2030 greenhouse gas reduction target. The waste sector currently aims to reduce emissions by approximately 9.1 million tons by 2030. Replacing the approximately 18 billion paper receipts issued annually (as of 2022) with electronic receipts could reduce emissions by about 8 million tons, accounting for roughly 4% of the national reduction target. This shows that electronic receipts can serve as a meaningful carbon reduction measure, not merely an administrative efficiency initiative.

However, it is necessary to examine whether electronic receipts are being implemented in a sustainable way. The current domestic electronic receipt system faces three major limitations. The first one is system fragmentation. Currently, electronic receipt services are fragmented across card companies, retailers, local governments, and government platforms. So, consumers may be confused about where to check and redeem their carbon points. In fact, participating company information and point tracking are handled by the Korea Environment Corporation, while retailers use their own apps and point systems, and local governments operate through local currency programs. This undermines accessibility and convenience for consumers, making it more difficult to encourage participation in the carbon points program.

Body

Consumption is an essential part of everyday life. Therefore, it is necessary to foster new consumption habits that reduce carbon emissions by promoting a sustainable culture of consumption. To this end, I propose an electronic receipt system aimed at storing receipt data and reducing carbon emissions, as outlined below.

a. Development of a Government-Led Integrated E-Receipt Platform

To ensure the effectiveness and widespread adoption of electronic receipts, it is essential to establish a government-led integrated platform. Currently, electronic receipt systems provided by credit card companies, franchises, and individual stores are operated separately. This creates inconvenience, and the lack of integrated management also limits the impact of carbon reduction efforts. If a government-led integrated platform appears, citizens could automatically receive electronic receipts after purchases. Then, consumers would be able to conveniently access and manage them through a government-certified system. Furthermore, just as Government24 functions as a central hub for public services, the e-receipt platform could serve as a one-stop platform that allows users to issue, store, and access e-receipts, while also earning, redeeming, and donating carbon points. Beyond serving as a record-management system, such a platform could become a credible national indicator for monitoring and assessing carbon reduction outcomes. In addition, users would be able to track how the carbon points they accumulate are reinvested for social benefit. This would provide a stronger incentive for participation than financial rewards alone. Ultimately, a government-led integrated e-receipt platform would improve public convenience while serving as a critical foundation for the transition to a carbon-neutral society.

b. Introducing the K-Ecolog Initiative

Based on this, I propose K-Ecolog, a government-led integrated e-receipt platform. K-Ecolog, derived from Korea, Eco, and Log, aims to be a national eco-friendly platform centered on e-receipts. Its primary objective is to establish an e-receipt system that enables participation by both consumers and small businesses. It also seeks to leverage consumption data not merely for record-keeping, but to drive charitable giving and carbon reduction. In other words, K-Ecolog transforms everyday consumption into environmentally responsible action, creating a virtuous



K-Ecolog 운영 시안

cycle in which carbon reduction and social giving reinforce one another. Citizens can enjoy better convenience and transparency in tracking their consumption while contributing to the collective effort to reduce carbon emissions.

K-Ecolog provides four key functionalities. The first is “E-Receipt Access.” Through this, users can view their e-receipts for 30 days by default, with optional storage and access for up to one year. The second feature is “Carbon Point Rewards and Donations.” Through this, users can track their accumulated points and choose how much they would like to donate. The third one is “Carbon Point Conversion and Donations.” Through this, users can redeem their points as local currency or contribute them directly to carbon reduction projects and research programs. The final feature is “Carbon Reduction Tracking.” By seeing the impact of the projects they support, users are encouraged to continue their environmental actions.

In this way, K-Ecolog is more than just an e-receipt platform. First, the carbon point system enables small individual actions to collectively generate meaningful carbon reduction outcomes. Second, users can donate their points to environmental research and projects, driving green innovation. Third, linking carbon points to local currency supports local economic growth. Finally, it promotes social inclusion by ensuring participation from digitally disadvantaged groups. Therefore, K-Ecolog would function as a government-led sustainability platform that promotes environmental protection, innovation, local economic growth, and social inclusion.

c. Encouraging Participation of Digitally Vulnerable Groups



디지털 취약 계층을 위한 디자인

One of the greatest challenges in the widespread adoption of e-receipts is the risk of excluding digitally vulnerable groups, including older adults and people with disabilities. These groups may be unable to fully benefit from e-receipts due to limited digital literacy or difficulties using smartphones and mobile applications. In light of these concerns, some argue that paper receipts should be maintained alongside e-receipts. However, this would reduce the effectiveness of e-receipt adoption. Moreover, it would make it difficult to fully phase out paper receipts. Therefore, it is essential to design the system in a way that enables digitally vulnerable groups to participate actively.

First, provide a large-text viewing option. Offer large-text and high-contrast modes to ensure easy access for users with visual impairments. In addition, introduce an ARS voice

guidance service for users who are not familiar with using smartphones. This would allow users to access their electronic receipts or check their carbon points with a simple phone call. If kiosk-linked services are also provided at public institutions, banks, hospitals, and community centers, even people without smartphones can easily access the system.

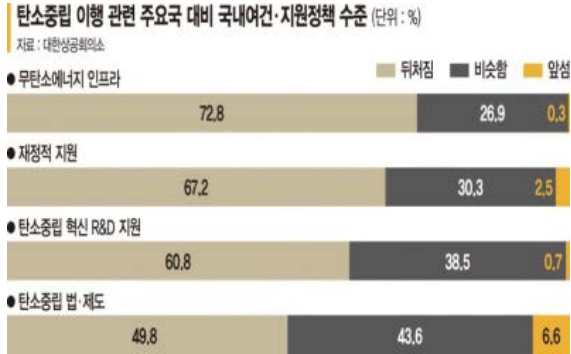
Furthermore, it is important to provide electronic receipt education programs at the community level. Staff at welfare centers, community centers, and hospitals can explain how to use electronic receipts and operate support desks that assist with initial registration and app installation. This can significantly increase participation among vulnerable groups while also improving public awareness. Through these efforts, the electronic receipt system can evolve from a policy primarily used by younger generations into an inclusive initiative that encourages participation from people of all ages and backgrounds. This will ultimately contribute to reducing digital inequality and strengthening social cohesion.

d. Carbon Point Donations and Social Dissemination

The Republic of Korea has committed to achieving carbon neutrality by 2050. However, the Republic of Korea continues to lag behind other major economies in carbon-free energy infrastructure, financial support, carbon-neutral R&D, and the legal and institutional foundations for achieving carbon neutrality. In particular, carbon-free energy infrastructure (0.3%) and research and development support (0.7%) remain underdeveloped.

To address these challenges, government policy alone is not enough. Active participation from the private sector and building public consensus are also essential. To this end, I propose introducing a carbon point donation program. Carbon emissions reduced through the use of electronic receipts are converted into points. Then, these points can be donated, creating a virtuous cycle through small-scale contributions. Successful examples can already be found domestically. For example, the city of Gangneung donated incentives earned through carbon points to 122 environmentally vulnerable households. By this, it advanced both environmental awareness and social welfare within the local community.

In addition, Naver's Happy Bean platform allows users to convert small amounts of accumulated points into "Beans" and donate them to social initiatives, attracting strong public participation. These examples suggest that small-scale giving is already well established in Korea. Like these examples, Korea has already developed a strong culture of small-scale charitable giving. Therefore, a carbon point donation program can go beyond encouraging charitable giving and develop into an environmentally responsible ecosystem that links individuals, communities, and the nation.



First, individuals can easily contribute through their everyday consumption, making environmentally responsible behavior a part of their daily lives. Second, communities can use donated points to support vulnerable groups and implement environmental projects, creating tangible and meaningful change. Third, at the national level, accumulated donation data can be used to quantify carbon reduction outcomes and report progress to the international community, strengthening the credibility of the country's carbon neutrality efforts. Ultimately, carbon point donations can evolve beyond a simple environmental policy into a citizen-driven model of social innovation. While each donation may be small, the collective impact can be substantial when large numbers of people participate. This can serve as a social catalyst for accelerating the transition to a carbon-neutral society.

e. Collaboration with Public Institutions

For the K-Ecolog platform to be successfully established, close cooperation among relevant public institutions is essential, in addition to strong government leadership. First, the Ministry of the Interior and Safety should serve as the lead agency responsible for developing and overseeing the integrated electronic receipt platform, drawing on its experience operating Government24.

This would provide a trusted public electronic receipt system for both citizens and businesses while ensuring data security and reliability. The Ministry of Environment would then integrate the existing Carbon Point Program with the platform and oversee the management of point donations and the reporting of carbon reduction outcomes. This would enable objective evaluation of carbon reduction outcomes and maximize their broader social impact.

In addition, the Ministry of Economy and Finance would play a key role in securing funding and designing the program framework. By linking carbon points with local currencies, the

program can convert them into tangible economic value. It can also encourage voluntary public participation by providing financial support to increase the value of the points. Finally, the Ministry of SMEs and Startups would oversee integration with small business POS systems and implement related support programs. By this, the foundation can be established for the seamless issuance of electronic receipts at stores nationwide. When each institution fulfills its respective role and contributes its expertise, K-Ecolog can become a natural part of everyday life and evolve into a sustainable environmental policy with long-term impact.

| Conclusion

K-Ecolog goes beyond simply replacing paper receipts. It lays the foundation for a broader social transition in which everyday consumption becomes a form of environmental action. Beyond its direct impact of reducing waste generated by paper receipts, K-Ecolog offers a broader approach to advancing sustainability. It also encourages individuals to contribute to net-zero goals through their everyday actions by enhancing carbon point incentives and introducing a donation system. In addition, as an inclusive platform accessible to all citizens, including digitally vulnerable groups, it can enhance public acceptance of environmental policies. Furthermore, by supporting the collective effort to build a net-zero society, it can strengthen public trust. Today, policies that fail to consider the environment are increasingly losing their place in the market and society. Therefore, K-Ecolog should be strongly promoted as a national model for advancing a sustainable future.

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1. Background of the proposal
2. Current Policies and Limitations
3. Proposed Idea
4. Institutional Justification
5. Expected Benefits
6. Conclusion

Resource Circulation

02

Kim Tae-gyu / Pusan National University

A Convenience Store-Based Used Battery Collection and Carbon Point System for Sustainable Development



ESG E(환경) 부문 실적 확보
+ CSR 활동 사례로 활용 가능
-기업 정부 시민이 협력하는
3자 거버넌스 모델 구축

1. Background of the proposal

Today, the issue of waste batteries should be viewed as a critical challenge that extends beyond waste management. It must be understood within the broader context of addressing climate change and advancing the transition toward a circular economy.

Batteries are one of the most common single-use power sources used in everyday life, powering devices such as TV remote controls, air conditioners, toys, and wireless computer mice. Thus, used batteries should be properly collected and recycled after use. In reality, however, many people are unaware of how to properly dispose of used batteries. Moreover, due to poor collection infrastructure, a large number of used batteries are still being landfilled or incinerated with general household waste. The environmental consequences arising from these disposal processes are too significant to ignore.

According to statistics from the Ministry of Environment, more than 20,000 tons of waste batteries are generated each year. However, data from the Korea Battery Recycling Association show that the recycling rate for manganese and alkaline batteries was only about 31% in 2022. In other words, approximately two out of every three batteries are still not recycled and are released into the environment. Such a low collection rate contributes to both resource loss and increased greenhouse gas emissions. Although waste batteries do not emit carbon directly, they generate significant indirect greenhouse gas (GHG) emissions during landfill disposal and incineration. Incineration can release carbon dioxide (CO₂), along with harmful substances such as nitrogen oxides (NO_x) and dioxins, thereby contributing to air pollution. Also, when waste batteries are disposed of in landfills, heavy metals like mercury, lead, and cadmium, can leach into soil and groundwater. This can pose long-term risks to ecosystems and human health. Thus, the proper collection and recycling of waste batteries are essential to protecting environmental safety.

This issue is not unique to the Republic of Korea but is also a shared global challenge.

The European Union (EU) already established requirements for the collection and recycling of used batteries through the Battery Directive in 2006. It also set strict collection targets for its member states, requiring a minimum collection rate of 45% by 2025. Japan has also established collection points at convenience stores and drugstores through partnerships between local governments and private companies. This has made it easier for consumers to dispose of used batteries as part of their daily routines. These international examples show that the Republic of Korea's low collection rate stems from shortcomings in policy design and the lack of collection systems integrated into daily life, rather than infrastructure alone.

In the Republic of Korea, waste battery collection is currently concentrated in public facilities such as schools, apartment complexes, and community centers. However,

these collection locations often do not align with citizens' daily routines due to the growing number of single-person households, the increase in the working population, and changing lifestyles. School-based collections are becoming less effective as the school-age population continues to decline, while collection points at community centers and apartment complexes remain inaccessible, resulting in low public participation. Consequently, this system has created a recurring cycle in which collection bins are available but rarely used.

Against this backdrop, there is a need for infrastructure that is more closely integrated into citizens' daily lives. With more than 50,000 convenience stores operating nationwide, they are easily accessible in nearly every community. Many are open 24 hours a day, making them readily available to people at any time. In addition, convenience stores already serve as everyday service platforms by providing parcel pickup and delivery, utility bill payment, and ATM services. This makes them well suited to be expanded into waste battery collection points. Therefore, a convenience store-based waste battery collection system has the potential to address the limitations of the current system while encouraging voluntary public participation.

Ultimately, the “Convenience Store–Based Battery Collection and Carbon Point System” is more than just an environmental campaign. It is a strategic solution capable of addressing multiple challenges at once, including national greenhouse gas reduction targets, the transition to a circular economy, and the promotion of ESG management. This context demonstrates that the proposal represents a timely and effective solution rather than a mere idea.

2. Current Policies and Limitations

The Republic of Korea currently operates a range of waste battery collection programs but these face several limitations in terms of their effectiveness. Major examples include the Carbon Point System, local government-led waste battery collection campaigns, and smart collection systems. Although these programs have been introduced by the Ministry of Environment, local governments, and private companies, they have yet to achieve meaningful results in terms of sustained public participation and long-term engagement.

First, the limitations of the Carbon Point System. This rewards households and businesses with points for reducing their consumption of electricity, water, and natural gas. Later, efforts were made to connect the program with activities such as used battery collection. However, because the system is primarily designed to reward energy-saving achievements, it has a limited connection to used battery collection. Also, the incentives for returning used batteries are often too small to citizens or the process of

using the system is complex, making its benefits less noticeable to the public. Ultimately, the Carbon Point System does not serve as a fundamental solution to the used battery problem.

Second, limitation of local government-led collection campaigns. Local governments conduct intensive waste battery collection campaigns during specific occasions such as Environment Day and Earth Day. These campaigns typically organize events for students and local residents to encourage a temporary increase in collection volumes. However, because they are one-time events, they have limitations to sustain long-term participation. Once the campaigns end, public interest declines, and collection rates tend to return to their previous levels, creating a recurring cycle. Moreover, differences in local government budgets and staffing result in significant regional disparities, while there is also a lack of a standardized management system.

Third, smart, reward-based collection systems also have limitations. In some areas, automated collection machines have been installed to reward users with points when they deposit waste batteries. However, the rollout of these systems has been slow because collection machines are available only at a limited number of locations and involve high maintenance costs. Furthermore, because of insufficient public awareness campaigns, many citizens are unaware that the program even exists. Accordingly, although smart collection systems are an interesting technological approach, they remain difficult to scale up for nationwide implementation.

The current waste battery collection systems share a common limitation in that they are not well aligned with citizens' daily routines. Most collection bins are concentrated in specific locations, such as community centers, schools, and apartment complexes. However, social changes, including the growing number of single-person households and the shift toward work-centered lifestyles, have made these locations less accessible because citizens no longer visit them regularly. As accessibility declines, public participation also decreases. Consequently, even if collection systems are in place, they are unlikely to achieve meaningful results unless citizens can easily use them in their daily lives.

Also, the current system is not sufficient to encourage lasting changes in citizens' behavior. Raising awareness through campaigns alone is not enough to promote long-term behavioral change in everyday life. This implies that the current system lacks two essential elements, namely an effective incentive mechanism to encourage participation and convenient accessibility.

Finally, most existing programs have been implemented through government-led initiatives, resulting in limited participation from the private sector. Although approaches led by the Ministry of Environment or local governments provide institutional legitimacy,

nationwide expansion remains challenging because of financial constraints and administrative limitations. By contrast, many private companies have strong incentives to participate as part of their ESG strategies and CSR initiatives. However, the current system provides little institutional support for this. Ultimately, the lack of collaboration between the public and private sectors has been unable to make meaningful synergies.

In summary, the used battery collection systems face the following challenges.

- ① A reward structure that is not directly linked to battery returns
- ② Limited sustainability due to one-off campaigns
- ③ Collection infrastructure with limited accessibility
- ④ Insufficient public-private collaboration

Addressing these challenges requires a new approach that combines infrastructure integrated into citizens' daily lives with a digital incentive system.

3. Proposed Idea

The core of this proposal is a convenience store-based Carbon Point System linked to used battery collection. This is an everyday, user-centered platform designed to overcome the limitations of existing systems and make participation in used battery recycling a natural part of daily life. This proposal consists of three main pillars.

3.1 Utilizing Convenience Stores as Collection Hubs

There are currently more than 50,000 convenience stores operating nationwide. This creates a far more extensive and accessible infrastructure network than apartments, schools, or community centers. Because many convenience stores operate 24 hours a day, they offer exceptional accessibility and convenience.

This helps overcome the limitations of existing collection points and enables citizens to conveniently return used batteries within their everyday routines. For example, when a customer visits a convenience store to buy a drink, they can also drop off their used batteries at a collection bin. This makes battery disposal a natural part of routine daily activities. In other words, it enables people to participate in environmental protection without requiring additional time or effort.

In addition, if convenience store headquarters were to run a nationwide campaign, standardized collection bins and promotional materials could be deployed across all locations, allowing the initiative to serve as a brand-level ESG activity. This could also

enhance corporate reputation and strengthen CSR efforts.

3.2 QR Code–Based Digital Reward System

The second component is a digital reward system linked to QR code verification. This approach goes beyond simply depositing used batteries into a collection bin. It is designed to allow participants to verify their contribution and receive immediate rewards.

Specifically, after depositing used batteries into a collection bin at a convenience store, users scan the QR code attached to the bin.

Once the scan verifies the user's account, rewards are automatically given through integration with the Ministry of Environment's Carbon Point platform or the convenience store's mobile app.

Rewards can be structured in a variety of ways, including the following.

Carbon Point rewards: Linked to the Ministry of Environment's Carbon Point platform, allowing all citizens to participate under a unified system.

Convenience store loyalty points: Integrated with the loyalty programs of major convenience stores, such as CU, GS25, and 7-Eleven.

Local currency rewards: Provided in partnership with local governments, creating additional benefits for local businesses and communities.

By diversifying the types of rewards, the system can strengthen participation incentives across a wide range of groups. For example, students may favor convenience store points, whereas middle-aged and older participants may find local currency rewards more appealing. Therefore, a multi-tiered incentive structure can significantly broaden public participation.

3.3 Establishing a Public–Private Partnership Governance Framework

The third one is a partnership framework involving the Ministry of Environment, local governments, and convenience store headquarters. Existing systems have tended to rely heavily on a specific stakeholder(a government agency or a private company). However, this proposal secures both sustainability and effective implementation through a tripartite governance framework.

Ministry of Environment: Provides the Carbon Point platform and supports the institutional legitimacy of the system.

Local governments: Provide budgetary support, coordinate policy integration, and oversee local-level promotion and management.

Convenience store headquarters: Install collection bins, operate the reward platform, and lead promotional campaigns.

By working together, these three stakeholders can secure policy legitimacy, administrative support, and private-sector execution capacity. It also serves as an innovative partnership model that brings together private-sector ESG efforts and government climate policies.

This framework has potential for expansion into other areas of resource circulation.

3.4 Operational Scenario and Implementation Phases

This proposal can be implemented through the following phases.

Phase 1: Pilot Implementation

Collection bins will be installed at 500 selected convenience stores in major metropolitan areas, including Seoul and Busan. Establish a QR code verification system and evaluate its convenience.

Phase 2: Nationwide Expansion

Expand the program to 50,000 convenience stores within two years. Diversify reward mechanisms based on local characteristics (e.g., local currency rewards in rural areas and point-based rewards in urban areas).

Phase 3: Institutionalization

Fully integrate the system with the Carbon Point Program and align it with national carbon neutrality policies. Use collection data to refine policies and adjust incentive mechanisms. In the long term, expand the system to include the collection of small electronic waste, such as discarded mobile phones and chargers.

3.5 Expected Participation Framework

Under this system, citizens become active participants, convenience stores serve as resource-circulation hubs, local governments provide administrative support, and the Ministry of Environment serves as a system administrator. This goes beyond a simple collection system. It can serve as a new carbon neutrality model that brings together citizens, businesses, and governments.

4. Institutional Justification

This proposal is not merely a conceptual idea. It has a strong institutional foundation, as it is closely aligned with current legal frameworks, national policy objectives, and international trends. In particular, the project's alignment with the National ESG(Environment, Social, Governance) Strategy, the Framework Act on Resource Circulation, and the Climate Action 1.5°C Campaign clearly demonstrates its validity.

4.1 Alignment with the National ESG Strategy

These days, ESG management has become an essential agenda rather than a choice for companies both in Korea and around the world. In particular, the environmental pillar is closely linked to the transition toward a carbon-neutral society. It serves as a key indicator of corporate reputation and sustainable business management. If convenience store headquarters participate in this initiative, they can go beyond CSR(Corporate Social Responsibility) efforts and secure their ESG performance. For example, if major convenience store chains such as GS25, CU, and 7-Eleven participate in this system, they can increase sales while quantifying and reporting their environmental performance. This can help strengthen the trust of investors and consumers. Moreover, ESG management extends beyond the activities of individual companies but emphasizes industry-wide collaboration and the creation of social value. Thus, if convenience store chains nationwide participate, it could serve as a model for ESG implementation across the broader retail sector. In addition, it can contribute positively to ESG indicators at the national level.

4.2 Consistency with the Framework Act on Resource Circulation

The Republic of Korea enacted the 「Framework Act on Resources Circulation」 in 2018.

Through this, the Republic of Korea declared a shift from viewing waste as a mere disposal target to recognizing it as a valuable circular resource. The Act stipulates to promote resource circulation throughout the entire process, including waste reduction, reuse, recycling, and energy recovery. Used batteries contain both heavy metals and valuable rare metals.

Consequently, while improper disposal poses significant environmental risks, used batteries also have considerable value as a recoverable resource. So, establishing an effective collection system for used batteries is directly aligned with the principles of the Framework Act on Resources Circulation. In particular, the proposed convenience store-based collection system goes beyond the limitations of the existing approach, which is

centered on apartments and schools. This is highly consistent with the intent of the Act, as it establishes a circular resource collection network embedded in everyday life. In other words, it contributes to a national shift toward viewing used batteries not as mere waste, but as circular resources.

4.3 Alignment with the Climate Action 1.5°C Campaign

Since the Paris Agreement, the government has been strengthening its NDC(Nationally Determined Contribution) to reduce greenhouse gas emissions. In addition, the government is promoting public participation through the Climate Action 1.5°C Campaign. The campaign emphasizes everyday behavioral changes that citizens can actively adopt, such as saving energy, using public transportation, and properly separating waste for recycling. Properly separating the used batteries is a prime example of citizen participation in climate action. Furthermore, this initiative goes beyond simple waste separation but integrating incentive mechanisms such as Carbon Points. As such, it is fully consistent with the spirit of the campaign, as it enhances incentives for citizen participation.

4.4 Validity as a Public–Private Partnership Model

This initiative presents a tripartite governance model that brings together the government, local authorities, and private-sector companies. This structure simultaneously ensures administrative legitimacy(government), policy implementation capacity(local governments), and economic sustainability(private-sector companies). It is also a way to overcome the limitations of existing systems that have been driven primarily by a single stakeholder. Therefore, this initiative has secured a stable institutional foundation. Taken together, this initiative demonstrates legal, policy, and social legitimacy.

5. Expected Benefits

If implemented, this initiative is expected to create a wide range of positive environmental, economic, and social impacts. This goes beyond simply improving the collection rate of used batteries. It is particularly significant because it can create value across multiple aspects, including national carbon neutrality efforts, stimulating local economies, and fostering awareness among citizens.

5.1 Environmental Benefits

First, the improvement of used battery collection rates. By utilizing convenience stores nationwide, the current collection rate of approximately 31% is expected to increase to more than 60%. This represents more than an increase in collection volumes, as it can fundamentally mitigate the environmental risks arising from landfill disposal and incineration. Second, indirect greenhouse gas emission reductions. When used batteries are incinerated, carbon dioxide(CO₂), nitrogen oxides(NO_x) are released. When landfilled, heavy metals can leach into soil and groundwater, undermining long-term efforts to reduce carbon emissions. Accordingly, increasing collection rates directly contributes to carbon neutrality. In particular, according to statistics from the Ministry of Environment, each ton of used batteries that is landfilled or incinerated can generate several hundred kilograms of carbon dioxide equivalent(CO₂e). Increasing the collection rate by 30% could result in indirect reductions of several thousand tons of greenhouse gas emissions annually. Third, expanding resource recycling. Batteries contain significant amounts of valuable metals, including zinc(Zn), manganese(Mn), nickel(Ni), and lithium(Li). These resources are critical materials used in renewable energy systems, electric vehicle batteries, and advanced electronics. Therefore, expanding the collection of used batteries goes beyond waste reduction and carries strategic significance for national resource security. If valuable metals that are currently dependent on imports can be recovered and recycled domestically, this could make a significant contribution to establishing a circular economy.

5.2 Economic Benefits

First, increased sales for small businesses. If convenience stores are utilized as resource circulation hubs, citizen visits are expected to increase. Customers visiting convenience stores to return used batteries are likely to purchase products at the same time. This creates an indirect economic benefit in the form of increased convenience store sales.

In fact, a small electronic waste collection program implemented in Japan reported that stores equipped with collection bins had an average increase of 8–12% in customer visits.

Second, stimulating local economies. If the rewarding system is linked to both Carbon Points and local currencies, citizens can use the incentives they earn from participating in collection activities at local businesses. This can stimulate local consumption and contribute to the development of a circular economy at the municipal level.

Notably, it could play an important role in revitalizing local economies as they continue to recover from the impacts of COVID-19.

Third, strengthened corporate ESG performance. If convenience store headquarters

participate in the system, they can quantitatively secure their performance in the environmental component of ESG. This can serve as a positive signal to investors both at domestic and abroad. It can also strengthen brand image and contribute to long-term sales growth.

5.3 Social Benefits

First, increasing environmental awareness among citizens. Rather than being limited to participation in a one-time campaign, everyday engagement supported by incentive mechanisms can reinforce environmentally responsible behavior among citizens. In other words, it helps people recognize that environmental protection can also bring personal benefits, thereby encouraging sustainable behavioral change.

Second, environmental education impacts. Significantly, when students dispose of used batteries at convenience stores and receive immediate rewards, they can learn the importance of resource circulation through everyday experience. In this way, it moves beyond textbook-based environmental education and offers experiential learning opportunities rooted in everyday life situations. In the long term, it can help foster environmentally responsible citizenship.

Third, raising awareness of the transition to a carbon-neutral society. Climate action can sometimes feel like a distant and abstract concept to citizens. However, by conveying the message that “properly disposing of a single used battery can contribute to carbon neutrality”, this initiative helps connect broader goals with individual actions. This can help make carbon neutrality a part of everyday life throughout society.

Fourth, the expansion of public-private collaboration. The Ministry of Environment, local governments, and private-sector companies jointly operate the program. As a result, it enables the implementation of collaborative governance rather than a top-down, administration-led policy approach. This experience could serve as a valuable model for collaboration in future resource circulation and environmental policies.

5.4 Comprehensive Benefits

In conclusion, this initiative can simultaneously deliver three major benefits: resource circulation and greenhouse gas reduction from an environmental perspective, local economic revitalization and enhanced corporate ESG performance from an economic perspective, and increased public awareness and the promotion of a collaborative culture from a social perspective. This represents a comprehensive set of benefits that is difficult to achieve through a single policy instrument. It can be regarded as a practical solution that is closely aligned with national carbon neutrality strategies.

6. Conclusion

The issue of used battery collection extends beyond simple resource management and is directly linked to the national challenges of addressing the climate crisis and achieving a carbon-neutral society. Currently, the Republic of Korea's used battery collection rate remains in the 30% range. Compared with international targets for resource circulation and greenhouse gas reduction, this remains at a very low level. Existing policies and campaigns have had their own value. However, they have failed to overcome limitations, like one-time events, limited accessibility, and a lack of long-term sustainability.

In response, this initiative is designed to leverage convenience stores as an accessible, everyday-life infrastructure, enabling resource circulation activities to take place in locations that are most convenient for citizens. The more than 50,000 convenience stores across the country can evolve beyond their role as retail facilities and function as resource circulation hubs on the path toward a carbon-neutral society. Additionally, a QR code-based verification and reward system can provide participants with direct and immediate incentives, creating a motivation that existing programs have been unable to achieve.

This initiative goes beyond environmental effects, creating economic and social value at the same time. By expanding the collection of used batteries, this initiative creates environmental value through greenhouse gas reduction and valuable metal recycling, economic value through increased convenience store sales and local currency circulation, and social value through better environmental awareness and educational benefits for citizens. In particular, it operates as a governance model that brings together the government, local governments, and private-sector companies. This makes it possible to secure both policy legitimacy and private-sector implementation capacity.

In the long term, this system can be expanded to support the collection of other types of electronic waste, including discarded mobile phones, chargers, and small household appliances. This can serve as a catalyst for advancing a broader circular economy, going beyond the issue of used battery collection alone. It will also serve as a leading example of how small actions by individual citizens can contribute to achieving national greenhouse gas reduction targets and realizing a carbon-neutral society.

In conclusion, the "Convenience Store-Based Carbon Point System Linked to Used Battery Collection" represents a practical and sustainable solution to the environmental challenges facing our society today. If put into practice, this would allow us to achieve two goals at the same time, addressing the climate crisis and establishing a resource circulating society. Ultimately, it can serve as a new model for a carbon-neutral society built through the collective efforts of businesses, government, and citizens, as well as a responsible choice for future generations.

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1996: 54.9% → 2023: (approximately) 86.8%
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I Introduction

- a. The Emergence of the Climate and Environmental Crisis
- b. Recognizing the Challenges of Agricultural Waste and Carbon Emissions in Rural Areas
- c. Existing Solutions and Limitations

I Body

- a. The Need for a Rural Currency Card System
 - a-1. Ensuring Fairness and Transparency
- b. Introducing a Waste Voucher System
 - b-1. Vendor Selection and a Competitive Framework
 - b-2. Expanding Accessibility and Supporting Elderly Farmers

I Conclusion

I References and Sources

Policy Proposal

03

Kim Ha-eun/ Jeonbuk National University

Illegal Burning: Heating Rural Communities and the Planet

영농폐기물, 사각지대 속 처리 곤란

폐비닐·폐농약용기 이외의 폐기물은 처리 방법이 모

농민들 "시설 구매보다 철거에 더 많은 비용 소요"



폐비닐



Abstract

From the perspective of an environmental engineering student, this proposal examines the impact of illegal agricultural waste burning on carbon emissions in the era of climate change. It reviews the limitations of current collection systems and legal enforcement measures, and proposes policy improvements through a rural currency card and waste voucher system. Ultimately, the proposal offers a practical solution that can simultaneously reduce greenhouse gas emissions, improve rural environmental realities, and lower social costs.

| Introduction

a. The Emergence of the Climate and Environmental Crisis

Unpredictable disasters have become a part of everyday life, and the climate crisis is no longer a problem of the future. Spring and autumn have become noticeably shorter, and the balance of the seasons has long been disrupted. Record-breaking heavy rainfall, severe cold waves, and recurring heatwaves continue to affect our daily lives. Among these challenges, wildfires represent one of the most visible disasters of the climate crisis. A single spark can turn decades-old forests into ashes and release vast amounts of carbon into the atmosphere, complicating efforts to achieve carbon neutrality.

The international community has already recognized the severity of the climate crisis. Through the Paris Climate Change Agreement adopted in 2015, countries established a shared goal of limiting the increase in global average temperature to 1.5°C above pre-industrial levels. This goal is widely regarded not merely as a declaration but as a minimum commitment necessary for our survival. In line with this global effort, the Republic of Korea pledged to achieve carbon neutrality by 2050. It is also advancing institutional and societal measures to reduce greenhouse gas emissions and strengthen climate adaptation.

For the sake of future generations, we must slow the pace of the climate crisis. If we fail to act now, the world of tomorrow cannot be taken for granted. With this sense of urgency, the Republic of Korea has set a goal of achieving carbon neutrality by 2050. To achieve this goal, efforts are underway across all sectors of society.

As the Earth moves from warming to heating and now to boiling, environmental considerations can no longer be treated as optional. It is time to confront environmental challenges that have long been overlooked across industries and in our daily lives, and to respond to them with urgency.

b. Recognizing the Challenges of Agricultural Waste and Carbon Emissions in Rural Areas

Agriculture serves as the foundation of human survival and remains an essential pillar of everyday life. As long as human societies exist, the generation of waste is inevitable.

Paradoxically, agriculture, which sustains our food supply, is increasingly recognized as one of the key factors making carbon neutrality more difficult to achieve. Thus, if agricultural waste is poorly managed, carbon neutrality will remain little more than a declaration.

Agricultural waste, including used plastic film, pesticide containers, and crop residues such as pepper stalks, continues to pose a threat to rural environments. In 2023, approximately 290,000 tons of waste plastic film were generated, while only 200,000 tons were collected. This raises questions about the whereabouts of the remaining 90,000 tons. When considering the frequent occurrence of illegal agricultural waste burning, it cannot be ruled out that some of the uncollected waste was illegally burned or buried.

영농폐비닐 발생량

『영농폐기물조사』

수목기간: 년 2004 ~ 2023 / 자료종산일: 2024-12-17 / 수석정보

시도

읍면/동읍면

행정현황

영고현제

새영입기

파면제사

단위: 톤

지역명	재질명	2023 발생량	2) 수거량	3) 재활용량
계	계	290,017	200,903	161,193
	하수슬 LDPE	32,587	368	-
	밀짚용 LDPE	150,724	98,136	-
	HDPE	88,410	102,342	-
	기타(PVC, EVA, PO)	18,297	58	-

영농폐농약용기 발생량

『영농폐기물조사』 한국농촌과학

수목기간: 년 2004 ~ 2023 / 자료종산일: 2024-12-17 / 수석정보

시도

읍면/동읍면

행정현황

영고현제

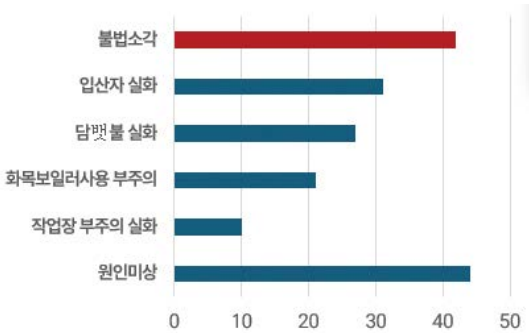
새영입기

파면제사

단위: 개

지역명	재질명	2023 발생량	2) 수거량	3) 재활용량
계	계	73,822,298	81,475,076	81,523,910
	유기	-	8,550	15,090
	플라스틱	56,116,308	60,055,504	60,208,180
	농약포장용	17,705,990	21,411,022	21,103,660

► Agricultural Waste Plastic Film and Pesticide Container Generation (2004–2023)



► Major Causes of Wildfires in 2024

Under the ‘Waste Control Act’, agricultural waste is classified as municipal waste. Although individuals are, in principle, responsible for its disposal, many farmers face significant challenges in managing it on their own. As such, illegal burning is often chosen as a means of disposal. However, illegal burning causes air, soil, and water pollution simultaneously. In particular, burning waste plastic film releases gases that significantly increase carbon emissions, accelerating global warming. Moreover, when sparks are carried by the wind into nearby forests, they can trigger large-scale wildfires. The fact that waste burning is the leading cause of wildfires underscores the severity of the problem.

Wildfires do more than damage forests. They release enormous amounts of carbon, making it difficult to achieve carbon neutrality. Carbon neutrality refers to the concept of minimizing greenhouse gas emissions and offsetting the remainder through absorption

and mitigation to achieve net-zero emissions. However, when wildfires occur frequently, carbon emissions exceed the amount of carbon absorbed, making carbon neutrality difficult to achieve.

According to a Newsis report, approximately 300,000 tons of agricultural residues are generated each year. However, the collection rate stands at only 62.5%. As a result, the remaining 37.5% is likely left unattended or illegally burned.

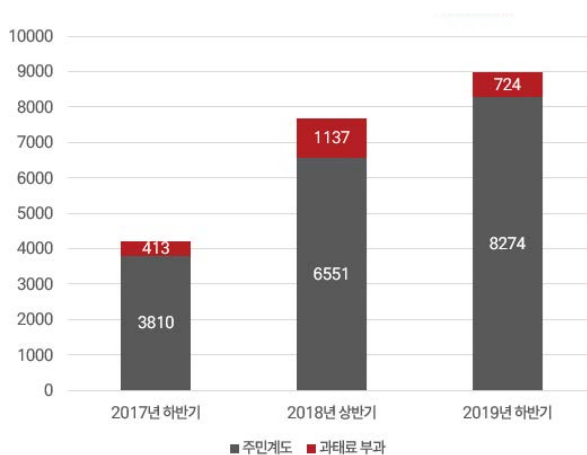
Especially when examining its contribution to air pollution emissions, its impact becomes even clearer. In 2019, the burning of agricultural residues generated 7,194 tons of fine particulate matter (PM_{2.5}), accounting for 8.2% of total domestic emissions. Carbon monoxide (CO) emissions reached 146,827 tons, representing approximately 1.94% of the national annual total. In addition, black carbon emissions amounted to 1,614 tons, equivalent to 11.4% of total emissions. These figures demonstrate that the burning of agricultural waste extends beyond a waste disposal practice and constitutes a major source of pollution that must be addressed through national environmental policy.

The problem is the response that follows detection. According to a recent survey, 1,546 cases of illegal burning were detected across nine provinces and metropolitan cities. However, not a single case resulted in a reduction of public interest direct payment subsidies. The fact that sanctions remain largely ineffective is considered one of the reasons why illegal burning continues to persist. Thus, the issue of illegal agricultural waste burning cannot be addressed merely as a matter of convenience in rural areas. It is a critical challenge that must be managed to achieve carbon neutrality and improve air quality. Alongside stronger institutional sanctions, practical support policies should be introduced to encourage voluntary participation by farmers.

It cannot be said that rural communities are responsible for all climate and environmental pollution. We need to understand the reasons that have driven them to act in this way and make an effort to address those challenges. Only then can lasting change be achieved. Only then can meaningful change take place.

c. Existing Solutions and Limitations

The Republic of Korea currently operates a legal framework for waste management under the 'Waste Control Act'. In particular, Article 8(2) imposes an administrative fine of up to KRW 1 million on those who illegally burn or dispose of waste outside authorized waste treatment facilities. In addition to this legal framework, the Korea Environment Corporation operates a collection and management program for agricultural waste, including waste plastic film and pesticide containers, to help farmers dispose of such waste more conveniently. On the surface, the laws and systems are already in place, with measures intended to deter illegal burning and dumping.



▶ Number of Illegal Burning Cases Detected for Particulate Matter Emissions (Cases)

However, as noted earlier, these laws and policies often fall short of achieving their effect in practice. Even when cases of illegal burning or dumping are detected, they frequently result in warnings rather than administrative fines. This is largely due to a shortage of enforcement personnel and the reluctance of authorities to impose strict penalties in consideration of the unique circumstances of rural communities. As a result, the deterrent effect of the law has been significantly weakened. Without effective enforcement, many farmers may conclude that illegal burning carries no significant penalties.

Another limitation of the current collection and management program is its narrow scope of eligible waste items. The Korea Environment Corporation collects waste plastic film and pesticide containers, but a much wider range of agricultural waste is generated in rural areas. This includes seedling trays, pepper stalks, materials left behind after dismantling greenhouses, and various types of packaging waste. Most of these items fall outside the existing collection system. Local governments also require farmers to handle such waste themselves, classifying it as municipal waste generated through individual business activities. As a result, farmers are left to shoulder the cost of disposal. In many cases, they are left with few practical alternatives, leading them to resort to illegal burning or dumping.



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► Limitations of the Collection and Management Program and Waste Types Subject to Collection Restrictions

Demographic factors in rural areas are also exacerbating the problem. According to a Hankuk Ilbo report, rural communities have a disproportionately high share of older residents. As such, transporting waste to designated collection sites can be a significant burden. In areas where collection points are insufficient, elderly farmers without trucks or other equipment often find it nearly impossible to transport waste on their own. As these physical constraints coincide with gaps in the existing system, illegal burning continues to occur frequently in rural areas.

As a result, although the current legal framework appears robust on paper, its effectiveness in practice remains limited. Also, existing policies have been criticized for failing to adequately reflect on-the-ground realities, as they focus on only a narrow range of waste categories. Administrative directives that simply prohibit burning are insufficient to resolve the problem. A more comprehensive and practical support system that reflects the circumstances of farmers and the structural realities of rural communities must be established. Otherwise, current measures will remain little more than a formal declaration, and the problem of illegal burning will continue to recur.

Body

The issue of agricultural waste should be viewed as an environmental challenge for society as a whole, rather than simply as a problem faced by individual farmers. The current system has clear limitations, as it collects only a limited range of waste items, such as waste plastic film and pesticide containers. Illegal burning continues to persist due to rural population aging and various physical constraints. As such, structural improvements are essential, including expanding the range of waste collected and strengthening support from local governments, rather than relying on regulatory measures.

a. The Need for a Rural Currency Card System

The current agricultural waste management system places a significant burden on individual farmers. As discussed earlier, the existing collection program covers only a limited range of waste items, such as waste plastic film and pesticide containers. Other types of agricultural waste, including seedling trays, pepper stalks, and greenhouse residues, must be handled by farmers themselves. At this point, many farmers resort to illegal burning due to disposal costs and the lack of practical disposal options. To address these challenges, this proposal introduces the Rural Currency Card System.

The Rural Currency Card System operates by providing a 20% cashback on eligible purchases made with funds loaded onto the card, subject to an annual spending limit. For farmers, the system helps reduce waste disposal costs, lowering the incentive for illegal burning and encouraging the use of legitimate disposal methods. At the same time, the government is not required to bear the full cost of the program, as it provides only partial financial support, keeping the fiscal burden manageable. The system can improve administrative efficiency by encouraging farmers to participate voluntarily in lawful waste management practices.



► Conceptual Image of the Rural Love Card (Generated by ChatGPT)

a-1. Ensuring Fairness and Transparency

The greatest challenge facing the Rural Currency Card System is preventing misuse and fraudulent use. However, this is a challenge that can be effectively managed. First, the card can be restricted for use only at authorized waste disposal service providers, ensuring that it cannot be used for purchases outside designated categories. Local currency card programs already operate in a similar manner, designating participating merchants and restricting card use to specific business sectors.

In addition, the introduction of a real-time monitoring system would allow transaction records to be managed transparently. If card usage data are recorded directly within the

administrative system, authorities can promptly identify any misuse and take corrective action when necessary. Similar technologies are already being used in many regions to prevent the misuse of local currency cards. Therefore, incorporating such a monitoring framework into the Rural Currency Card System is both technically and institutionally feasible.



► Images of Local Love Gift Certificates and Local Love Cards

b. Introducing a Waste Voucher System

Under this system, the government or local authorities would establish partnerships with waste management companies and provide vouchers to farmers. Farmers could then use these vouchers when collecting or disposing of agricultural waste through designated service providers, significantly reducing their disposal costs.

The level of voucher support should be determined based on the average cost of waste disposal, covering at least 50% and up to 70% of the expense. This would help alleviate the financial burden on farmers. Also, they would be more likely to choose legal disposal methods rather than resorting to illegal burning or dumping. From the perspective of governments and local authorities, this approach allows the use of public resources far more efficiently than directly covering waste disposal costs.

b-1. Vendor Selection and a Competitive Framework

The success of the Waste Voucher System depends on the quality and services of waste management companies. To this end, it is necessary to recruit participating companies through a competitive selection process and establish transparent evaluation criteria. By partnering with the government, companies can benefit from stable revenue growth. Consequently, competition among service providers is likely to increase. Accordingly, service quality will improve naturally, allowing farmers to dispose of agricultural waste under better conditions. This can be regarded as an efficient way of operating the system by leveraging market mechanisms.

b-2. Expanding Accessibility and Supporting Elderly Farmers

Rural areas have a relatively high proportion of older adults. Accordingly, providing vouchers only in digital form may limit their effectiveness in practice. To address this challenge, vouchers should be offered in both digital and paper formats. Younger farmers could conveniently use vouchers through a mobile application, while older farmers could receive paper vouchers from local agricultural cooperatives. This approach would make the system more accessible.

This is important because it goes beyond simply announcing a policy and focuses on creating a system that can function effectively in farmers' daily lives. In particular, utilizing community-based institutions such as agricultural cooperatives can reduce the administrative burden while providing farmers with familiar points of service, increasing utilization.

| Conclusion

The problem of agricultural waste remains unresolved in many rural areas. Although regulations and penalty provisions are in place, weak enforcement continues to drive farmers toward illegal burning and dumping. The limited scope of waste collection programs and the burden of disposal costs placed on individual farmers often leave them feeling powerless and frustrated. An agricultural system that fails to account for environmental sustainability can no longer endure. If these challenges remain unaddressed, the well-being and safety of future generations will also be at risk. What is needed now is not superficial administrative measures, but practical support systems and fundamental solutions that reflect realities on the ground.

Addressing the agricultural waste problem has become an urgent necessity, and meaningful change is needed now to build a more sustainable future for rural communities. Illegal burning is damaging rural areas and contributing to global warming. It is time to put out the fires in our countryside and ignite hope for the planet. Consequently, it is imperative to strongly urge the eradication of illegal burning and the implementation of effective solutions.

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I Introduction

- Limited Awareness of the Climate Crisis and Its Causes
- Theoretical Foundations

I Body

- Challenges in Current Green Marketing Practices
- Proposal for Green Marketing 2.0
- Overview of Key Strategies
- Expected Outcomes

I Conclusion

I References and Sources

Marketing

04

Yang Ji-min / Hankuk University of Foreign Studies (Seoul)

Green Marketing 2.0: Rethinking Advertising Language

Abstract

This proposal presents a “Green Marketing 2.0” strategy to address the climate crisis. This paper addresses the fact that public awareness of the climate crisis remains largely superficial and does not lead to meaningful behavioral change. It seeks to propose an alternative to the widespread use of vague environmental terminology in everyday life. Based on theoretical foundations, this highlights the significant influence of language use on perception formation and behavioral change. In particular, this introduces “Green Marketing 2.0” as a new approach to corporate green marketing strategies, encouraging consumers to embrace genuinely sustainable consumption. It identifies shortcomings in the advertising language used for environmentally friendly products and suggests several improvements, including the use of clear terminology, using negative wording, and a consumer-benefit framing. The introduction of a new green marketing strategy is expected to improve consumer perceptions and promote sustainable consumption, ultimately leading to behavioral change. In conclusion, the proposed approach calls for a shift toward more responsible corporate marketing strategies and highlights the potential for broader adoption through future government regulation and improvements in language usage across society.

| Introduction

a. Limited Awareness of the Climate Crisis and Its Causes

From climate change to the climate crisis, and from global warming to global heating, the language surrounding environmental issues has evolved alongside their increasing severity. Humanity, in turn, has made considerable efforts to confront these challenges.

It is undeniable that once these issues gained broader attention, related discussions accelerated and brought about significant changes within a relatively short period of time. Most notably, the international community ushered in a new era of climate and environmental action through the adoption of the Paris Climate Change Agreement and the Sustainable Development Goals (SDGs) in 2015. In response, countries have adapted their policies at their own pace. Citizens also began to take climate and environmental issues more seriously. The rapid changes that took place from the late 2010s to the early 2020s made a sustainable future seem increasingly achievable. However, as the pandemic eased and economies began to recover in the early 2020s, the world appeared to be slipping back into old patterns.

To be sure, growing numbers of people have expressed concern over climate and environmental issues and called for stronger action. In many cases, however, such responses have been short-lived, and sustained behavioral change remains difficult to find. The limitations of climate action is that meaningful actions and efforts are often taken only by those who are already concerned with the issue. When public interest is lacking, governments have little incentive to prioritize the issue, and the international community is ultimately less likely to give it the attention. For challenges that require collective action on a global scale, a shared understanding of the problem is essential. Despite decades of international agreements reached through a number of climate negotiations, governments' continuous policy-making, and persistent vocal demands by citizens, progress in addressing the climate crisis has remained slow. This is because people still lack a genuine understanding of the climate crisis itself. Without such understanding, meaningful behavioral change is unlikely to occur. Public awareness is particularly important in this regard. While there is a growing perception that awareness of climate and environmental issues has improved, especially among younger generations, repeating a few symbolic slogans such as "Protect the planet," "Avoid single-use products," or "Reduce carbon emissions" does not necessarily indicate a deeper understanding of the issue. Genuine awareness must translate into sustained changes in behavior.

Why, then, do so many people still fail to genuinely grasp the severity of the climate crisis? While there are undoubtedly many factors, this proposal focuses on the widespread and often indiscriminate use of environmental terminology in everyday life. Language plays

a critical role in shaping an individual's perception. The words and expressions chosen when communicating a particular idea can influence individual perceptions and social understanding. One of the most familiar examples is the analogy of a glass filled halfway with water. Looking at the same glass, one person might say, "The glass is only half full," while another might say, "The glass is already half full." This simple example illustrates how a person's perspective is reflected in the language they use. The same principle applies to climate and environmental issues. Someone who describes the issue as "climate change" may view it differently from someone who refers to it as a "climate crisis." Likewise, government policies that group a wide range of climate and environmental issues under the single label of "environmentally friendly" can influence public perception differently from policies that distinguish among specific concepts such as decarbonization and renewable energy. In other words, language plays a crucial role in shaping public understanding. The careful use of appropriate terminology can therefore contribute to more effective responses to the climate crisis.

b. Theoretical Foundations

Some may question whether the use of appropriate language can truly influence individual and societal perceptions. To support this argument, the paper draws on two key strands of literature. In his theory of Frame Analysis(1974), sociologist Erving Goffman argued that individuals interpret and understand situations through a cognitive framework known as a "frame". Because these frames are shaped by factors such as cultural norms, personal experiences, and social relationships, each individual develops a distinct set of frames. As such, individuals understand and interpret the world through different frames, or perspectives. So, individuals perceive the same situation differently, leading to miscommunication and misunderstanding. Because people act according to their perceptions, differences in perception can also lead to differences in behavior.¹⁾ Upon encountering this theory, one hypothesis came to mind. If people's perceptions, or frames, of a particular issue such as the climate crisis can be aligned to some extent, their actions may become more aligned as well. If so, it may also be possible to promote collective behavioral change. This hypothesis naturally led to the question of how people's perceptions can be changed. According to "Public Understanding of Climate Change Terminology (2021)", a study examining the relationship between public perceptions and climate-related terminology, people acquire new information through the lens of their existing perspectives. To explain this phenomenon, the author introduces the concept of a "personal lens." This concept is similar to Goffman's notion of a frame discussed above. The researchers presented participants with the same climate-related terms. The researchers then analyzed the participants' responses regarding the meanings they

1) Erving Goffman, *Frame analysis: An essay on the organization of experience* (MA: Harvard University Press, 1974).

associated with those terms. By that point, participants had likely already developed their own personal lenses shaped by their sociocultural backgrounds and experiences.

The results showed that participants gave different responses when asked about the meanings of the same terms. This was likely because some participants were familiar with climate and environmental issues, while others were not. This once again demonstrates that differences in public perceptions can lead to miscommunication and hinder collective behavioral change. The researchers argued that clear terminology is essential for minimizing such communication barriers, particularly in fields like climate and environmental issues that require specialized knowledge. If a term is defined clearly and unambiguously, differences in perception among individuals are likely to be reduced. The study concluded that more aligned perceptions would have a positive influence on similar forms of behavior, including active climate action.²⁾

Drawing on these two theories, this proposal advances the following argument. Meaningful climate action requires a proper understanding of the problem. It also argues that the use of clear terminology is essential for fostering a genuine understanding of the problem. In other words, clear terminology can contribute to a more sustainable future and support progress toward net-zero emissions.

| Body

In general, the actions available to citizens in responding to the climate crisis are often limited to small changes in everyday life, such as avoiding single-use products and properly sorting waste for recycling. While these efforts are certainly important, the changes humanity needs are broader and more far-reaching in scope. At the same time, bringing about rapid change at the international and governmental levels presents significant practical challenges. Hence, this paper introduces a policy designed to encourage corporate change while promoting behavioral change among consumers.

Accordingly, this proposal introduces Green Marketing 2.0, a strategy centered on corporate advertising messages, as outlined below.

a. Challenges in Current Green Marketing Practices

In today's consumer market, a number of products are marketed as environmentally friendly. For example, products are often marketed using labels such as "eco-friendly

2) Wandt Bruine de Bruin et al, Public understanding of climate change terminology (Berlin: Springer Nature, 2021).

detergent," "upcycled keychain," and "zero-waste," suggesting that they have little or no negative impact on the environment. These claims are frequently promoted through product packaging. This proposal seeks to address the indiscriminate use of environmental terminology in product marketing. This is because it remains unclear whether such terminology actually encourages sustainable consumption. There are three major problems with this approach. First, environmental marketing claims are often used indiscriminately even when the sustainability of a product remains unclear, which can ultimately generate negative reactions among consumers. Notably, promotional messages for many environmentally marketed products repeatedly rely on terms such as "eco-friendly," "eco," and "green." As consumers are exposed to these expressions over and over again, they may become desensitized to them, find them repetitive, and eventually experience message fatigue. Second, such simplistic messages are unlikely to generate strong marketing appeal for environmentally marketed products. The repeated use of uninformative terminologies can even lead consumers to question whether a product is genuinely environmentally friendly. A decline in product credibility is unlikely to be a positive outcome for businesses. Finally, the excessive use of environmentally themed marketing can lead to accusations of greenwashing, regardless of a company's original intentions. Advertising a product that is not environmentally friendly through labels and such as "eco-friendly" or "environmentally conscious" constitutes intentional greenwashing. However, most cases of greenwashing are not necessarily intentional. Rather, they often arise from a lack of awareness and from factors that companies fail to fully consider. But now, we are living in a society where simply claiming ignorance is no longer an acceptable excuse. This reflects the extent to which climate action has become a serious societal priority.

In line with this shift, corporate marketing strategies must also evolve. Companies have a responsibility to be accountable for the environmental impacts of their business activities, and strategies such as these do little to contribute to a sustainable future. When environmental claims are overused on products that consumers encounter in their daily lives, people may become less sensitive to the seriousness of the climate crisis. This, in turn, can hinder more active climate action.

b. Proposal for Green Marketing 2.0

For this reason, when promoting environmentally friendly products, companies should address these shortcomings and adopt a marketing strategy built on a fundamentally different perspective. In other words, the core objective of the proposal is to help companies use advertising messages more effectively so that consumers choose environmentally friendly products over alternative options. Achieving a sustainable future ultimately requires a reduction in overall consumption. However, since consumption itself

cannot be completely avoided, sustainable consumption through the purchase of products with a lower environmental impact becomes increasingly important. Nonetheless, even if companies adopt a new green marketing strategy, it will ultimately fail to bring about behavioral change unless consumers choose to purchase the environmentally friendly products.

Therefore, maximizing the effectiveness of this requires careful identification of its initial target audience. Companies should take the lead by targeting middle- and high-income parents with young children as their primary consumer group. Having young children often means having a stronger stake in the well-being of future generations. Also, the relatively stable financial circumstances of middle- and high-income households mean that they are more likely to have the purchasing power needed to choose environmentally friendly products, which are often priced at a premium. Over the long term, children raised under such parental guidance are also more likely to develop an interest in sustainability as they grow up. For this reason, companies should focus on this group as their primary target and adopt the following three Green Marketing 2.0 strategies. The new Green Marketing strategy proposed in this paper consists of the following elements.

c. Overview of Key Strategies

(1) Use of Clear Terminology

Before Improvement	After Improvement
	

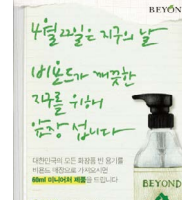
The first strategy is to use clear and precise terminology. (Before Improvement)

Conventional advertising messages have often relied on imprecise terminology. The terms “eco-friendly,” “eco,” and “green” shown in the example do not explain why the product is environmentally friendly or what specific environmental benefits it provides.

Such claims can undermine trust in the message itself, the product, and the company behind it, while also increasing consumer fatigue toward these expressions.

Consequently, if a product is genuinely environmentally friendly, its environmental benefits should be clearly reflected in its marketing messages. (After Improvement) As shown in the example, marketing messages can be more effective when they specify a product's environmental benefits. Using clear terms and labels such as "carbon-reducing," "100% biodegradable," or "low-carbon" helps consumers understand why a product is environmentally friendly.

(2) Using negative wording

Before Improvement	After Improvement
	 No plastic, There is Cornbag 한편의 비닐소수용량은 500ml로 인한 생분해성 제제로 1년내 저탄소화가 기대됩니다.

The second strategy is to use negative wording. (Before Improvement)

Traditional green marketing has largely relied on positive messages like “We are GOOD.”

However, by focusing solely on the environmentally friendly image of a company or product, such messages may fail to resonate with consumers and can even provoke resistance. Therefore, companies should strategically employ negative wording like “We are NOT BAD” approach to communicate the same idea more effectively. (After Improvement) As shown in the example, phrases such as “No Plastic” use negative wording to make the message more attention-grabbing that consumers will notice and engage with the product. By doing so, companies can capture consumers’ attention more effectively.

(3) Presenting a human-friendly approach

Before Improvement	After Improvement
	여행 가기 전 이것저것 챙기다 보니 점점 무거워지는 가방, 이런 불편함 없으셨나요? 여행 시 필수로 챙겨야 하는 삼투, 비치키스, 풀클렌징, 만만치 않은 액체 제품의 무게와 가방 안에서 흐르지 않을까 고민이죠. 이런 걱정과 불편함은 이제 그만~ 등구발 Better than Liquid 여행용 키트는 삼투바, 린스바, 폼비(선풍비치키스) 3가지로 다 합쳐도 달걀 1개 정도의 무게(60g)입니다. 

The final strategy is to adopt a Human-Friendly Approach. (Before Improvement)

Most conventional advertising messages have primarily adopted an environment-centered perspective. Specifically, these messages focus solely on a product's environmental benefits and fail to provide a compelling reason for consumers to choose it. In an era where similar environmental terms are used indiscriminately, such messaging can actually weaken a product's appeal and reduce consumers' willingness to purchase it, especially when it comes at a higher price than competing alternatives.

Accordingly, marketing messages should communicate not only how a product benefits the environment, but also how it benefits the people who use it. (After Improvement)

For example, as shown in the image, companies can highlight that solid personal care products, such as shampoo and body wash bars, are more convenient and practical for consumers while also being better for the planet than liquid alternatives. Another example would be a diaper advertisement using a message such as, "Safer for your baby, better for the planet." If an environmentally friendly diaper is also safer for the baby who will use it, it is likely to be far more appealing to parents as consumers. That is, companies should adopt a consumer-benefit framing and emphasize the benefits that consumers themselves can gain from the product.

d. Expected Outcomes

In conclusion, because advertising copy, that is, language, has a significant influence on human cognition, new marketing strategies are likely to serve as a new persuasive appeal. When consumers encounter advertising copy that differs from what they normally expect, it can create a cognitive "speed bump" that interrupts their usual thinking process. Just as drivers pay attention to and slow down for even the smallest speed bump, consumers are

inevitably influenced by even subtle changes in advertising copy when making purchasing decisions. This will naturally enhance public awareness of the climate crisis and lead to direct behavioral changes, including the promotion of sustainable consumption. Meaningful shifts in consumer behavior, such as changes in consumption patterns, will also drive businesses and governments to take action.

Greater public awareness and behavioral changes driven by citizens will provide businesses, governments, and the international community with a strong rationale for taking more proactive action on the climate crisis. In other words, they will create a compelling justification for accepting the initial costs. Policy improvements by businesses and governments are also expected to reduce carbon emissions generated throughout the production and consumption processes. Ultimately, this can play a significant role in advancing a more sustainable future.

| Conclusion

Based on the Green Marketing Strategy 2.0, this proposal strongly advocates for the environmental responsibility of both businesses and consumers. If this strategy proves to be effective, it could be expanded to strengthen government certification schemes, such as the Eco-Label and Environmental Product Declaration, while allowing only products that meet the relevant certification standards to display environmentally related claims.

Furthermore, I hope it will encourage changes in the terminology used not only in advertising copy but also by the media and in government policies. Ultimately, we hope this proposal aims to enable improvements in environmental terminology across various sectors to be effectively used in promoting more proactive responses to the climate crisis.

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I Introduction

- Current Ink Usage Situations
- Recognition of Issues Related to Ink Consumption in Cans
- Ink Reduction Strategies

I Body

- Label-Free Can Multipack Initiative
- Idea of Ink Usage Minimization
- Proposal to Expand QR Code Policies under the Food Labeling and Advertising Act

I Conclusion

I References and Sources

Resource Circulation

05

Seo Myung-hoon / Kangnam University

Reducing Carbon Emissions through Lower Ink Usage (in Cans)

	전 세계 생산
캔	약 4000억
잉크(캔 생산에 필요)	약 40만

Abstract

Approximately 400 billion cans are produced annually, wasting a significant amount of ink. Measures to reduce ink consumption can be categorized into three main purposes: product logos, product colors, and food information. This paper proposes three ink-saving strategies: label-free can multipack packaging, minimizing ink usage, and expanding QR code policies under the Food Labeling and Advertising Act. As several companies have already introduced label-free cans, this proposal encourages a broader adoption of them.

| Introduction

a. Current Ink Usage Situations

Ink is used in almost every type of product. It is commonly used in paper, snack packaging, cans, and food containers to display or promote brand and product information. Taking snack packaging as an example, it is often fully covered with printed elements, including product names, characters, flavor descriptions, and various certification marks. Due to the extensive surface area of individual snack packaging, the cumulative ink consumption across millions of distributed units nationwide is substantial.

One company that has reduced excessive printing on snack packaging and saved ink with environmental considerations is Crown Confectionery. For Earth Day, the company launched its eco-friendly “C-Corn Chips” product. It removed the signature yellow color associated with the brand as well as the corn illustrations, leaving only the product name and an Earth Day logo on the package. As a result, the company announced that it reduced ink usage by 70% and cut carbon emissions by 200 kilograms.

The same applies to beverages. Drinks are typically packaged in plastic bottles and aluminum cans, while label-free plastic bottles are already widely available on the market. This paper focuses on aluminum cans rather than plastic bottles and explores the potential of label-free aluminum cans.

b. Recognition of Issues Related to Ink Consumption in Cans

Cans are theoretically considered to be 100% recyclable. In the Republic of Korea, the collection rate for cans is 96%, while the recycling rate is 81%. Due to their recyclability, the can market has continued to grow, leading to a significant increase in production. According to Mordor Intelligence’s Food Cans Market Size and Share Analysis Report, the food can market was valued at USD 2.75 billion in 2025 and is projected to reach USD 3.219 billion by 2030, growing at a compound annual growth rate (CAGR) of 3.2%. However, it is worth considering whether the industry has become overly reliant on recyclability alone while continuing to increase production. Suppose that approximately 400 billion cans are produced annually. In addition to metal, ink is also required in the manufacturing process. If each can use just 1g of ink, total annual ink consumption would reach 400,000 tons. It may be difficult to visualize a quantity, but it becomes easier to understand when compared to discarding a 400,000-ton ship every year.

Then, how can we reduce ink consumption in cans? Simply using less ink may not be practical enough. Instead, by examining specific aspects, more effective strategies for reducing it can be explored.

c. Ink Reduction Strategies

To begin with, it is important to understand why ink is used on cans. If those purposes can be replaced or simplified, ink usage could be significantly reduced. The main purpose of ink on cans can be categorized into three areas: product logos, product colors, and food information. First, product logos must be printed on the surface of a product to promote the brand. Second, colored ink is used to reflect the product's brand identity or highlight its distinctive characteristics. Finally, cans contain consumable contents, so manufacturers must provide food information on the packaging. What if these three major uses of ink could be simplified? To explore this, let us examine several examples from industry.

One company that eliminated the function of product logos is The Coca-Cola Company.

Its flagship beverage, Coca-Cola, once carried out a campaign in the Middle East promoting a world free from discrimination. Just as people should not be judged by labels, the company released beverage cans without its trademark. As a result, the cans featured only a simple red-and-white surface along with the campaign message.

A company that eliminated the use of product colors is Guangzhou Wanglaoji Pharmaceutical Co., Ltd (Wong Lo Kat Pharmaceutical). The company produces Wong Lo Kat, a beverage often referred to as a national drink in China. For World Environment Day, Wong Lo Kat Pharmaceutical introduced a beverage can designed to reduce ink consumption. While conventionally produced beverage cans were covered with red and yellow colors, as well as various trademarks, labels and other printed elements, the ink-saving version featured only the product name, "Wong Lo Kat," and omitted all other colors and markings. According to the company, a conventionally produced can uses about 1 gram of ink, whereas a can produced using its ink-saving method requires only 0.005 grams. This amounts to a 99.5% reduction in ink usage. Wong Lo Kat Pharmaceutical highlighted the potential impact of this eco-friendly, ink-saving product when introducing it to the market. The company stated that if all of the approximately 400 billion cans produced worldwide were manufactured using this method, nearly 398,000 tons of ink could be saved annually.

Eliminating the third purpose of ink use, which provides food information is not easy. Under the Food Labeling and Advertising Act (hereinafter referred to as the "Food Labeling Act"), companies cannot legally sell food products without the required information. However, the key lies in understanding who established such regulations in the first place: the government.

Among government agencies, the primary authority responsible for food-related regulations is the Ministry of Food and Drug Safety. This ministry has been actively

exploring ways to manage the growing volume of food information that changes each year. The ministry introduced the “Food QR” policy to replace complex and difficult-to-read food labels with QR codes. A more detailed discussion will be provided in the main section of this paper.

Finally, there is Lotte Chilsung Beverage. To strengthen its image as an environmentally responsible company and to work closely with the government on its net-zero initiatives, the company works closely with relevant stakeholders and publishes annual sustainability reports.

According to the 2024 Sustainability Report of Lotte Chilsung Beverage, there is one notable reference to a label-free can product: the Cantata Label-Free NB Can. The Cantata coffee beverage moved away from the conventional can design that relied on plastic labels. Instead, the company removed the label and printed directly onto the can, adopted a more environmentally friendly printing process, and used eco-friendly ink, contributing to the reduction of carbon emissions. Lotte Chilsung Beverage continues to conduct research and development on plastic-related manufacturing processes and environmentally friendly plastic technologies. It is hoped that the company will accelerate research and development related to sustainable can packaging as well.

| Body

a. Label-Free Can Multipack Initiative

Based on the insights from the examples above, this is the following idea. The first idea is label-free multipack can packaging. Label-free bottled beverages are already available on the market in multipack formats. This is because selling individual label-free bottles would violate the Food Labeling Act. Some consumers purchase bottled beverages individually, while others buy them in multipacks. The same applies to canned beverages. Then, is an ink-printed label really necessary even for consumers who purchase beverages in multipacks? For retailers, labels are clearly necessary but individual consumers already know what type of beverage they purchased, so they would not need a label. This does not mean that labels are removed entirely. As with label-free bottled beverages, the outer multipack packaging contains the product label and the food information. Likewise, label-free cans could also be sold in multipack packaging, just as bottled beverages.

Some cafés use plain silver cans (label-free cans) to package coffee instead of relying on plastic cups or paper cups. They also attach stickers to indicate the type of coffee or beverage inside. However, when comparing the surface area of a 500mL can that requires printing, stickers may actually offer a more effective way to reduce ink consumption.

b. Idea of Ink Usage Minimization

The second one is to minimize ink usage. One might argue this is similar to the first idea. However, the first one involves selling plain silver cans without using any ink during the production process. In contrast, the second idea can be viewed as an alternative approach that retains only the minimum amount of printing necessary to identify the product. Most cans are printed across their entire surface, with ink covering the full 360-degree exterior of the can. One approach is to adopt an ink-saving method similar to that used for Wong Lo Kat beverages, where ink is applied only to the product name. However, certain products, such as beer and caffeinated beverages, require special consideration. For these beverages, mandatory labeling requirements must be provided by law. If mandatory information such as alcohol content, caffeine content, and key ingredient content is printed in text alongside the beverage name, there would be little need to worry about the effectiveness of this ink-saving approach.

c. Proposal to Expand QR Code Policies under the Food Labeling and Advertising Act

The third idea is to expand the QR code policy under the Food Labeling Act. First of all, canned beverages are food products consumed by people. Therefore, there is a large amount of information that must be provided, including the product name, nutrition facts, food type, ingredients, expiration date, storage instructions, allergen information, food safety reporting number, and sodium content. It is true that a large amount of ink is used to print all of this information in dense text. Through amendments to the Food Labeling Act, the Ministry of Food and Drug Safety is implementing a policy that replaces part of the required food information with QR codes by applying the Real-Time Food Information Service (hereinafter referred to as “Food QR”) under a regulatory sandbox pilot program. If food information is replaced with QR codes, the ink currently used to display the information can be saved. The current Food QR policy was introduced to help people who have difficulty reading small food labels with the naked eye. It replaced all food information with QR codes except for seven mandatory food labeling items. However, if efforts to minimize ink usage continue to gain attention, it is expected that a complete transition to QR-based labeling may eventually become possible. If this happens, only the product name, expiration date (or manufacturing date and use-by date), and a QR code would remain on canned beverages. Food labeling requirements would be dramatically reduced, which is expected to significantly decrease ink consumption as well.

Conclusion

There are various ways to reduce ink consumption. Although can labels offer benefits in vending machines, online shopping, convenience stores, and retail settings, there are cases in which they are not necessarily required. If companies are already producing label-free plastic bottles, they should also actively consider producing label-free cans. Many companies have already gone through extensive trial and error in this area.

However, rather than relying on excessive ink printing to advertise on cans, companies should strongly consider producing label-free and ink-reduced cans to support environmental protection and carbon neutrality.

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I Introduction

- The Problem of Climate Crisis
- Related Technologies and Cases

I Body

- Selection of Candidate Project Sites
- Installation of Heat Recovery Systems Using Heat Pumps
- Connection to End-Use Applications
- Operation and Data Collection
- Strengthening Public Communication

I Conclusion

I References and Sources

Platform

06

Lee Yeon-woo / University of Seoul

A Carbon-Neutral Thermal Platform Utilizing Subway Station Waste Heat

Abstract

This paper presents the background, methodology, and potential applications of a carbon-neutral thermal platform based on the recovery of surplus heat from subway stations. The proposal was developed as a practical solution to one of the most pressing challenges associated with the climate crisis, particularly the urban heat island effect. Using ArcGISpro, the study calculates and visualizes a "Candidate Site Suitability Score," identifying candidate sites grounded in real-world spatial data. It also examines the feasibility of the project by estimating the budget required for actual facility construction for actual facility construction.

Through this proposal, the study seeks to demonstrate a specific pathway toward more sustainable cities. Also, this expects to contribute to the realization of carbon neutrality and net-zero goals in ways that citizens can directly experience.

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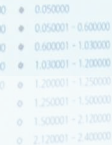
송파구_읍면동

총생할인구수



송파구_역사정보

높이(m)



0 1 2 3 4 Kilometers

| Introduction

a. The Problem of Climate Crisis

In the Republic of Korea, rapid urbanization has led to the extensive development of underground spaces in urban areas. Although these spaces continuously generate heat, much of this thermal energy is discharged without being utilized and ultimately goes to waste. Among underground spaces, subway stations are particularly recognized as concentrated places of surplus thermal energy, including ventilation exhaust heat and heat contained in underground air. However, the Republic of Korea has yet to establish any policies that recover and utilize this surplus thermal energy as part of its carbon neutrality efforts. In contrast, many countries increasingly recognize waste heat recovery and reuse as a key strategy for achieving carbon neutrality. In London, the United Kingdom, pilot projects have been implemented to supply heat recovered from subway ventilation systems to nearby buildings for heating. Likewise, Paris, France, has launched initiatives that capture heat from the metro system and use it to heat public facilities. These examples show a growing trend among major cities worldwide to harness surplus thermal energy from urban underground spaces. Thus, the Republic of Korea should pursue a subway station-based surplus heat recovery platform.

Given this, the urban heat island effect has emerged as a major environmental issue in recent years. The urban heat island effect refers to the phenomenon in which temperatures in urban areas are higher than nearby regions. It results from complex factors, including dense clusters of high-rise buildings, the expansion of asphalt and concrete surfaces, and increasing levels of anthropogenic heat. In this context, surplus heat from subway stations is more than simply a byproduct of urban activities. It is both a consequence of the urban heat island effect and a secondary factor that further intensifies it. Subway stations are structurally prone to heat accumulation below ground level. Human body heat generated by large numbers of passengers, heat emitted from electronic equipment and lighting systems, frictional heat produced by subways, and ventilation waste heat generated by ventilation systems and equipment rooms all contribute to rising indoor temperatures. So, temperatures inside subway stations remain consistently higher than those of the outdoor environment. When this accumulated heat is simply released into the atmosphere through ventilation shafts and exhaust outlets, it can further contribute to the urban heat island effect. When heat is released in concentrated areas around station entrances and nearby roads, it can further raise already elevated urban temperatures, thereby exacerbating the urban heat island effect. This can lead to a range of environmental challenges, including increased cooling energy demand and deteriorating air quality.

b. Related Technologies and Cases

No direct precedent exists for recovering and reusing surplus heat from underground spaces. However, there are studies involving the recovery and reuse of surplus heat itself.

These studies and precedents can serve as a basis for further developing this proposal.

The first case is the recovery of wastewater heat. This case was found during a site visit to the Hanam Union Environment Energy Town. The facility integrates a waste incineration plant, a wastewater treatment plant, and a food waste recycling facility within a single complex. It uses heat recovered from waste incineration to provide heating and cooling to nearby communities, while wastewater heat is utilized as an internal energy source for the wastewater treatment plant. If applied to subway stations, this approach could be expanded without being limited by the location-specific constraints of being situated near wastewater treatment plants or waste treatment facilities.

The second case is the district heating and cooling system on Subway Line 9. During the construction of Line 9, deep geothermal wells were installed at seven stations, and geothermal energy was used to generate electricity equivalent to 9% of the energy required for heating and cooling the stations. This inevitably required large-scale construction involving deep geothermal drilling and the installation of new facilities. However, if applied to the proposed system, heat recovery could be expanded at low cost by utilizing existing facilities in underground spaces where heat already exists, without the need for additional excavation.

Body

Therefore, heat pump-based heat recovery systems should be installed within existing subway station infrastructure. By establishing an urban thermal resource recovery platform that recycles surplus heat from underground urban spaces for heating, hot water supply, and ventilation, various challenges associated with underground surplus heat can be addressed. The detailed implementation process of this proposal is outlined below.

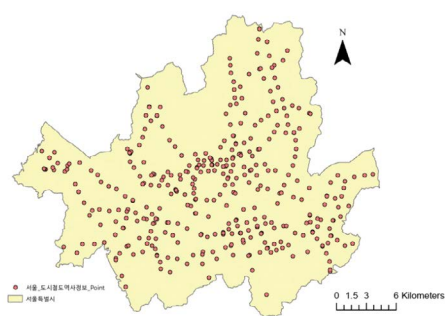
a. Selection of Candidate Project Sites

With the large number of subway stations in the Republic of Korea, candidate sites should be selected based on the surrounding conditions to determine where this proposal can be most effectively implemented. It is desirable to begin with a pilot project at stations where surplus heat is generated in sufficient quantities and where implementation conditions are favorable. To achieve this, clear selection criteria are required to identify suitable stations

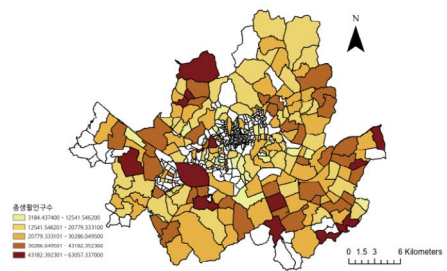
for the pilot project.

This proposal considers four factors in the site selection process: station location, passenger volume, the location of subway station ventilation rooms, and an analysis of the surrounding thermal environment. In this study, the analysis of the surrounding thermal environment refers to surface temperature.

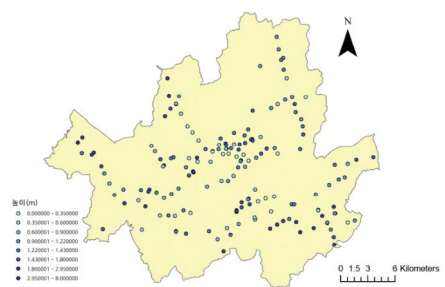
For the accurate spatial analysis, the locations of Seoul subway stations, passenger volume, ventilation room locations, and surface temperature data were visualized using ArcGIS Pro, as shown below. The four factors were then integrated to generate a "Candidate Site Suitability Score," which was visualized using a color scale.



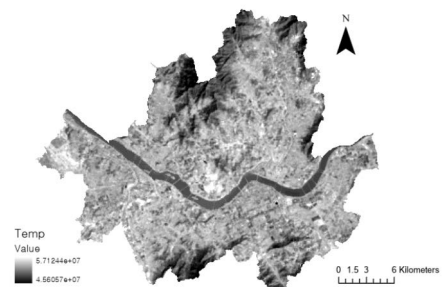
[Figure 1] Locations of Subway Stations



[Figure 2] Passenger Volume



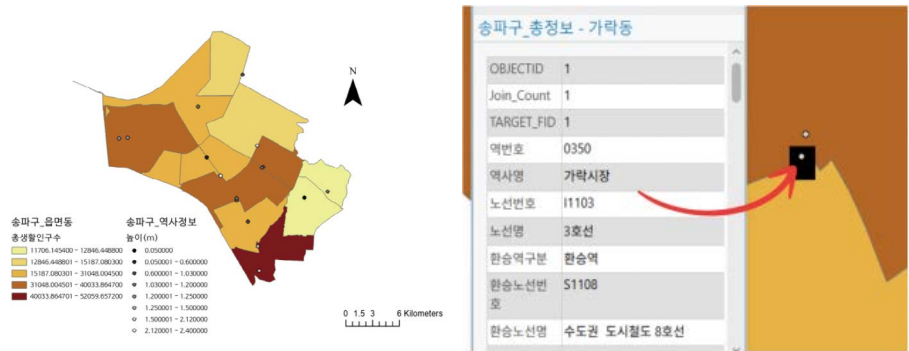
[Figure 3] Ventilation Room Locations



[Figure 4] Surface Temperature Data

This study initially sought to conduct a spatial analysis of subway stations across the Seoul Metropolitan Area. However, due to insufficient data for the four selected factors, the analysis was limited to Seoul. For point data such as those shown in Figures 1 and 3, a spatial join was performed by matching the data with administrative boundary units at town, township, and district levels town, township, and district levels using the Spatial

Join tool. For raster data in TIFF format, such as that shown in Figure 4, the data were converted into SHP vector format prior to analysis. Finally, data preprocessing was conducted so that the vector dataset representing eup, myeon, and dong administrative boundaries contained information on all four factors for each administrative unit. The four factors were subsequently assigned equal weights and summed to calculate the Candidate Site Suitability Score for each eup, myeon, and dong in Seoul. Among the districts, Songpa-gu provided the clearest visual representation of the analysis results.



[Figure 5] Data of Songpa-gu

[Figure 6] Information on Garak Market Station

Figure 5 presents only the Candidate Site Suitability Score data and ventilation shaft point data for Songpa-gu. Based on the analysis, stations with high passenger volume, low ventilation room elevation, and high surface temperatures in their surrounding areas were identified, Garak Market Station on Seoul Metro Line 3 emerged as the most suitable site for the pilot project.

This analysis has limited reliability because it is based on a simple linear model. It is also constrained by the fact that some information is missing from the datasets used in the analysis. In addition, the weighting of the four factors requires further refinement. Nevertheless, if these limitations are addressed and the analysis is integrated with data from local governments and the wider Gyeonggi region, it could serve as a useful tool for developing guidelines and policies on surplus heat recovery in areas where subway stations are located. Beyond this, it could be used as both a decision-making tool and evidence for related policy decisions.

b. Installation of Heat Recovery Systems Using Heat Pumps

After selecting the candidate site, the most important step in this proposal is the installation of heat pumps and heat exchangers. First, Table 1 summarizes the types of

heat that can be recovered using heat pumps and the potential heat sources available for recovery.

[Table 1] Recoverable Heat Sources.

Heat Source	Description	Location within Subway Stations	Recovery Potential
Heat from Underground Air	Warm air accumulated in ventilation shafts, mechanical rooms, and station platforms	Station concourses, ventilation rooms, and station connecting passages	Recoverable (Using heat pump systems)
Wastewater Heat	Warm wastewater flowing through sewage pipes near the station	Pipelines buried beneath public land around subway stations	Highly promising based on the Hanam case)
Mechanical Heat	High-temperature air (above 20°C) discharged from existing ventilation systems	Air circulation ducts connecting station platforms to the outside	Recoverable (Install heat exchanger)
Geothermal Heat	Deep subsurface temperatures beneath the station foundation (approximately 15°C or higher)	Typically located at B2 or higher	Lower priority if excavation is not required

To recover the heat sources described above, source-specific recovery systems can be established by installing small-scale heat pumps and plate heat exchangers near sewage pipelines, ventilation shafts, and mechanical rooms within subway stations. The detailed installation process is described below.

Method 1. Installation of Heat Pumps and Heat Exchangers

[Table 2] Heat Pumps and Heat Exchangers by Heat Source

Heat Source	Heat Pump	Heat Exchanger
Wastewater Heat	Wastewater Source Heat Pump	Screw-Type or In-Pipe Heat Exchanger (HEX)
Subway Ventilation Waste Heat	Air Source Heat Pump	Air-to-Water Heat Exchange or Total Heat Exchanger
Hybrid System (Wastewater and Waste Heat)	Hybrid Heat Pump	Combination of Plate and In-Pipe Heat Exchangers

The first method is simply to install heat pumps and heat exchangers. For wastewater heat, a Wastewater Source Heat Pump(WSHP) can be used to recover heat at

temperatures ranging from 15°C to 25°C. For subway ventilation waste heat, an Air Source Heat Pump(ASHP) can recover heat from exhaust air with temperatures above 30°C. In the case of hybrid heat sources, a Hybrid Heat Pump (HHP) can be utilized. Heat pumps can be installed in available spaces near ventilation rooms or electrical rooms within the station. Because different types of heat exchangers are required for different heat pump systems, it is most desirable to first determine which heat source should be recovered at the target subway station through an analysis of the surrounding conditions and then install the heat exchanger and heat pump best suited to that heat source.

In particular, it is essential to conduct a preliminary assessment of the existing power infrastructure and the feasibility of connecting the relevant equipment.

Method 2. Installation of Capillary Tube Mats

The second method is to install capillary tube mats. This approach has already been implemented in Tokyo. In that case, capillary tube mats were installed at Shibuya Station to enable natural ventilation. The surface temperatures of the ceilings and floors in the platform area were cooled to below the ambient air temperature through the use of Clina capillary mats. This helped maintain a comfortable thermal environment for passengers. As a result, it is possible to develop a radiant-cooled subway station that achieves a high level of thermal comfort, improved energy efficiency, and ease of maintenance.

One of the primary considerations in designing this installation process is cost. Of the two methods presented above, the more practical approach is the first method, which involves the direct installation of heat pumps and heat exchangers. Accordingly, the installation costs of these two devices were examined. To provide a detailed cost estimate, the installation location, operating conditions, and system operation method were assumed to reflect typical operating conditions. The electrical room and ventilation room were considered as the proposed locations. The analysis assumed that access to either sewer pipelines or ventilation shafts was available, that the necessary power supply infrastructure was in place, and that no interference with existing foundation structures would occur. The operating system was configured with automatic controls capable of switching between heat sources based on operating conditions. Also, it was assumed that the recovered heat would be converted into secondary energy.

[Table 3] Estimated Installation Cost

Component	Estimated Cost	Description
Heat Pump (100 kW Capacity)	Approximately KRW 40–60 million	Varies depending on whether a wastewater-source, air-source, or hybrid system is used
Heat Exchanger (Industrial-Grade HEX)	Approximately KRW 20–30 million	Based on a scroll-type unit
Auxiliary Equipment (Piping, Pumps, Control Systems, etc)	Approximately KRW 20–40 million	Varies according to site conditions and scale
Installation Labor and Construction Costs	Approximately KRW 10–20 million	May increase or decrease depending on the level of interference with existing facilities
Total Estimated Installation Cost	Approximately KRW 90–150 million	Based on a medium-scale (combining wastewater and air-source heat)

Based on the assumptions outlined above, the estimated installation costs are presented in [Table 3]. Taking into account the heat pump, heat exchanger, auxiliary equipment, and installation labor, the total estimated installation cost ranges from approximately KRW 90 million to KRW 150 million. This estimate is based on a medium-scale system designed to recover both wastewater heat and air-source heat. It is difficult to determine a definitive installation cost because the cost of auxiliary equipment can vary substantially depending on site conditions and project scale. Even so, upon reviewing these cost estimates, the first observation is that the project is substantial in scale. Moreover, the project requires a significant overall budget. In this context, one option to consider is the use of government subsidy programs.

The Ministry of Trade, Industry and Energy of the Republic of Korea currently operates a support program for water-source and air-source heat pump systems, providing up to KRW 200 million in financial assistance per project site. The Korea District Heating Corporation offers financial support programs for heating-related facilities and the installation of automatic control systems with energy-saving modes. These programs provide support ranging from KRW 3 million to KRW 5 million per project site. Especially, installing an automatic control system with an energy-saving mode can help minimize energy consumption because the system automatically adjusts its operation according to the available heat source. Even by utilizing only these two government subsidy programs, a substantial portion of the previously estimated installation cost could be covered, suggesting that the proposed system is financially feasible.

c. Connection to End-Use Applications

The recovered heat can be integrated into the station's heating, ventilation, and air conditioning (HVAC) system. It can be used in areas with consistent heating demand, such as staff rooms, restrooms, and platforms. One effective approach would be to store the recovered heat in the form of hot water and supply it when needed. Especially during the summer, heat accumulated on station platforms can be recovered and repurposed for uses such as providing hot water in restrooms. So, the system can provide a more comfortable underground environment for subway passengers.

d. Operation and Data Collection

Information collected during operation, such as recovered thermal energy (kWh), electricity consumption (kWh), and CO₂ emissions reductions (tons), should be converted into data and systematically recorded. The resulting data can be used to support future project expansion to other sites and facilitate the transition toward more automated system operation. Real-time data collection can be achieved by integrating IoT-based flow and temperature sensors, power meters, and a Supervisory Control and Data Acquisition (SCADA) system. Furthermore, carbon neutrality performance can be translated into measurable indicators, supporting the development of a net-zero city.

e. Strengthening Public Communication

The collected data, including recovered heat sources and their associated carbon emissions reductions, should be publicly disclosed. A public display system, similar to the air quality information boards shown in the image on the left, could be installed in areas where passengers can easily view it. The display could present messages such as, "Station XX is currently recycling underground thermal energy." To enhance public understanding, the information could also be visualized in a more intuitive manner, for example: "Today, the recovered heat from Station XX is sufficient to provide heating for approximately 25 households," or "Today's CO₂ emissions reductions are equivalent to planting 30 trees." This approach can enhance public environmental awareness and has the potential to be expanded as an energy conservation campaign. Moreover, by enabling citizens to directly perceive the impacts of carbon neutrality efforts in their daily lives, it can help build public trust and support for related policies. In the long term, it may also contribute to the broader adoption of citizen participation in energy conservation and increase public acceptance of carbon neutrality policies.



[Figure 7] Fine Dust Information Board

Conclusion

This system can address the long-standing issue of wasted underground heat in urban areas and contribute to mitigating the urban heat island effect. Following pilot projects at selected stations in Seoul, the system could be expanded to the entire Seoul Metro network, as well as to other underground facilities such as ventilation systems in the Seoul metropolitan area and underground parking structures. Likewise, the system could be integrated with a variety of urban heat sources, including waste heat from building heating and cooling systems, server heat from data centers, and process heat from industrial facilities, enabling the development of an integrated heat recovery network. Such a network could establish a city-wide energy circulation system and serve as a key piece of infrastructure for building a sustainable city.

The impacts of this project on achieving net-zero goals can be summarized in four key areas. First, it can reduce energy costs. By recovering and reusing heat that would otherwise be wasted, the system can offset electricity and gas consumption. As such, it is expected to reduce urban energy operating costs over the long term. Second, it can reduce carbon emissions. By lowering dependence on fossil fuels, the system can directly contribute to reducing greenhouse gas emissions. Third, the system can be expanded with relative ease. Because it utilizes existing infrastructure, no additional land acquisition is required, allowing for cost-effective and phased expansion. Finally, it represents a citizen-oriented policy. Even without direct participation, citizens can observe how the spaces they use contribute to carbon neutrality through station information displays and public awareness campaigns. This extends beyond the adoption of a technical solution and can foster greater environmental awareness and broader public support. Ultimately, the project can enhance both the acceptance and feasibility of carbon neutrality policies while helping establish tangible carbon-neutral infrastructure that citizens can directly experience in their daily lives.

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[Figures]

Fine Dust Information Board Image: <http://www.newsggam.com/news/articleView.html?idxno=85888>

[GIS Using Data]

USGS Earth Explorer Landsat 8 Satellite Data (Band 10)

Seoul Metro Ventilation Shaft Inventory

Ministry of Land, Infrastructure and Transport–Korea National Railway: National Urban Railway Station Information Standard Dataset

Seoul Open Data Plaza: Seoul Living Population Data by Administrative Dong (Korean Nationals)

I Introduction

- Southeast Asia and Korean Tourists
- The Status of SDGs Achievement and Environmental Realities in Southeast Asia
- Ecotourism and International Development Cooperation

I Body

- Night Market Eco-Program
- Improving the Efficiency of Waste Management Standards
- Establishing Community Cooperatives in Tourist Destinations
- Foundations and Expected Impacts of an International Development Cooperation Project

I Conclusion

I References and Sources

International Cooperation

07

Lee In-hye / Seoul National University

Policy Recommendations for Eco-Tourism Development Cooperation in Southeast Asia

Abstract

This paper presents the theoretical concept of ecotourism, a form of tourism that seeks to achieve carbon neutrality and protect the natural environment while minimizing environmental impacts. It also explores why this concept should be applied particularly to Korean tourism in Southeast Asia and proposes practical strategies for its implementation. The paper addresses the question, "Why Southeast Asia?" by examining the high proportion of Korean tourists visiting the region and the environmental challenges that continue to hinder progress toward achieving the Sustainable Development Goals(SDGs). Also, it proposes several measures to promote ecotourism in practice, including the development of eco-programs in night markets, improvements in waste collection systems, and the establishment of community cooperatives in tourist destinations. Moreover, the paper analyzes the characteristics of these initiatives as international development cooperation programs by examining their public benefits, broader impacts, and the potential advantages that the Republic of Korea could gain from their implementation. Through this, the paper presents a model for the future direction of environmentally sustainable tourism.

| Introduction

a. Southeast Asia and Korean Tourists

Southeast Asian countries such as Thailand, Laos, and Vietnam are among the most popular tourist destinations for Korean travelers seeking leisure. Before the COVID-19 pandemic, more than 10 million Korean tourists visited ASEAN member states in Southeast Asia in 2019. This figure was more than twice the number of Korean tourists who traveled to Japan during the same period. For example, according to the Ministry of Information, Culture and Tourism of Laos, 165,328 Korean tourists visited Laos in 2015.

However, the number increased year by year, reaching 203,191 in 2019, approximately 30% higher than in 2015. Although the number temporarily declined following the COVID-19 pandemic in 2020, it has since stabilized, and the number of tourists visiting Southeast Asia appears to have surpassed pre-pandemic levels.

In particular, in several countries such as Vietnam and Thailand, Korean tourists account for a significant share of total international tourist arrivals. In Vietnam, Korean visitors have consistently ranked second among all foreign tourists, following Chinese tourists. Korean tourists also consistently rank among the top five international visitor groups in other major tourist countries, including the Philippines, Thailand, and Indonesia. Especially, many Southeast Asian countries have not yet achieved a high level of development in their tertiary or higher industries. So, tourism remains a central pillar of their industries. For example, in Indonesia, the tourism sector accounts for as much as 11% of the country's GDP. Moreover, tourism contributed 4.8% of Southeast Asia's total GDP in 2024. This figure is projected to increase to 4.9% in 2025, making Southeast Asia among the fastest-growing tourism regions in the world.

Also, the growth in tourist arrivals has also had negative environmental impacts across Southeast Asia. According to Plastic Atlas (2021), a comparison of annual per capita waste generation by local residents and tourists in Vietnam found that residents generated 70 kg of waste per year, whereas tourists generated 114 kg, approximately 61% more. In the Maldives, local residents generated 23.4 kg of waste per capita annually, compared to 102.2 kg for tourists, meaning that tourists produced roughly five times more waste than residents. In Bali, residents generated 14.6 kg of waste per capita annually, while tourists generated 50 kg, a difference of approximately 3.5 times. These figures demonstrate that the environmental impacts of tourism on countries should not be overlooked. Furthermore, the influence of Korean tourists on the environment in these countries warrants careful consideration.

These highlight why we must take responsibility for the challenges associated with tourism in Southeast Asia. Although these issues do not originate within the Republic of

Korea, environmental impacts often extend beyond national borders and affect a wide range of regions. Moreover, considering the impact that Korean tourists can have on those countries through their travel, it is appropriate that we should take responsibility for this issue. The ways in which Korean tourists affect the environment in Southeast Asia should be regarded as an important issue both in the Republic of Korea and in the Southeast Asia countries themselves.

b. The Status of SDGs Achievement and Environmental Realities in Southeast Asia

The level of progress toward achieving the Sustainable Development Goals (SDGs) remains relatively low across many Southeast Asian countries. According to the SDG rankings, Thailand recorded the highest position among Southeast Asian countries, ranking 43rd globally. It was followed by Vietnam in 55th place, Indonesia in 75th, the Philippines in 98th, Laos in 115th, and Myanmar in 125th, placing many countries in the region in the lower tiers of the global rankings. These indicate that a number of Southeast Asian countries continue to face significant challenges in environmental protection and the achievement of net-zero emissions. More specifically, many Southeast Asian countries face common challenges in achieving SDG 14 (Life Below Water) and SDG 15 (Life on Land), including Thailand, Vietnam, Indonesia, the Philippines, Brunei, Cambodia, and Myanmar. SDG 9 (Industry, Innovation and Infrastructure) has been also identified as another area requiring significant improvement in countries such as Cambodia, Laos, and Myanmar. Tourism is an industry that relies heavily on both natural and human-made infrastructure while drawing value from marine and terrestrial ecosystems. Consequently, the level of SDGs achievement in Southeast Asia is closely linked to the tourism sector. Given that tourism is one of the major industries in many of these countries, the tourism sector and the achievement of the SDGs have significant implications for these countries' economic and social development.

In some riverside communities in Bangkok, Thailand, large floating waste containers are used to collect household waste from nearby residential areas. During the collection process, however, it is common for waste to spill into the river and drift downstream. This illustrates that waste management systems often face operational challenges even at the collection stage. Furthermore, even when waste is successfully transported to disposal or management facilities, inadequate waste separation remains a widespread problem, making proper processing difficult. These examples highlight how environmental issues, particularly waste management, have become significant social challenges across Southeast Asia, affecting both tourist places and local communities. As discussed above, this has led to growing calls for countries such as the Republic of Korea to take greater responsibility and contribute to addressing waste management and environmental pollution challenges in Southeast Asia.

c. Ecotourism and International Development Cooperation

Ecotourism refers to a form of travel that seeks to minimize environmental impacts while allowing visitors to experience and enjoy nature. The concept extends beyond the natural sciences, encompassing more than the protection of ecosystems and the conservation of natural landscapes. It also includes sustainability principles related to the development of local communities and countries from a socio-economic perspective. Particularly, the concept of ecotourism promoted by the Association of Southeast Asian Nations (ASEAN) emphasizes both people-centred and sustainable development and sustainable and inclusive tourism development. It seeks to foster environmentally responsible development through social contributions. As mentioned earlier, tourism plays a significant role in many Southeast Asian economies. Given the importance of the sector, the development of ecotourism is expected to have a substantial impact on these countries.

Therefore, this paper proposes several international development cooperation measures to promote and advance ecotourism. International development cooperation is a broader concept that encompasses Official Development Assistance (ODA). ODA refers specifically to assistance provided by public institutions, including national governments and local authorities. In contrast, international development cooperation extends beyond the public sector and includes initiatives undertaken by non-governmental actors such as NGOs, civil societies, and private companies. Also, ODA includes both concessional loans and grants. However, regardless of the form of assistance, it is officially recognized as ODA only when the grant element exceeds 25%. By comparison, international development cooperation is broader in both scope and eligibility criteria. It generally refers to a wide range of efforts aimed at removing barriers that prevent people in developing countries from enjoying freedom, peace, and a better quality of life, regardless of the sector. In the field of tourism, civil society organizations and private companies engaged in the tourism industry often possess more practical experience and specialized expertise than central governments. Therefore, this paper adopts international development cooperation, a broader and more flexible concept than Official Development Assistance (ODA).

However, cases in which developing countries receive unconditional and one-sided assistance simply because they face poverty and food insecurity are becoming increasingly rare. Instead, donor countries are increasingly linking international development cooperation to their own national interests when providing support. In fact, Japan's legislation on international development cooperation explicitly states that such cooperation should be conducted in a manner that serves the national interest. This reflects one of the key differences between the traditional concept of "international aid" and the broader concept of "international development cooperation." The term aid has often been associated with the image of one-sided assistance provided by donor

countries. In contrast, international development cooperation, as the term cooperation suggests, is based on a framework that not only supports recipient countries but also incorporates elements of mutual diplomatic, economic, and social cooperation between the parties involved.

Accordingly, the Republic of Korea's ecotourism-focused international development cooperation with Southeast Asian countries can contribute to the development of the tourism industries by improving socio-economic conditions in that region. Ultimately, it should be carefully designed so that these benefits generate positive returns for the Republic of Korea as the donor country. To this end, the concluding section of this paper examines in detail the potential impacts and expected benefits that the promotion of ecotourism in Southeast Asia may bring to the Republic of Korea. It can serve as an institutional foundation for fostering mutual coexistence in pursuit of the public good of environmental protection, based on positive relations between the donor country, the Republic of Korea, and recipient countries in Southeast Asia, as well as strengthened infrastructure in the recipient countries.

| Body

As such, this paper proposes the Republic of Korea-led international development cooperation program to help Southeast Asian countries establish and implement effective ecotourism programs centered on environmental protection, waste reduction, and carbon neutrality. This paper consists of three main components: developing waste management measures for night markets, improving the efficiency and improvement of existing waste collection systems, and establishing local community cooperatives to support ecotourism. By taking into account both the natural and socio-economic environments of local communities, it seeks to identify approaches that promote mutual benefits for both residents and tourists.

a. Night Market Eco-Program

Tourist night markets are among the major sources of environmental problems in Southeast Asia. Night markets are among the places that generate large amounts of waste, including plastic bags used for packaging, wooden skewers for street food, and disposable paper food containers. According to the Pollution Control Department under Thailand's Ministry of Natural Resources and Environment, residents and visitors in Pattaya, home to one of the country's most well-known night markets, generated approximately 3.9 kg of waste per person per day prior to the COVID-19 pandemic. This is comparable to the level of waste generated in Singapore, whose GDP per capita reached

USD 89,370 in 2024, more than ten times that of Thailand (USD 7,172 in 2024). This highlights the substantial contribution of tourist destinations, particularly night markets, to local waste generation. Given that, effective strategies are needed to manage waste from night markets and significantly reduce overall waste volumes.

First, a program could be introduced to convert food waste generated in night markets into compost and distribute it to nearby farms. This approach is already being implemented through several initiatives supported by the Global Green Growth Institute (GGGI) and the Korea International Cooperation Agency (KOICA). For example, KOICA is carrying out a project in the Cusco region of Peru from 2023 to 2027 to establish a composting facility capable of processing up to 12 tons of organic waste, including food waste, per day. This type of project could be adapted and applied to address waste management problems in night markets. Food waste generated within night markets could be collected, processed into compost, and distributed to nearby farms through a dedicated waste-to-compost program. Such an initiative could positively contribute to reducing food waste, protecting the environment, and improving the appearance of tourist night markets, while also supporting the development of nearby farms and increasing agricultural productivity through the use of environmentally friendly compost.

Second, recyclable waste generated in night markets could be transformed into upcycled souvenirs and sold within the markets. Upcycling is one of the creative approaches to reducing waste by converting discarded materials into distinctive products, such as decorative items and everyday household goods. However, upcycling remains relatively uncommon in everyday life. One reason is that many people consider it inconvenient, while others perceive upcycled products as lacking practical value. In contrast, tourists visiting overseas night markets often make purchasing decisions based less on practicality and more on aesthetics and the symbolic value of the country. In the Republic of Korea, the eco-friendly fashion brand NUKAK showcased a variety of upcycled products, including card holders made from discarded banners, at the Banpo Hangang Park Bamdokkaebi Night Market, which was held for approximately six months from March to October 2018. In addition, several night market events have incorporated upcycling initiatives, including the 1883 Imagination Platform Night Market in Incheon in 2025 and the Chilseong Night Market in Daegu in 2023. Building on the ideas demonstrated by these initiatives, a strategy could be introduced to create and sell distinctive products that reflect the identity of the local area by utilizing waste generated in night markets. Based on this approach, products such as key chains and pouches made by upcycling used wooden chopsticks, plastic bottle caps are likely to attract strong demand from tourists compared with conventional markets. In addition to supporting environmental protection, they can also contribute to the livelihoods of night market vendors.

b. Optimization of Waste Collection Systems

The second solution is to improve the efficiency of the waste collection process. To enhance the waste management measures discussed above, it is necessary to consider how waste can be collected and consolidated effectively for processing. To this end, this paper proposes improving the accessibility of the waste collection process as a fundamental step toward the effective management of waste generated in tourist places.

In many parts of Southeast Asia, narrow unpaved roads make it difficult for conventional large waste collection trucks to access and collect waste efficiently. For this reason, illegal dumping has become widespread, with waste often being discarded in convenient locations rather than at designated collection points. This has a negative impact on the environmental landscape of tourist places. To address these challenges, one possible solution is to deploy small electric waste collection vehicles that can operate effectively on unpaved roads. Their compact size would allow them to navigate narrow streets and improve the efficiency of waste collection. In addition, public waste bins are often difficult to find in some tourist places across Southeast Asia. Differences in waste-sorting symbols compared with those used in the Republic of Korea can also make it challenging for tourists to dispose of waste properly. To address these issues, additional waste bins of various sizes could be installed throughout public areas, while waste-sorting labels could be redesigned to be more visible and easier to understand.

The impact of improving the waste collection process on local environmental realities can be seen in the Green Light Project, a joint initiative launched by Kia and Good Neighbors in 2019. As part of the project, new green waste bins should be installed in Mai Chau District, Hoa Binh Province, Vietnam. Also, a 1.5-ton waste collection truck was introduced to transport waste efficiently to a newly established waste treatment facility. In other words, the project created a system designed to improve the effectiveness of waste collection. Therefore, the average monthly volume of waste collected increased from 253 tons in 2020 to 280 tons in 2021, exceeding 400 tons in 2022. Furthermore, total annual waste collection fees rose by 22%, from VND 34 million (approximately KRW 1.96 million) to VND 41.6 million (approximately KRW 2.4 million). This case clearly shows the environmental benefits that can result from more effective waste collection systems. Based on these, we can understand that improving waste collection measures in tourist places could contribute to positive improvements in the local environmental landscape quality.

c. Establishment of a community-based tourism cooperative

The third solution places greater emphasis on strengthening the sustainability of local communities and socio-economic conditions than on the natural environment itself. The

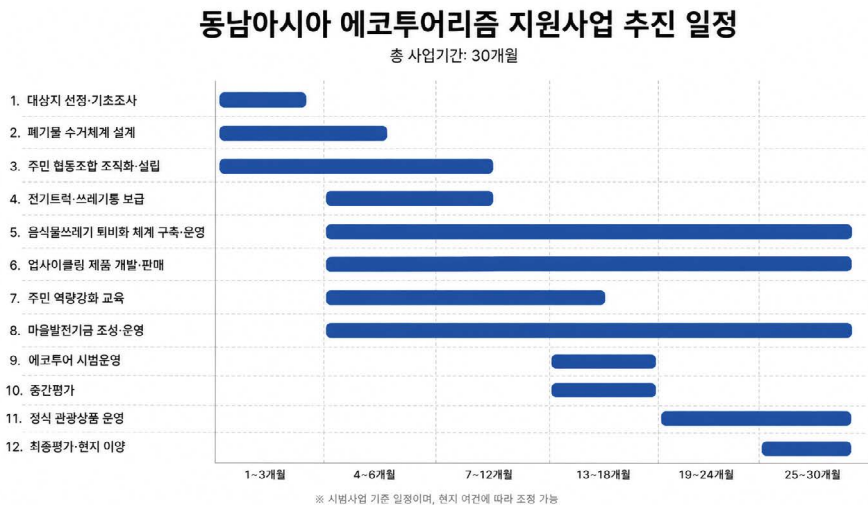
Indonesian media platform 'Jakarta Times' has consistently emphasized the socio-cultural benefits of ecotourism, including benefits for whole local communities by creating jobs and the promotion of cultural heritage. It is important that both tourists as consumers and governments play an active role for the development of the tourism industry. However, the efforts of local residents and other individuals working in the tourism sector are equally essential. Nevertheless, tourism activities are currently dominated by large foreign travel agencies, leaving local residents with limited incentives to develop and implement ecotourism programs themselves. Even when such programs are introduced, local communities often receive few direct benefits from increased tourist arrivals or environmental improvements. So, the local stakeholders who support tourism services have little motivation to actively engage. As such, the development of ecotourism programs remains limited. Consequently, the benefits generated by ecotourism should be directed toward local residents in order to provide incentives to them. This would help increase participation among local stakeholders. In light of this, the establishment of cooperatives for residents in tourist places could be considered. The reason cooperatives are considered is that they can unite otherwise dispersed community members around shared interests, thereby enhancing group cohesion. They can also facilitate collective action toward a common goal: promoting the whole local community's benefit.

Accordingly, cooperatives could be established among residents of tourist places, and tourism capacity-building programs could be provided to those members on the question: "What incentives can ecotourism bring to the local community?" This is part of a job training program designed to create sustainable employment by helping local residents secure stable jobs in specialized tourism-related fields, including food service, retail, and interpretation. Beyond this, a portion of the revenue generated through ecotourism could be allocated, following deliberation within the cooperative, to a community development fund dedicated to projects that benefit the local community, such as the construction of hospitals and wells. Similarly, it is unrealistic to exclude large tourism agencies that hold significant advantages in terms of capital and infrastructure within the Southeast Asian tourism industry, a solution is also needed to promote cooperation between tourism companies and local residents. If a large tourism company seeks to develop ecotourism programs in a particular area, regulatory measures could be introduced requiring the company to actively employ local residents as guides and local coordinators, while allocating a portion of its revenue to the local community. In this way, incentives could be created for tourism industry stakeholders to actively adopt ecotourism, leading to higher levels of participation. This is also consistent with the fundamental principles of ecotourism, reflected in a message repeatedly emphasized by Malaysia's Minister of Tourism, Arts and Culture: "It is not simply the number of tourists that matters. Ordinary local residents, restaurant owners, homestay operators, and handicraft artisans should all be able to benefit from tourism." In this sense, it provides a foundation for truly sustainable development by pursuing not only the protection of natural landscapes and

the environment at tourist places, but also the well-being of all members of the local community.

d. The Foundation and Effect of the International Development Cooperation Project

The Gantt chart below presents the implementation process and estimated timeline for each stage of the proposed international development cooperation(ODA) project. It was developed with reference to GGGI's 『Green City Action Plan, Vientiane Capital 2023–2030 (2024)』, the ASEAN Secretariat's 『ASEAN Community-Based Tourism Standard, 2nd Edition (2022)』, and the KOICA Environmental Management Guidelines.



[Chart- Vertical: 1. Beneficiary Selection and Baseline Assessment / 2. Design of the Waste Collection System / 3. Organization and Establishment of Community Cooperatives / 4. Deployment of Electric Trucks and Waste Bins / 5. Establishment and Operation of a Food Waste Composting System / 6. Development and Marketing of Upcycled Products / 7. Community Capacity-Building Training / 8. Establishment and Management of a Community Development Fund / 9. Pilot Implementation of Ecotourism Programs / 10. Midterm Evaluation / 11. Launch of Official Tourism Products / 12. Final Evaluation and Handover to Local Stakeholders]

[Chart - horizontal: Months 1–3 / Months 4–6 / Months 7–12 / Months 13–18 / Months 19–24 / Months 25–30]

*The timeline is based on a pilot project and may be adjusted depending on local conditions.

Of course, a number of factors would need to be considered in the actual implementation of the program. Moreover, the one-year timeline presented in this chart reflects only the initial implementation phase and does not take into account the time required for the program to become fully operational and achieve meaningful outcomes. Nevertheless,

the chart remains valuable in that it examines the feasibility of the proposed program in accordance with the implementation process and provides a framework for further discussion.

The budget required for the ODA project would primarily depend on the funding decisions of KOICA and the Export-Import Bank of Korea. But, the proposed program targets Southeast Asia, additional support could be sought, if necessary, from regional organizations such as the Mekong Institute and other relevant international institutions operating in the region. At the same time, a sustainable source of funding could be secured through mechanisms such as cooperative membership fees paid by local residents.

In conclusion, the international development cooperation program proposed in this paper to promote ecotourism in Southeast Asia has the potential to generate far-reaching impacts across multiple sectors of society.

First, from a socio-economic perspective, the tourism industry generates a broader range of positive externalities than almost any other sector. An externality is an unintended loss or benefit imposed on a third party as a result of the actions of an economic actor that affect parties other than those directly involved in the activity. The development of the tourism industry does not simply enhance convenience for tourists or generate economic profits for those employed in the sector. It also brings increased consumption, economic growth, and job creation throughout the wider region in which the tourist place is located. This, in turn, contributes to the growth of other industries, including agriculture, fisheries, and manufacturing. In the long term, it could contribute to poverty reduction and broader industrial development across Southeast Asia. The local community's socio-economic development generated through these externalities can contribute to progress toward multiple Goals, particularly SDGs 1 and 2 on poverty and hunger, as well as SDGs 8 and 9 on economic growth and infrastructure development.

Second, from an environmental perspective, the program can contribute to carbon neutrality by reducing waste, promoting waste separation, expanding recycling and upcycling practices, and maintaining clean tourist places. Especially, whereas environmental efforts have traditionally concentrated on industrial zones, agricultural regions, and large cities, this program focuses on the tourism sector as a distinct area of industries. In doing so, it can extend environmental efforts to smaller-scale areas that have often been overlooked. UNEP notes that food waste composting can reduce the flow of organic waste into landfills and open dumping sites, thereby decreasing greenhouse gas emissions and pollution while preventing issues such as odors, pests, and fires. Through this program, it would be possible to reduce gaps in waste management that allow illegal dumping to occur and provide a sustainable alternative to harmful chemical fertilizers. Along with this, it can promote a circular tourism model by transforming

waste materials such as plastics, bottles, cans, tarpaulins, and packaging into upcycled products and selling rather than simply discarding them. Such programs are particularly significant because they represent not only improvements in physical infrastructure but also institutional and socio-cultural interventions aimed at transforming local waste management practices. It can contribute simultaneously to SDG 13 on climate action and SDGs 14 and 15 on the protection of marine and terrestrial ecosystems.

| Conclusion

The adoption of an international development cooperation program to promote ecotourism, centered on three key measures, namely establishing ecotourism initiatives in night markets, improving waste collection systems, and creating community cooperatives in tourist places, could generate positive spillover effects for both the Southeast Asian recipient countries and the Republic of Korea as the donor country. Also, the significance of the ecotourism program lies in the fact that its benefits extend beyond environmental protection to encompass local communities, ecosystems, tourists, and the country as a whole.

Furthermore, the measures proposed in this paper are presented not as a form of unilateral or donor driven Official Development Assistance(ODA), but as part of a broader framework of international development cooperation. Accordingly, the proposed program should be pursued in a way that moves beyond the one sided provision of benefits from Korea to Southeast Asian countries and tourism ecosystems, with a focus on fostering long term mutual benefit. An international development cooperation program can achieve long term sustainability only when it is recognized that the objective extends beyond charitable assistance to Southeast Asian countries. Such programs can be maintained over time when they create opportunities for both the recipient countries and Korea to benefit, materially and non materially, while advancing together through a shared development process.

It is also important to recognize that the benefits of this international development cooperation program can be shared not only to the recipient countries but also to the Republic of Korea. Demand for sustainable tourism is already substantial among the public. Since the early 2010s, travel agencies such as HanaTour and Mode Tour Network have consistently introduced sustainable travel programs that incorporate overseas volunteer activities and environmentally friendly contents, and these programs have generally recorded high levels of participation. With strong public demand already in place, government efforts to establish additional supporting infrastructure could enable demand for this type of tourism to grow in a more sustainable and long lasting manner.

In addition, a series of serious crimes reported in Southeast Asian countries, including Cambodia, in recent years has significantly increased public concerns about traveling to those regions. In this context, demonstrating a commitment at the national level to improving tourism conditions in the region could serve as a catalyst for revitalizing the tourism industry and restoring economic momentum. From the perspective of developing Korea's tourism industry, the ecotourism program proposed in this paper offers more than a means of supporting Southeast Asian countries. It can also help meet growing public demand for tourism, alleviate concerns about travel to the region, and generate diplomatic benefits through improved relations and cooperation with recipient countries. For the benefit of Korea, humanity as a whole, and a more sustainable world, the practices of ecotourism should be adopted and firmly established as soon as possible.

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Proposals from Future Generations for a Net-Zero Future

8th Cohort Proposal Collection



8th

Policy

- Beyond Overconsumption and Carbon Colonialism:
A New Model – CPCJ Framework **169**
----- Park Si-yeon / Sookmyung Women's University

Green Campus

- Weather Data-Based Campus Energy Demand Forecasting System **177**
----- Jung Ji-woon / Inha University

Energy

- Green Shore Power Supply Policy for Eco-Friendly Vessels **187**
----- Park Ho-jin / Korea Maritime and Ocean University

Air Pollution

- Eco-Friendly Fleet Rating System for Heavy-Duty Trucks **199**
----- Shin Min-kyu / Dong-A University

Economics

- Eco Money Report **209**
----- Choi Ha-jin / Gachon University

Recycling

- Phasing Out Thermal Recycling of Plastics **217**
----- Lee Yeon-seon / Ewha Womans University

Policy

- Expanding the Emissions Trading System Target to Scope 3 **225**
----- Kim Tae-min / Chonnam National University (Gwangju)

I. Introduction

II. Body

- Environmental Issues in the Age of Overconsumption
- Is the Net-Zero Policy Approach Sufficient? — Overlooking the Demand Side
- Is the Net-Zero Policy Approach Sufficient? — Overlooking Carbon Colonialism
- Proposed Solution — The CPCJ Framework

III. Conclusion

Policy

01

Park Si-yeon / Sookmyung Women's University

Beyond Overconsumption and Carbon Colonialism: A New Model – CPCJ Framework



- 과잉소비행태의 주범, 패스트패션
패션 산업의 탄소 배출량이 2025년까지 2020년 대비 2배 이상 증가할 것이라는 전망
- 초저가 대량 판매 플랫폼의 등장과 환경문제
중국, 프랑스, 미국, 브라질 등 지역에서 심각한 수준의 온실가스 배출
- 테무의 패스트 패션 제품은 패션 산업이 배출하는 탄소 배출량의 10%를 차지
- 블랙 프라이데이 기간 중 구매한 가정을 플라스틱과 섬유 제품의 최대 80%가 매립되거나 소각(Purnell, 2019)

Introduction



Image Source: YouTube (Song Field, JJ)



Image Source: TEMU

The rise of ultra-low-cost e-commerce platforms has accompanied the rapid evolution of the global e-commerce market, enabling these platforms to attract hundreds of millions of users and exert unprecedented influence worldwide. Launched in September 2022, Temu is a sister company of the Chinese famous e-commerce platform Pinduoduo. Since its launch, it has grown into one of the world's largest e-commerce platforms, operating in more than 80 countries. Temu offers a wide range of products, including electronics, clothing, household goods, and toys, at deeply discounted prices. By directly connecting manufacturers with consumers and leveraging economies of scale through bulk purchasing, the platform also provides global shipping services. More recently, the rise of so-called Temu haul content across social media has demonstrated the growing influence of ultra-low-cost platforms. This trend has fostered a new consumer culture in which people showcase how many trendy items they purchased and how little they paid for them.

Ultra-low-price, high-volume sales platforms do not simply stop at selling cheap goods. Ultra-low-cost platforms actively encourage consumption through attention-grabbing messages such as "Limited-Time Deals" and "Selling Out Soon." They further gamify shopping by offering free gifts, bonuses, and personalized recommendation algorithms,

leaving consumers with little time to make thoughtful purchasing decisions. The problem is that these mechanisms further exacerbate the longstanding environmental impacts of the fast fashion industry. At a time when approximately 92 million tonnes of textile waste are discarded worldwide each year, the rapid expansion of ultra-low-cost platforms generates substantial greenhouse gas emissions throughout the entire product lifecycle, including production, packaging, transportation, and consumption, while reinforcing a cycle of overconsumption. In particular, the fact that these platforms generate approximately 4.8 times more packaging waste than conventional brick-and-mortar retailers highlights a new environmental challenge arising from the shift toward digital retail.

This proposal focuses on the problems of overproduction and overconsumption, particularly in the fast fashion industry, and explores a framework for promoting a healthier and more sustainable policy framework.

Body

a. Environmental Issues in the Age of Overconsumption



At the heart of overconsumption practices lies fast fashion. According to UNEP, the fashion industry accounts for approximately 10% of global carbon emissions, and emissions are projected to increase by 60% by 2030, reaching 2.8 billion tonnes. In Europe, 4–9% of distributed textile products are discarded without ever being used, and 87% of secondhand clothing is incinerated or sent to landfill. Moreover, less than half of all secondhand clothing is collected for reuse or recycling, and of that, only 1% is actually recycled into new garments.

The emergence of ultra-low-cost mass-market platforms has further intensified the environmental impacts of the fast fashion industry. When greenhouse gas emissions generated throughout the entire product lifecycle, including production, packaging,

transportation, and consumption, are taken into account, fashion products sold on Temu have a substantial carbon footprint. Furthermore, up to 80% of the plastic and textile products purchased during the Black Friday shopping season are discarded before reaching the end of their useful life and are ultimately sent to landfills or incinerated (Purnell, 2019).

b. Is the Net-Zero Policy Approach Sufficient? — Overlooking the Demand Side

According to Chapter 5 of Working Group III of the IPCC Sixth Assessment Report (AR6), demand-side measures, including lifestyle changes and shifts in the way people use services across sectors such as buildings, transport, and food, have the potential to reduce direct and indirect greenhouse gas emissions by 40% to 70% by 2050. Yet in practice, demand reduction is rarely incorporated into NDC targets.

Consequently, despite improvements in energy efficiency and the ongoing transition to renewable energy, global CO₂ emissions reached an all-time high in 2022. This is because increases in income, population, and consumption offset those gains, preventing an overall decline in emissions. This phenomenon is known as the rebound effect, in which improvements in efficiency lead to higher levels of consumption.

So why has demand been left out of net-zero policy? First, policies that restrict consumption face the greatest political resistance. Second, consumption-based emissions are difficult to measure due to global supply chains. Third, achieving international consensus on which country bears responsibility is difficult. There is also the problem that, although Scope 3 emissions account for a significant share of total corporate emissions, measurement and reporting remain voluntary or partial, limiting reliability and comparability. Discussions on strengthening regulatory and disclosure standards have gained momentum since the 2020s, but the current level remains insufficient.

c. Is the Net-Zero Policy Approach Sufficient? - Overlooking Carbon Colonialism



Image Source: 123RF



Image Source: NowNews

There is another critical blind spot in net-zero policy: the issue of justice. Developed countries are also outsourcing pollution and carbon emissions to the Global South, a structure commonly referred to as carbon colonialism. Environmental economist Miyamoto Ken'ichi(宮本憲一) described this climate inequality arising from the global economic system as the "export of pollution," while climate researcher Laurie Parsons conceptualized it as "carbon colonialism."

As one example, about 40,000–50,000 tonnes of fast fashion waste are dumped in Chile's Atacama Desert every year. Most of these garments were originally consumed in Europe and the United States before being transported to redistribution hubs in South America. Items that could not be resold or processed were illegally dumped in the desert, forming mountains of waste.

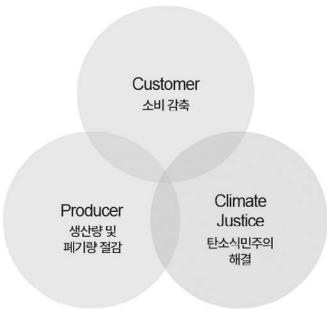
In this way, developed countries appear, on a statistical basis, to have reduced their emissions, while in reality they are shifting pollution and waste to regions with weaker regulations or generating emissions abroad, thereby evading responsibility. In other words, carbon emissions are not actually reduced, but only responsibility is transferred across borders.

This conflict between the Global North and South over reduction responsibilities has even erupted in official settings. At COP26, Indian Environment Minister Bhupender Yadav criticized that the West, despite having historically emitted the most carbon, now demands reductions solely from developing countries. While former U.S. President Obama remarked that developing countries had not done enough to address climate change, highlighting the intense debate over responsibility.

The country-specific NDC targets agreed upon at major global summits such as Paris or Glasgow set limits only on what occurs within national borders, without setting any limits on environmental impacts that occur beyond them. In an era of globalization, this narrow focus on domestic indicators alone can be interpreted as a fragmented approach that

avoids confronting the full scope of the problem.

d. Proposed Solution — The CPCJ Framework



Building on these problems, this proposal puts forward a policy framework intended to complement existing approaches. The framework aims to break the structure of overconsumption → overconsumption → climate inequality across three axes: consumption, production, and justice.

First, the Customer dimension focuses on consumption. In existing net-zero policies, consumption has been left almost entirely to individual choice. Under CPCJ, however, "absolute consumption reduction" itself is established as a policy goal and incorporated into binding policy instruments such as NDCs. Also, algorithms used by ultra-low-cost platforms to encourage overconsumption, such as infinite scrolling, repeated coupon offers, psychologically manipulative countdown timers, and personalized discount recommendations, should be recognized as environmental risks and made subject to regulatory oversight. Finally, evaluation metrics such as a "Repair Index" are introduced, designed so that repair, reuse, and secondhand circulation become more advantageous choices than purchasing new products.

Second, the Producer dimension focuses on producer responsibility.

The key point here is that policy intervenes not merely in how environmentally friendly production methods are, but in how much is produced in the first place. Under CPCJ, disclosure of carbon emissions is mandated across the entire value chain, including raw material sourcing, manufacturing, packaging, international transport, use, and disposal.

This allows corporate environmental performance to be evaluated based on "total production volume" rather than "emissions per unit." Moreover, companies are encouraged to set clear targets for the proportion of recycled materials used and for production volume reductions, creating a structure that curbs overproduction itself.

The final axis is Climate Justice. To address the problem of carbon colonialism, CPCJ monitors and regulates all forms of corporate exploitation, including environmental destruction. It also formally designates the environmental damage borne by producers in the Global South as "climate debt." The costs of pollution and waste generated by consumption in developed countries are returned in the form of compensation and financial support, managed institutionally in connection with the UNFCCC's Loss and Damage Fund. In summary, this expands net-zero from a matter of "reduction targets" to a matter of just transition.

| Conclusion

Net-zero is not a failed concept, but rather a design that remains incomplete. If demand is left unaddressed and responsibility remains confined within national borders, net-zero will amount to little more than the management of numbers. This is because supply-side reforms reliant on technological advancement, combined with accounting methods limited to territorial boundaries, cannot fundamentally resolve the structural contradictions embedded within global supply chains. Therefore, to achieve a genuine response to the climate crisis, the scope of net-zero must be expanded into a shift toward a just paradigm.

It is now necessary to institutionalize absolute consumption reduction and hold companies accountable for the total volume of their production. Furthermore, we face the challenge of redesigning the framework of responsibility to ensure the fair redistribution of the climate debt that developing countries in the Global South have long borne as a result of overconsumption in developed countries. This challenge is not one that concerns only policy researchers, nor is it a topic confined to international conferences. Everyone living in this era already stands at the center of this transition. Now is the time for all of us to make responsible decisions and build a well-designed framework that can ensure long-term sustainability.

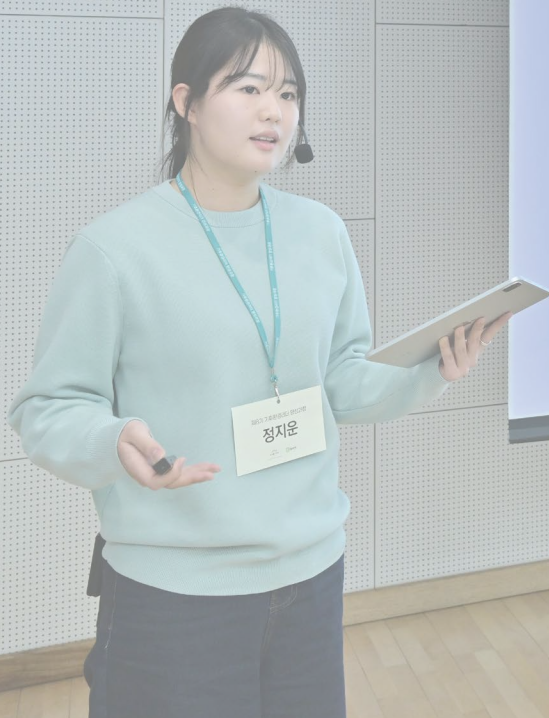
1. Limitations of Existing Campus Heating and Cooling Operations
2. The Need for Weather-Data-Based Energy Demand Forecasting
3. Proposed Structure of the Weather-Data-Based Energy Demand Forecasting System
4. Expected Benefits and Potential Applications
5. Conclusion
6. References

Green Campus

02

Jung Ji-woon / Inha University

Weather Data-Based Campus Energy Demand Forecasting System



계절성 약화 ★★ ★

최근 기후 패턴은 빠르게 변하고 있
뿐 아니라 일교차 폭염 한파 일시
있다. 따라서 과거 평균을 기준으로
고정 난방·냉방 기간은 더 이상 유효

As extreme weather events and seasonal variability intensify, there is a growing need to rethink how university campuses operate their heating and cooling systems. Many universities currently operate heating and cooling schedules based on fixed dates, but this often fails to align with actual temperature changes.

For example, when relatively cool weather persists into early summer, unnecessary cooling is provided. Conversely, sudden cold spells in late autumn or early spring can leave heating insufficient. Such operations not only waste energy but can also lower students' satisfaction with indoor environments and lead to an increase in complaints.

In particular, climate change has made the boundaries between seasons increasingly irregular, making it difficult to determine heating and cooling demand based solely on fixed periods such as "summer" or "winter." Thus, there is a growing need for data-driven operations that reflect actual outdoor conditions and building usage patterns.

This paper proposes a method for forecasting heating and cooling energy demand on campus using weather data, and for using these forecasts to more efficiently adjust the timing and duration of heating and cooling operations. It also examines the limitations of existing fixed-schedule operations and suggests the potential of a forecast-based operational model that leverages outdoor condition data such as temperature, solar radiation, and wind speed.

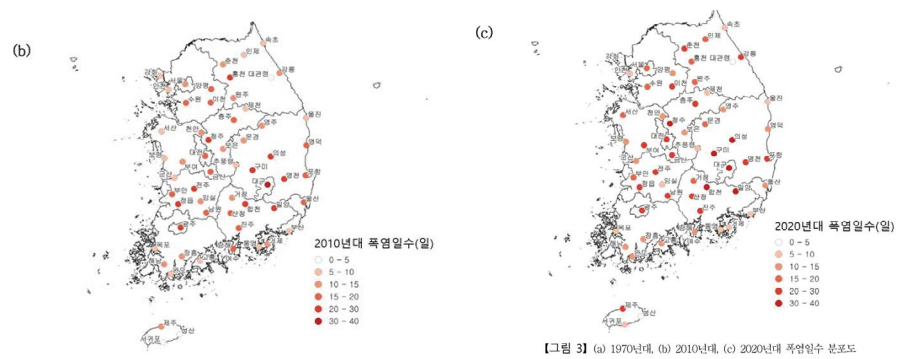
1. Limitations of Existing Campus Heating and Cooling Operations

Currently, most university campus heating and cooling systems operate according to fixed schedules. In fact, Inha University also operates its heating and cooling systems according to fixed start and end dates for each semester, as shown in Figure 1. After the facility inspection period, the cooling systems are activated simultaneously across campus. Typically, cooling operates from May to September, and heating from November through April of the following year. While this approach is simple and stable from a management standpoint, it has the limitation of frequently failing to align with actual temperature changes.

1. Heating operation ends: April 24, 2026 (Fri.) <Last day of the midterm examination period>
 2. Cooling system inspection: April 27 to May 12, 2026
 3. Cooling operation begins: May 13, 2026 (Wed.) (Scheduled)

[Photo 1] Example of Inha University's heating and cooling operation schedule

For instance, if temperatures remain higher than average even in November, heating may be activated unnecessarily. Meanwhile, if a sudden cold spell occurs in early March, indoor temperatures can drop sharply after heating has already been turned off for the season. Furthermore, as shown in [Figure 1] and [Table 1], recent heatwaves and abnormal weather patterns have increasingly caused late-season heat to persist into September and October, yet because the existing cooling period has already ended, an adequate response is often not possible.



[Figure 1] Korea Meteorological Administration: Distribution of Heatwave Days, (b) 2010s, (c) 2020s

[Table 1] Korea Meteorological Administration: Decade-by-Decade Statistics on Heatwave Days, Tropical Night Days, and Cold Wave Days

	1910'	1920'	1930'	1940'	1950'	1960'	1970'	1980'	1990'	2000'	2010'	2020'
Heat wave Days	7.7	10.3	10.4	12.2	8.1	8.2	7.8	7.9	10.1	8.0	13.3	16.9
Tropical Night Days	6.7	10.8	7.6	7.2	7.9	11.1	9.3	8.9	12.8	13.6	19.7	28.0
Cold Wave Days	3.7	3.5	3.8	4.7	3.5	2.8	2.2	1.6	0.4	0.8	1.3	1.1

These issues extend beyond mere inconvenience and can lead to energy waste and operational inefficiency. In practice, universities consume a substantial amount of heating and cooling energy because they operate large buildings, including lecture halls, libraries,

research facilities, and so on. Accordingly, repeated unnecessary heating or cooling operation inevitably increases both power consumption and operating costs.

In addition, unlike typical office facilities, university buildings are characterized by significant variation in usage patterns depending on the period like exam periods, vacations, late-night study periods, concentrated use of specific buildings, and so on. However, the current fixed-schedule operation does not adequately reflect these real-world usage conditions.

2. The Need for Weather-Data-Based Energy Demand Forecasting

In recent years, data-based operational systems have been expanding across various fields. Particularly, in the field of building energy management, there has been a growing number of attempts to forecast electricity usage by jointly analyzing weather information and energy consumption data. This approach goes beyond simply monitoring current temperatures. Its purpose is to predict how heating and cooling demand will change in response to future outdoor weather conditions.

Universities are also spaces that could benefit from this kind of forecast-based operation. For the facilities operations team, information such as "how much will cooling demand increase this week," "from what point should heating preparations begin," and "when peak power demand is likely to occur" is far more useful for actual operations than simply knowing "it's hot today."

Specifically, the Korea Meteorological Administration's API makes it relatively easy to obtain a range of outdoor condition data, including temperature, solar radiation, wind speed, and humidity. By analyzing this data alongside historical heating and cooling usage data, it becomes possible to observe how energy consumption changes under specific weather conditions. This makes it possible to forecast heating and cooling energy demand in advance and to adjust both the operating period and the intensity of operations more efficiently.



[Photo 2] Image of the Korea Meteorological Administration's API Hub Page

This system is also highly feasible in that it improves operational efficiency by leveraging existing data, rather than installing large-scale new equipment. Some universities abroad are already using BEMS (Building Energy Management Systems) or EMS (Energy Management Systems). In addition, there is potential for further development into a more sophisticated campus energy management framework if linked with such systems in the future.

3. Proposed Structure of the Weather-Data-Based Energy Demand Forecasting System

This proposal puts forward an approach that forecasts heating and cooling demand by jointly utilizing weather data and historical energy usage data. The system consists of four main stages, including weather data collection, historical electricity consumption analysis, predictive model development, and operational optimization.

First, weather data on outdoor conditions, including temperature, humidity, wind speed, and solar radiation, are collected through the Korea Meteorological Administration (KMA) API. Notably, heating and cooling load is not determined by temperature alone. For instance, on a day with the same 30°C temperature, higher humidity can result in a higher perceived temperature, increasing cooling usage and on days with strong solar radiation, indoor temperatures can rise rapidly, increasing cooling load. By contrast, cooling demand may decrease during periods of strong wind or sustained cloudy weather.

In addition, university campuses are characterized by significant differences between buildings. Large lecture buildings see concentrated student use during specific time periods, libraries tend to have high usage at night, and research buildings often require a certain baseline level of cooling year-round due to the operation of laboratory equipment,

regardless of season. As such, rather than operating the entire campus under a single uniform standard, it is necessary to consider building-specific usage characteristics together with time-of-day patterns.



[Photo 3] Campus Operating Even at Night

Next, the collected weather data is compared with historical heating and cooling energy usage data to analyze correlations. For example, this makes it possible to identify the temperature threshold beyond which cooling usage increases sharply, or how power usage patterns differ during exam and vacation periods. This type of analysis has the advantage of reflecting actual operational patterns more accurately than simple average values.

Based on this, a regression-based forecasting model can be built to predict future heating and cooling loads. For instance, this approach forecasts in advance how much cooling energy usage is likely to increase when conditions such as "rising average temperatures next week," "increased solar radiation," and "the start of the exam period" occur together. This allows the facilities operations team to anticipate the possibility of energy peaks in advance and to adjust the timing and intensity of heating and cooling operations more efficiently.

Notably, this system is not intended solely to reduce energy consumption. Because heating and cooling operations are directly linked to the comfort and satisfaction of students and staff with their indoor environment, the system should be applied in a way that improves operational efficiency while minimizing inconvenience to users. As an example, if a sudden cold wave is forecast, the heating shutoff date could be temporarily extended. Also, during periods when heatwaves are expected, cooling operations can be scheduled in advance in advance.

Furthermore, the importance of "peak power management" has been growing in the

power sector in recent years. When cooling demand becomes concentrated during certain hours in the summer, overall electricity consumption rises sharply. This goes beyond a simple increase in electricity costs and is closely linked to the stability of the power supply. Therefore, an operational approach that forecasts heating and cooling demand in advance and shift peak demand could become an important element of future campus Net Zero operating strategies.

This system is highly feasible in that it improves operational efficiency by leveraging existing weather data and energy usage data, rather than requiring a complete overhaul of existing facilities. There is also potential for it to develop into a more sophisticated energy management system if linked with BEMS (Building Energy Management Systems) or EMS (Energy Management Systems), which are already in use at some universities and public institutions.



[Photo 4] Korea Energy Agency's BEMS (Building Energy Management System) Conceptual Diagram

4. Expected Benefits and Potential Applications

If a weather data based heating and cooling demand forecasting system is introduced, the maximum anticipated benefit will be improvement of operational flexibility in heating and cooling systems.

Under the current fixed operating approach, heating and cooling systems are often operated regardless of actual outdoor temperatures. By contrast, a forecasting based approach reflects seasonal weather conditions, making operations more efficient.

For example, if November is warmer than usual, the start of the heating season can be adjusted accordingly. Likewise, if a severe cold spell is expected in late winter, the end of the heating season can be extended to maintain a stable indoor environment. If prolonged heat waves are forecast during the summer, cooling operation plans can also be established in advance to enable a response.

The second expected benefit is improved energy efficiency. Universities operate a wide range of buildings, including lecture halls, libraries, and research facilities, each with distinct occupancy patterns. By using forecast information, heating and cooling can be prioritized for buildings with higher occupancy, while operation in less frequently used spaces can be minimized to reduce unnecessary energy consumption.

The third expected benefit is lower operating costs and peak electricity management. By forecasting periods of high heating and cooling demand in advance, facility operation plans can be prepared ahead of time. This also helps mitigate excessive electricity use during peak hours. Its value extends beyond lower electricity costs, as it also supports more stable facility operations.

Moreover, this proposal can be implemented at a relatively low cost because it utilizes existing weather data and energy consumption data rather than requires large-scale infrastructure. In the future, it could also be further developed by linking it with a Building Energy Management System (BEMS) to achieve a higher level of automation.

As a result, this system is expected to serve as a practical approach to campus operations that supports not only energy savings but also greater operational efficiency, improved user satisfaction, and progress toward carbon neutrality.

5. Conclusion

In recent years, climate change has blurred the boundaries between seasons, and the patterns of heatwaves and cold waves have also begun to differ from those of the past. Still, heating and cooling operations at universities are still largely based on fixed schedules, resulting in a recurring mismatch with actual weather conditions.

This paper has proposed a weather-data-based heating and cooling energy demand forecasting system as a way to address these limitations. By analyzing outdoor weather conditions, including temperature, humidity, and solar radiation, with past energy consumption data, the system can forecast heating and cooling demand and incorporate the results into operations. This is expected to enable more efficient campus management.

Specifically, this proposal has practical applicability in that it is based on weather and energy usage data that are already available, rather than the large-scale installation of new equipment. It also has the advantage of being able to consider both the university's academic calendar and building-specific usage characteristics, making it a management approach well suited to real-world operating conditions.

Energy savings begin not simply with reducing usage, but with using the right amount of energy where it is needed. Going forward, heating and cooling operations on universities should move away from fixed-schedule approaches and develop toward methods that reflect data and actual demand. It is hoped that this proposal can serve as a practical case for efficient energy operations and the achievement of carbon neutrality in universities.

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I. Introduction

- a. Overview and Problem Statement
- b. The "Paradox of Stillness" — The Core Mechanism Behind Port Air Pollution
- c. Policy Target: Busan Port

II. Body

- a. Problems and Limitations of the Current System
- b. Core Policy Proposal: Redesigning the Three-Pillar Incentive Paradigm
- c. Financial Support for Vessel Adoption: A Two-Track Financing Plan
- d. Phased Implementation Roadmap (4-Step Implementation Roadmap)
- e. Scalability and Policy Impact: The Green Smart Port Paradigm

III. Conclusion

IV. References and Sources

Energy

03

Park Ho-jin / Korea Maritime and Ocean University

Green Shore Power Supply Policy for Eco-Friendly Vessels

Abstract

This report proposes the introduction of an Alternative Maritime Power (AMP) policy to address the serious air pollution problems at domestic ports, including Busan Port. Even while at berth, ships continue to operate their onboard engines, creating the "Paradox of Stillness" by emitting air pollutants. To address this, the report proposes a four-pillar policy package: (1) an incentive system based on CO₂ reduction performance, (2) a port usage fee reduction system centered on environmental contribution, (3) an organic link between carbon neutrality and economic benefit, and (4) financial support for vessel construction and retrofitting. It further proposes a four-stage implementation roadmap for the gradual realization of this policy. Ultimately, the goal is to validate this model at Busan Port and propose it to the IMO, positioning Korea as a "First Mover" leading global eco-friendly shipping standards.

Introduction

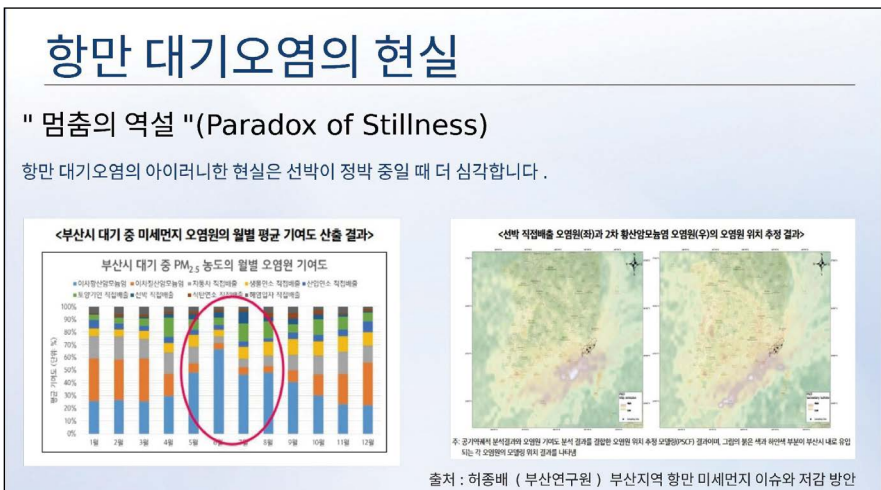
a. Overview and Problem Statement

Ports, where massive trade vessels constantly come and go, function as the dynamic heart of our economy. Behind this prosperity, however, lies a "dark shadow" that often goes unnoticed and it is the serious problem of air pollution in port areas. This report proposes the Alternative Maritime Power(AMP) policy as the most practical and innovative solution to this structural problem.

b. The "Paradox of Stillness" — The Core Mechanism Behind Port Air Pollution

While automobiles typically emit exhaust only when running, ships are different. Even while berthed at port, ships must continuously run large auxiliary engines to supply onboard power for lighting, heating and cooling, cargo handling, and other functions. Although ships are stationary, pollutant emissions continue to increase. This is the essence of the "Paradox of Stillness."

Clear quantitative data supports this. An analysis of the contribution of different sources to ambient fine particulate matter (PM_{2.5}) in Busan found that emissions from ships account for an overwhelmingly large share of overall air quality deterioration. This share rises sharply during the summer months (May–August), and source-apportionment modeling has visualized how high concentrations of pollutants generated at the port are carried by air currents deep into the inland urban area.

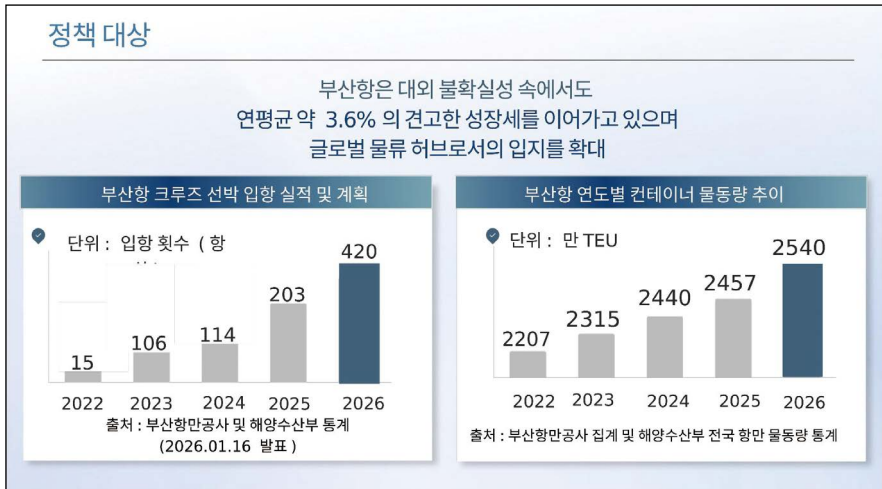


▲ [Figure 1] Monthly Contribution of Ship-Related Sources to PM_{2.5} in Busan (left) and Estimated Locations of Ship-Based Pollution Sources (right)

Source: Heo Jong-bae (Busan Development Institute), "Port-Related Fine Dust Issues and Reduction Measures in the Busan Region"

c. Policy Target: Busan Port

The primary target of this policy proposal is Busan Port, a key logistics hub in Northeast Asia. Busan Port has maintained robust annual growth of approximately 3.6%, reaching a container throughput of 25.4 million TEU in 2026, while port activity is also expanding rapidly, with the number of cruise ship calls increasing dramatically from 15 in 2022 to 420 in 2026. Behind this growth, the volume of pollutants emitted by "berthed vessels" has likewise increased proportionally.



▲ [Figure 2] Annual Container Throughput Trends at Busan Port (right) and Cruise Ship Arrival Records and Plans (left)

Source: Busan Port Authority and Ministry of Oceans and Fisheries Statistics (Published January 16, 2026)

Body

a. Problems and Limitations of the Current System

AMP (Alternative Maritime Power, also known as Shore Power) is an eco-friendly technology that allows a ship, while berthed, to receive electricity from the onshore power grid instead of running its own engines. Unfortunately, however, the situation on the ground differs significantly from expectations.

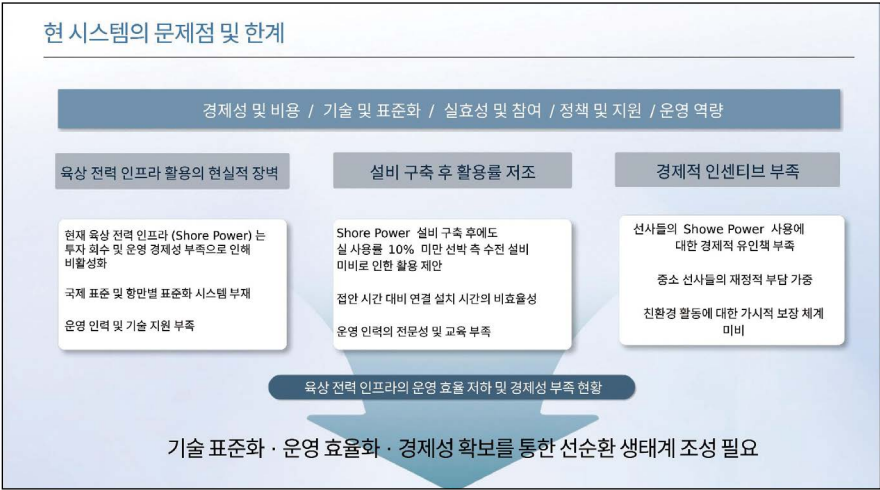
First, the extremely low utilization rate is the most striking reality. Despite the enormous budgets invested in building Shore Power facilities, actual on-site usage rates are below 10%. The greatest physical barriers are the structural inefficiency whereby connecting to

shore power takes longer than berthing the vessel itself, and the fact that many ships are not equipped with the onboard infrastructure needed to receive shore power.

Second, the lack of infrastructure standardization is also a serious problem. In the absence of international standards or a unified standardization system of ports, specifications differ from port to port, requiring shipping companies to adopt separate compliance measures for each port. Moreover, because operating these facilities tends to generate ongoing losses rather than returns on investment, operators have little incentive to actively expand the system.

Third, the lack of economic incentives is particularly detrimental to small and medium-sized shipping companies. With no economic motivation designed to encourage shipping companies to voluntarily use Shore Power, the high cost of equipment investment poses more than just a burden for cash-constrained small and medium-sized operators. It functions as an entry barrier that threatens their survival.

Fourth, the lack of personnel and technical support is the most fundamental weakness in on-site operations. Even where facilities physically exist, the absence of trained personnel capable of operating them properly and the lack of technical support systems mean that equipment is repeatedly left unused or operated inadequately. Ultimately, the current system has fallen into a "vicious cycle of inefficiency and financial losses" across the technological, economic, and operational dimensions. Breaking this cycle requires a fundamental paradigm shift.



▲ [Figure 3] Problems and Limitations of the Current System: The Vicious Cycle of Inefficiency and Deficits

Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)

b. Core Policy Proposal: Redesigning the Three-Pillar Incentive Paradigm

To address the problems identified above, this policy completely redesigns the policy paradigm around three core concepts: "data," "efficiency," and "profit."

① Tiered Incentive System Based on CO₂ Reduction Performance

Moving away from the existing uniform support approach, a precision measurement system is used to calculate the actual carbon reduction achieved by each vessel.

$$\text{Reduction(tonnes)} = \text{Usage time(h)} \times \text{Fuel consumption per hour(tonnes/h)} \times \text{Emission factor}$$

Based on this, a three-tier performance grading system (TIER SYSTEM) is introduced.

- TIER 1 (Top performers): Vessels exceeding target performance → Substantial benefits (maximum fee reduction rates, awards)
- TIER 2 (Strong performers): Vessels meeting the standard → Moderate-level benefits
- TIER 3 (General participants): Participating vessels → Basic benefits

② Port Usage Fee Reduction Linked to CO₂ Emissions

Rather than applying a uniform reduction rate based on vessel tonnage (size), the fee reduction regulations are revised to be based on "actual shore power usage."

- Sliding-scale fee reduction system: Reduction rates for port facility usage fees (entry fees, berthing fees, etc.) automatically increase in proportion to CO₂ reduction performance
- Transparent verification platform: A monitoring system is operated to cross-verify data submitted by shipping companies against actual usage and to allow immediate confirmation of cost-saving effects

③ An Organic Link Between Carbon Neutrality and Economic Benefit

Beyond simply offsetting costs, this pillar aims to simultaneously enhance shipping companies' "operational efficiency" and "brand value."

- Introduction of a Fast-Track system (berthing reservation priority): Provides tangible operational benefits, such as reduced waiting times, to high-performing participating vessels
- Structuring a "Double Benefit": Quantifies and promotes the combined economic benefit of fuel cost savings plus port usage fee reductions

- ESG marketing support: A "Green Port Partner" certification is awarded to help companies attract shippers and enhance their corporate image

친환경 선박 육상전원공급 정책의 핵심 개념		
핵심 개념	추진 과제	실행 계획
CO ₂ 감축량 기반 인센티브	정량적 데이터 기반의 '등급제 (Tier) 보상 체계' 구축 막연한 지원이 아닌, 실제 감축 성과를 정확히 측정하고 그에 상응하는 확실한 보상을 제공하여 선사의 참여 경쟁을 유도합니다.	정밀 측정 시스템 도입: 선박별 SHORE POWER 사용 시간을 분 단위로 정확히 측정하고, 이를 탄소 배출 감축량으로 자동 환산합니다. (감축량 (톤) = 시간 (h) × 시간당 연료소비량 (톤/h) × 배출계수) 3 단계 성과 등급제 (TIER SYSTEM) 수립: TIER 1 (최우수): 목표치 초과 달성 선박 → 파격적 혜택 제공 (예: 감연을 최대화, 보상), TIER 2 (우수): 기준 충족 선박 → 중간 수준 혜택 제공. TIER 3 (일반): 참여 선박 → 기본 혜택 제공 등급별 혜택 매뉴얼화: 각 등급에 따른 인센티브의 종류와 규모를 명문화하여 예측 가능성 확보.
CO ₂ 배출 연동 항만이용료 감면제	추진과제: '선박 크기' 중심에서 '실제 친환경 기여도' 중심으로 요금 체계 개편 기존의 관행적인 감면 방식을 탈피하여, 실제로 육상 전력을 사용하여 탄소 배출을 줄인 만큼 비용을 절감해주는 '직접 연동형' 구조로 전환합니다.	요금 부과 기준 전환: 기존 선박 톤수 (크기) 기준의 일괄적 적용을 배제하고, ' 실제 육상전력사용량 ' 기준으로 감면 규명 개편. 감면율 솔라이징 시스템 적용: CO₂ 감축 실적에 비례하여 항만 시설 사용료 (입항료, 접안료 등) 감면율이 자동으로 상향되도록 설계. 투명한 검증 플랫폼 구축: 선사가 제출한 데이터와 실제 사용량을 교차 검증하고, 비용 절감 효과를 즉시 확인할 수 있는 모니터링 시스템 운영.
소중립과 경제적 이익의 유기적 연결	추진과제: 비용 절감을 넘어선 '운영 효율성' 및 '브랜드 가치' 제고 친환경 노력이 단순한 비용 지출이 아니라, 선사의 이익 (비용 절감 + 운영 편의 + 마케팅) 으로 직결되는 선순환 구조를 완성한다.	Fast-Track (운영 혜택) 도입: 우수 참여 선박에게 '정박 예약 우선권' 을 부여하여, 대기 시간 단축 등 항만 운영 효율성을 보장. ' 이중 혜택 (Double Benefit) ' 구조화: ' 연료비 절감 ' 과 ' 항만 이용료 감면 ' 이라는 두 가지 경제적 이익을 수직화하여 선사들에게 줄보. ESG 마케팅 지원: 참여 선박 및 선사에 'Green Port Partner' 인증 등을 부여하여, 화주 유치 및 기업 이미지 제고 등 간접적 마케팅 효과를 누릴 수 있도록 지원

▲ [Figure 4] Conceptual Framework, Implementation Tasks, and Action Plan Structure for the Alternative Maritime Power Policy

Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)

c. Financial Support for Vessel Adoption: A Two-Track Financing Plan

While operational-stage incentives serve as a "motivation to encourage participation," support at the vessel adoption stage is an "essential precondition for realizing the policy." No matter how attractive the operational benefits, they cannot have any practical effectiveness unless vessels are physically equipped with the necessary power-receiving infrastructure.

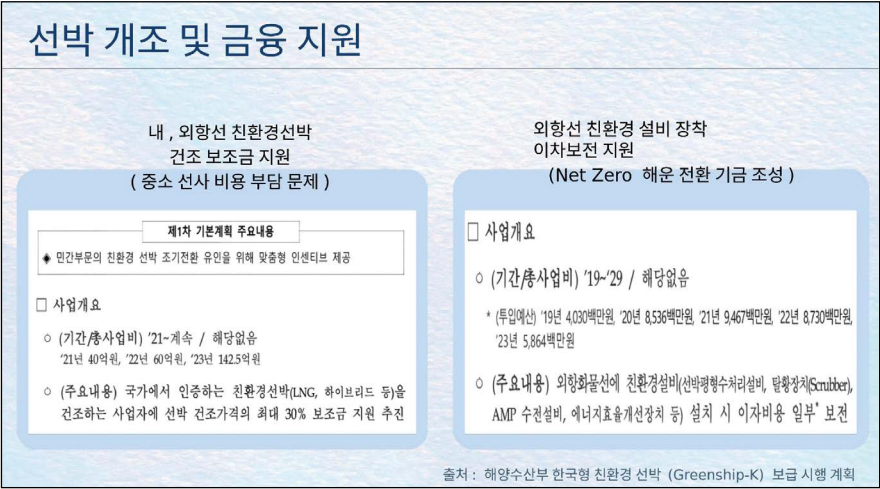
① Construction Subsidies for Eco-Friendly Domestic and Ocean-Going Vessels

For the construction of nationally certified eco-friendly vessels, the government provides a subsidy covering up to 30% of the vessel's price. This serves as seed funding that dramatically lowers the initial investment risk and market entry barriers for cash-constrained small and medium-sized shipping companies.

② Interest Subsidy Support for Installing Eco-Friendly Equipment on Ocean-Going Vessels (Net Zero Shipping Transition Fund)

This approach supports the retrofitting of existing large ocean-going vessels by installing

AMP shore power connection equipment. A "Net Zero Shipping Transition Fund" is established, through which the government subsidizes the loan associated with installing this equipment.



▲ [Figure 5] Vessel Retrofitting and Financial Support Framework
(Construction Subsidies and Interest Subsidies)

Source: Ministry of Oceans and Fisheries, Reference: Implementation Plan for the Distribution of Korean-Type Eco-Friendly Ships (GreenShip-K)

d. Phased Implementation Roadmap (4-Step Implementation Roadmap)

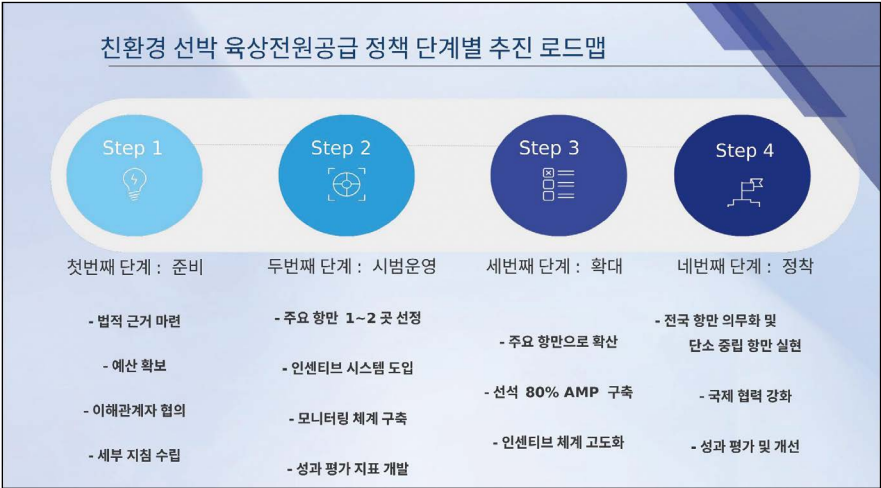
To successfully implement this policy, a four-stage implementation roadmap has been designed.

Step 1 (Preparation) establishes the foundation for policy implementation. This includes establishing the legal basis for the policy, securing budget, and developing detailed guidelines through consultation with stakeholders such as port authorities, shipping companies, and government agencies.

Step 2 (Pilot Operation) selects one to two major ports for demonstration projects. This involves introducing the incentive system, establishes establishing a real-time monitoring framework, and develops developing performance evaluation indicators for subsequent nationwide expansion.

Step 3 (Expansion) scales the policy to major ports nationwide based on the results of the pilot operation. AMP facilities are installed at 80% or more of berths, and the incentive system is further refined based on accumulated data.

In Step 4 (Establishment), the use of AMP will be made mandatory at ports nationwide, and carbon-neutral ports will be realized. Cooperation with international organizations such as the IMO will be strengthened, and the long-term institutionalization of the policy will be promoted through the continuous evaluation and improvement of performance.



▲ [Figure 6] Phased Implementation Roadmap for the Alternative Maritime Power Policy

Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)

e. Scalability and Policy Impact: The Green Smart Port Paradigm

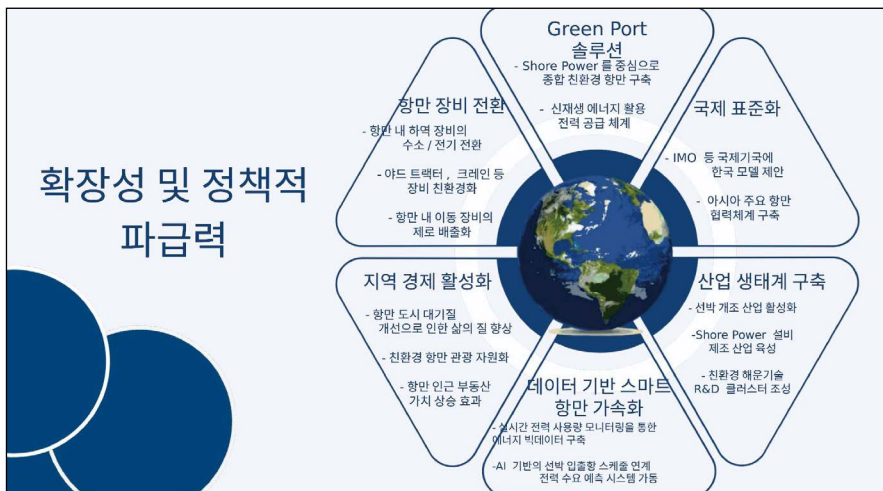
The Alternative Maritime Power policy is not merely a technical shift in the energy source used by vessels. It will serve as a “major game changer,” redefining the paradigm of Korea’s ports as “Green Smart Ports.”

The ripple effects of the AMP policy extend far beyond a simple technical transition. Across the following six areas, it creates a virtuous-cycle ecosystem that redefines the entire port paradigm as a “Green Smart Port”:

- Green Port Solutions: Building Shore Power as the central pillar of a comprehensive eco-friendly port powered by renewable energy, and converting the entire power supply system to renewable sources.
- Port Equipment Conversion: Cargo-handling equipment such as yard tractors and cranes will be replaced with hydrogen-and-electric-powered alternatives, enabling zero-emission operations for mobile port equipment.
- Leading International Standardization: Formally proposing the Korean model to

international organizations such as the IMO, and building cooperative frameworks with major Asian ports to secure Korea's status as a "First Mover."

- **Building an Industrial Ecosystem:** Jointly fostering the vessel retrofitting industry and the Shore Power equipment manufacturing industry, and establishing R&D clusters for eco-friendly shipping technologies to create a new industrial ecosystem.
- **Data-Driven Smart Ports:** Building energy big data through real-time monitoring of power usage, and operating AI-based power demand forecasting systems linked to vessel arrival and departure schedules.
- **Regional Economic Revitalization:** Improving air quality in port cities to enhance residents' quality of life, leveraging eco-friendly ports as tourism assets, and generating expected increases in property values near ports.



▲ [Figure 7] Scalability and Policy Impact: Structure of the Six-Area Virtuous-Cycle Ecosystem

Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)

Conclusion

Ports must no longer remain "stationary, ever-emitting pollution sources." While the current system is trapped in a vicious cycle of inefficiency and deficits across the technical, economic, and operational dimensions, this is a challenge that can be fully overcome with strong will and careful design.

The core of the "Alternative Maritime Power Policy" proposed in this paper is not simply about installing equipment. The goal is to create a virtuous ecosystem in which environmentally friendly practices become not a regulatory burden but the most reliable business strategy. This ecosystem will integrate four core policy measures, including a differentiated incentive system based on CO₂ emissions reductions, port fee reductions, stronger links between carbon neutrality and economic benefits, and financial support for shipbuilding and vessel retrofitting.

The goal of this proposal is to implement a four-phase roadmap that gradually expands the policy from a pilot program at the Port of Busan to mandatory adoption across ports nationwide, ultimately achieving net-zero emissions at all ports in the Republic of Korea. Furthermore, by proactively proposing this validated Busan Port model to the IMO and to cooperative frameworks among major Asian ports, Korea should firmly establish its position not as a mere policy follower, but as a "First Mover" leading global eco-friendly shipping standards.

The change that begins with Shore Power alone will extend into six interconnected virtuous cycles: the electrification of port equipment, a renewable-energy-based power grid, AI-driven smart ports, an eco-friendly industrial ecosystem, and regional economic revitalization. "A breathing port, thinking technology, and a standard that leads the world." The Alternative Maritime Power policy will be the starting point of that great journey.

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4. Government Policy Materials

- [6] Ministry of Oceans and Fisheries. Implementation Plan for the Distribution of Korean-Type Eco-Friendly Ships (Greenship-K). Ministry of Oceans and Fisheries Official Press Release.

5. Figure and Image Sources

- [Figure 1] Monthly Contribution of Ship-Related Sources to PM_{2.5} in Busan and Estimated Locations of Ship-Based Pollution Sources
Source: Heo Jong-bae (Busan Development Institute), "Port-Related Fine Dust Issues and Reduction Measures in the Busan Region"; reproduced from Park Ho-jin's presentation materials
- [Figure 2] Annual Container Throughput Trends at Busan Port and Cruise Ship Arrival Records and Plans
Source: Busan Port Authority and Ministry of Oceans and Fisheries Statistics (Published January 16, 2026); reproduced from Park Ho-jin's presentation materials
- [Figure 3] Problems and Limitations of the Current System: The Vicious Cycle of Inefficiency and Deficits
Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)
- [Figure 4] Conceptual Framework, Implementation Tasks, and Action Plan Structure for the Alternative Maritime Power Policy
Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)
- [Figure 5] Vessel Retrofitting and Financial Support Framework (Construction Subsidies and Interest Subsidies)
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- [Figure 6] Phased Implementation Roadmap for the Alternative Maritime Power Policy
Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)
- [Figure 7] Scalability and Policy Impact: Structure of the Six-Area Virtuous-Cycle Ecosystem
Source: Park Ho-jin, 8th Climate Environment Leader Presentation Materials (January 29, 2026)

I. Introduction

II. Body

1. Policy Background and Rationale
2. Policy Idea: Green Driving Grade System for Large Freight Trucks
3. Measurement Indicators and Grading Methodology
4. Implementation Method
5. Expected Effects and Risk Management
6. Potential for Expansion

III. Conclusion

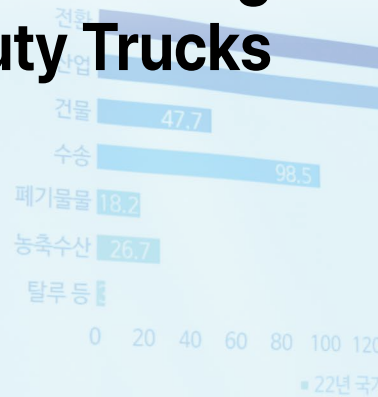
IV. References

Air Pollution

04

Shin Min-kyu / Dong-A University

Eco-Friendly Fleet Rating System for Heavy-Duty Trucks



산업-전환-수송-건설
전체 배출량증 약

Introduction

To respond effectively to the climate crisis, substantive reduction policies must be established with a focus on sectors that account for a large share of greenhouse gas emissions. The transport sector is one of the major parts of emissions in the national greenhouse gas emissions structure, alongside the industrial, transformation, and building sectors. It is also required to achieve a high level of reductions under the NDC. In particular, because the transport sector is closely tied to both everyday life and industrial activity, policy design must prioritize practical implementability over simple regulation.

Among them, large freight trucks deserve particular attention in transport-sector carbon reduction. Korea's freight transport system is heavily dependent on roads. According to 2023 data on the modal share of domestic freight transport, road transport accounted for 92.8%, while maritime and rail transport accounted for relatively small shares. This indicates that freight trucks occupy a dominant position within the domestic logistics system, and that improving the operational efficiency of freight trucks could become a core task for reducing transport-sector emissions.

In particular, large freight trucks account for a disproportionately large share of greenhouse gas emissions relative to their numbers. Freight trucks make up approximately 14.9% of all registered vehicles in Korea, yet they account for 33.7% of total greenhouse gas emissions across all vehicle types. Among these, large freight trucks exceeding 12 tonnes — despite representing only a portion of all registered freight trucks — account for more than half of total CO₂ emissions from freight trucks. This can be understood as "a small number of vehicles generate a large share of emissions." Accordingly, policies targeting large freight trucks can be expected to yield relatively high effectiveness in reducing transport-sector greenhouse gas emissions.

Building on this understanding, this paper proposes a Green Driving Grade System targeting large freight trucks of 12 tonnes or more. Rather than compelling the immediate replacement of existing large trucks, this policy measures indicators such as the empty running rate, load factor, and idling rate based on operational data from those vehicles. It then provides incentives to vehicles and companies that demonstrate high operational efficiency. The goal is to achieve substantive reductions in transport-sector carbon emissions while minimizing the burden placed on individual vehicle owners.

This policy is not intended to replace existing eco-friendly vehicle adoption policies, but rather to complement them as a transitional reduction measure for the period before full vehicle conversion can be achieved. Expanding the use of electric and hydrogen powered trucks is essential over the long term. However, a rapid transition across the entire heavy truck fleet is difficult to achieve because of challenges such as vehicle costs,

charging and refueling infrastructure, driving range, and load capacity. As such, a policy focused on improving the operational efficiency of currently operating vehicles can serve as a practical means of narrowing the transport-sector reduction gap until eco-friendly vehicles becomes widespread.

| Body

1. Policy Background and Rationale

There are two main reasons why a green driving grade system for large freight trucks is necessary. First, the structural characteristics of the large freight truck market. Korea's large freight truck market is heavily characterized by a structure of individual owner-operators working under subcontracting arrangements (Jiip system). Consequently, the cost burden associated with vehicle replacement or environmental regulation is likely to fall disproportionately on individual vehicle owners. Therefore, an approach that simply mandates the replacement of older vehicles or tightens regulations could increase the burden on, and resistance from, those on the ground.

Second, there is substantial potential to reduce emissions by improving operational efficiency without replacing vehicles. The empty-running rate for large freight trucks of 8 tonnes or more stands at approximately 28%, while the load factor remains in the low 80% range. Furthermore, considering that a significant portion of freight truck fuel consumption occurs during idling, carbon emissions can be reduced simply by decreasing empty backhauls, increasing load factors, and reducing idling time. In other words, in the large freight truck sector, not only "what is driven" but also "how it is driven" can serve as an important means of emissions reduction.

The pilot implementation corridor for this policy can be set as the Gyeongbu Expressway–Busan Port logistics axis. The Gyeongbu Expressway is one of the country's major highway sections with a high share of pollutant emissions, while Busan Port is a key port handling approximately 77% of Korea's container freight volume. In addition, traffic volume, vehicle classifications, time-specific traffic data, port cargo throughput, and truck entry and exit records along this corridor have already been largely digitized. By utilizing data from digital tachographs (DTG), GPS, and electronic waybills, it is possible to quantitatively measure speed, idling time, distance traveled, and load factor for large freight trucks. The Gyeongbu Expressway–Busan Port axis is therefore well suited as a pilot section for verifying the effectiveness of this policy.

In particular, the large freight truck sector cannot be adequately explained by individual drivers' driving habits alone. Because freight transport operates within a structure that

links shippers, logistics companies, transport companies, vehicle owners, and drivers, empty running and low load factors should be understood not merely as problems of individual drivers, but as problems of the logistics operating system as a whole. Therefore, rather than placing responsibility solely on drivers, a structure is needed that encourages the parties who order and manage transport services to choose eco-friendly operations. This is where the green driving grade system becomes particularly meaningful. By making the market more likely to select vehicles and transport companies with higher operational efficiency, and by designing the system so that these benefits flow back to drivers and vehicle owners on the ground, it can drive behavioral change across the entire logistics system.

2. Policy Idea: Green Driving Grade System for Large Freight Trucks

The core of this policy is to assign green driving grades of A, B, or C based on the operational data of large freight trucks weighing over 12 tonnes. Grades are calculated based on indicators that affect operational efficiency and carbon emissions, including empty-running rate, load factor, idling rate, and the proportion of constant-speed driving. Lower empty-running and idling rates, and higher load factors and constant-speed driving ratios, are evaluated as being closer to eco-friendly operation.

Rather than directly regulating owners, this system is designed to reshape the decision-making of shippers and logistics companies. Specifically, shippers and logistics companies that utilize large freight trucks with high green driving grades above a certain proportion receive incentives or benefits linked to carbon credits. Then, shippers and logistics companies are encouraged to preferentially select higher-grade vehicles, allowing eco-friendly operation to function as a competitive advantage in the market.

A particularly important point is ensuring that incentives do not remain solely with companies. In practice, it is drivers and vehicle owners who actually reduce empty running, reduce idling, and increase load factors. The system should therefore be designed so that a portion of the incentives received by companies is returned to the vehicle owners and drivers who achieved the actual reductions, in the form of "eco-driving performance bonuses." Through this structure, companies can secure ESG performance and Scope 3 reduction results, while vehicle owners and drivers can receive economic compensation for improving their driving habits.

What distinguishes this system is that it does not separate the responsibility for reduction from the reward for it. Existing environmental policies have often been designed to place costs on regulated entities, but this policy ensures that those who actually generate reduction outcomes receive a share of the benefit. Shippers and logistics companies secure ESG performance and carbon reduction results by utilizing higher-grade vehicles,

while vehicle owners and drivers receive performance bonuses tied to actual operational improvements. That means the system can increase policy acceptance by making eco-friendly driving a choice linked to economic incentives rather than simply an obligation.

3. Measurement Indicators and Grading Methodology

There are three core indicators used to calculate the green driving grade. The first is the empty-running rate, calculated by dividing empty-running distance by total distance traveled. A higher empty-running rate indicates a higher proportion of operation without cargo, which can increase unnecessary fuel consumption and carbon emissions.

The second is the load factor, calculated by dividing the actual load (in tonnes) by the vehicle's rated load capacity (in tonnes). Even over the same distance, a higher load factor reduces emissions per unit of freight transported. So, the load factor is an important indicator of the transport efficiency of large freight trucks.

The third is the idling rate, calculated by dividing the amount of fuel consumed during idling by total fuel consumption. Because idling consumes fuel and generates emissions even while the vehicle is stationary, reducing idling can produce relatively immediate reduction effects.

It is also necessary to separately measure the extent to which shippers and logistics companies use eco-friendly transport providers. This can be achieved using three indicators. The first is the eco-grade vehicle utilization rate, calculated by dividing the distance traveled by A-grade large freight trucks by the total distance traveled by all large freight trucks. The second is the eco-friendly transport volume ratio, calculated by dividing the tonne-kilometers transported by A-grade vehicles by total tonne-kilometers. The third is the eco-friendly transport contract ratio, calculated by dividing the annual transport costs contracted with A-grade transport companies by total transport costs. These indicators serve as a basis for assessing the extent to which companies actually select higher-grade vehicles in their transport operations.

Policy outcomes must be quantifiable in terms of carbon reduction. To achieve this, the annual change in CO₂ emissions per heavy duty truck, the change in emissions per ton kilometer, total CO₂ emissions reductions, and the financial value of those emissions reductions are measured together. The financial value of the reductions can be calculated by multiplying total carbon reductions by the carbon price. In this way, improvements in operational efficiency are not limited to a simple environmental activity but can also be linked to corporate ESG reports, performance indicators, and carbon credit management.

4. Implementation Method

Implementation can proceed in four stages.

Stage 1 involves designing the pilot program and establishing the target corridor. The Ministry of Land, Infrastructure and Transport and the Ministry of Environment, in cooperation with the Korea Expressway Corporation, the Busan Port Authority, and logistics associations, designate the Gyeongbu Expressway–Busan Port axis as the pilot corridor. Participants include owners of commercial freight trucks of 12 tonnes or more and the shippers and logistics companies that contract with them.

Stage 2 is the establishment of a data collection and grade rating system. DTG and GPS data are used to automatically calculate empty-running rates, idling time, speed patterns, and load factors. After establishing a baseline using national transportation survey statistics, the degree of improvement in individual vehicles' or companies' operational data relative to the baseline is measured. Based on this, green driving grades A, B, and C are assigned.

Ensuring data reliability is also critical to the operation of this system. If the green driving grade system is linked to actual incentives or emission credits, there is a risk of data manipulation or over-reporting. To prevent this, a system is needed to cross-verify data from DTG, GPS, electronic waybills, port entry/exit records, and fuel purchase data. In particular, using multiple data sources instead of relying on a single indicator makes it possible to assess actual driving performance more accurately while also improving the credibility of the policy.

Stage 3 is the implementation of incentives/credit allocation and a benefit-sharing mechanism for vehicle owners. Shippers and logistics companies that utilize higher-grade vehicles above a certain proportion have their reduction performance certified annually and receive carbon credits or incentives. At the same time, a contractual structure is established so that a portion of the benefits received by companies is returned, in the form of performance bonuses, to the vehicle owners and drivers who actually improved their operations. This ensures that reduction outcomes function as a direct incentive for frontline drivers, rather than remaining solely within corporate ESG performance.

Stage 4 is an evaluation and expansion. After operating the pilot program for two to three years, a comprehensive evaluation is conducted covering the cost per tonne of reduction, participation rates, vehicle owner satisfaction, and emission credit trading performance. If the policy's effectiveness is verified, it can be progressively expanded to other expressway corridors, port-linked sections, and ultimately to general national highway freight corridors.

5. Expected Effects and Risk Management

This policy can generate benefits for companies, vehicle owners, and the government. Companies can reduce their K-ETS compliance costs through verified reductions, or generate revenue by trading surplus emission credits. Data demonstrating the use of eco-friendly vehicles can also be used in ESG reports and as evidence of Scope 3 reductions. This can strengthen companies' environmental management capacity and serve as a competitive advantage in contracts with major shippers.

There are also benefits for vehicle owners and drivers. Whereas existing policies have tended to concentrate the burden of vehicle replacement or regulatory compliance on vehicle owners, the green driving grade system instead provides performance bonuses for improvements in driving habits. When actions such as reducing empty running, reducing idling, and increasing load factors connect to tangible rewards, drivers can have a direct motivation to participate in the policy.

From the government's perspective, this policy can contribute to achieving the transport sector's NDC reduction targets. In particular, because it can generate reduction effects through improved operational efficiency without requiring large-scale vehicle replacement, it can serve as a highly cost-effective reduction measure. Moreover, as operational data accumulates, the government can monitor transport-sector carbon emissions more precisely and use this data in future policy design.

However, risks also exist. The first is the possibility of data manipulation. To prevent this, waybills, GPS, port entry/exit records, and tachograph data should be cross-verified, alongside the parallel use of anomaly detection systems and on-site inspections. The second is the issue of fairness in baseline-setting. If baselines are set inaccurately, reductions may be credited even where no real reduction has occurred. To address this, the duration, distance, and route conditions of the pilot corridor must be clearly fixed, and if adjustments are necessary, the criteria for such adjustments must be transparently disclosed. Third is participation and equity problems. The allocation of performance bonuses can significantly affect the success or failure of the policy. In freight transport, vehicle owners and actual drivers are often different individuals, and the contractual relationships between transport companies and vehicle owners can be complex. If incentives remain solely with companies or transport companies, drivers who actually improve operations may not receive any compensation. To prevent this, the criteria for distributing performance bonuses must be clearly defined at the contract stage, with compensation based on actual operational records. Only then can drivers feel the necessity of participating in the system and have motivation to continue eco-friendly driving.

6. Potential for Expansion

The green driving grade system can be expanded in various directions following the pilot program. Spatially, the policy can begin along the Gyeongbu Expressway–Port of Busan corridor and gradually expand to major highway logistics corridors, including the Jungbu, Yeongdong, and Seohaean Expressways, as well as port-linked corridors connecting key ports such as the Port of Incheon, the Port of Gwangyang, and the Port of Pyeongtaek. In the longer term, it could extend beyond expressways to general national highway freight corridors, metropolitan urban logistics, and airport-linked sections, ultimately developing into a nationwide logistics carbon management system.

The scope of application can also be expanded. While the initial focus is on large freight trucks of 12 tonnes or more, the system could later be extended to medium and large freight trucks of 5 tonnes or more, as well as specialized vehicles such as refrigerated trucks, freezer trucks, and tank trucks. However, because vehicle types and operational characteristics differ, indicators such as empty-running rate, idling rate, and load factor would need to be adjusted accordingly for each vehicle type. Furthermore, by linking the system to urban delivery and last-mile vehicles, it could evolve into an urban eco-friendly logistics grading system.

At the institutional level, the system can be linked with ESG disclosure requirements, the Korea Emissions Trading Scheme (K-ETS), green logistics subsidy programs, and electric freight vehicle adoption programs. For example, a policy package could be designed in which subsidies are provided for vehicle and equipment investment, while incentives are provided for improvements in operational efficiency. Reduction performance above a certain threshold could also be linked to K-ETS offset credits, low-carbon certified logistics programs, and evaluation criteria in public procurement and large-shipper bidding processes.

The data dimension also offers significant scalability. By integrating and standardizing data from DTG, electronic waybills, ERP systems, and fuel purchase records, companies could automatically calculate their Scope 3 emissions and reductions in the transport and logistics sectors. This would allow the government to continuously monitor progress on the transport sector's NDC implementation. Ultimately, the green driving grade system has the potential to evolve beyond a simple vehicle evaluation scheme into an integrated platform combining transport-sector carbon reduction with logistics data management.

| Conclusion

The green driving grade system for large freight trucks offers a practical alternative that

can address the limitations of existing transport-sector reduction policies. While the adoption of eco-friendly vehicles and vehicle replacement are essential in the long term, replacing all large freight trucks within a short period of time is not feasible. Particularly, in a market structure dominated by individual owner-operators, the costs of vehicle replacement and the burden of regulation are likely to fall disproportionately on those on the ground. Hence, policies aimed at reducing carbon emissions by improving the operation of existing vehicles must be pursued.

This policy calculates green driving grades for large freight trucks based on operational data such as empty-running rate, load factor, and idling rate, and provides incentives to shippers and logistics companies that utilize higher-grade vehicles. At the same time, it encourages on-the-ground participation by returning a portion of these incentives to the vehicle owners and drivers who actually achieved the reductions. This represents a public-private collaborative policy model that simultaneously links corporate ESG performance, economic compensation for vehicle owners, and the government's transport-sector reduction targets.

As such, the core of this system lies not in mandatory regulation, but in changing the structure of market choices. It encourages shippers and logistics companies to select eco-friendly vehicles, provides drivers and vehicle owners with rewards for improving operational efficiency, and enables the government to manage reduction outcomes based on data. Given that vehicle replacement remains difficult in practice, the fact that carbon emissions can be reduced through operational efficiency improvements alone makes the green driving grade system a cost-effective and scalable policy option for transport-sector carbon reduction.

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Preface

Chapter 1: Problem Recognition — Household Consumption and Carbon Emissions

Chapter 2: Background and Necessity

Chapter 3: Proposed Idea — The Eco Money Report System

Chapter 4: Implementation Method and Phased Action Plan

Chapter 5: Expected Effects and Potential for Expansion

Conclusion

Economics

05

Choi Ha-jin / Gachon University

Eco Money Report



Preface

In an era where the climate crisis is no longer a distant future concern but a present-day reality, individuals are increasingly seeking ways to reduce carbon emissions in their everyday lives. However, few people are fully aware of just how much carbon is generated by the consumption activities they repeat on a daily basis.

This report is motivated by these concerns. This paper proposes a new system called the 'Eco Money Report', which measures carbon emissions in real time based on individual consumption data and directly links carbon-reducing behaviors to financial incentives. At its core, this idea aims to connect the broad goal of carbon neutrality with individuals' everyday financial activities, making it easy for anyone to practice eco-friendly consumption consistently.

Responding to the climate crisis is no longer a task for governments or corporations alone. Meaningful carbon reduction becomes possible only when each individual changes their everyday consumption patterns. The Eco Money Report aims to serve as a tool that helps people take that first step toward change.

Chapter 1: Problem Recognition — Household Consumption and Carbon Emissions

1.1 The Primary Driver Behind Household Carbon Emissions: "Consumption Activities"

According to greenhouse gas emissions statistics in Korea, over 60% of household carbon emissions originate from everyday consumption activities such as energy use, food consumption, transportation, and shopping (Korea Transportation Safety Authority, KOTEMS Internal Sector Greenhouse Gas Emissions Statistics). This figure is often overlooked, as it tends to be eclipsed by the industrial and energy supply sectors, yet it clearly demonstrates how significant an impact individual-level behavioral change can have on overall carbon reduction.

The problem is that most consumers are unaware of how much carbon their consumption behaviors generate. We purchase goods, order delivery food, and travel by public transportation or private car every day, yet our sense of the carbon footprint behind each of these individual actions remains very faint.

1.2 Invisible Carbon Consumption: A Concrete Example

A concrete example can illustrate just how much carbon everyday consumption behaviors generate.

Consider a scenario where, on a weekend evening, someone orders a whole chicken through a delivery app. The production and cooking process for a single chicken generates approximately 2.2 kg of carbon emissions. On top of this, an additional 1 kg is generated from the use of disposable containers, plastic packaging, and motorcycle delivery. As a result, a single order of delivery chicken generates a total of approximately 3.2 kg of carbon. In this way, the consumption behaviors we repeat without much thought continuously accumulate invisible carbon emissions.

1.3 The Entrenchment of Unconscious High-Carbon Consumption Patterns

When individuals repeat consumption behaviors without recognizing their carbon emissions, high-carbon consumption patterns become entrenched as everyday habits. Once formed, such habits are difficult to change through individual willpower alone. The societal goal of carbon neutrality cannot be achieved through macro-level policy alone; it requires concrete and effective institutional support that actively encourages changes in individuals' everyday behavior.

Chapter 2: Background and Necessity

2.1 Limitations of Existing Systems

Existing eco-friendly incentive programs currently in operation in Korea, such as the Carbon Neutral Point System, are primarily focused on energy conservation and the transportation sector. While these programs offer rewards for specific behaviors, they have limited capacity to fundamentally improve individuals' overall consumption habits.

From a behavioral economics perspective, people are more strongly motivated to change their behavior when rewards are immediate and tangible. Current programs lack the immediacy and visibility of rewards needed to drive sustained behavioral change, indicating a clear need for improvement.

2.2 The Spread of Value-Based Consumption Among MZ Generation and the Absence of Economic Incentives

Recently, interest in environmentally responsible consumption, often referred to as value driven consumption, has spread rapidly, especially among the MZ generation (Millennials and Gen Z). A substantial consumer base is forming that is willing to choose products based on environmental impact rather than price alone. However, eco-friendly consumption often comes with higher costs than conventional consumption, and there is currently a lack of economic incentive structures that would allow consumers to sustain such choices over time. This is precisely why a system is needed that allows consumers to feel, in practice, that eco-friendly choices are also connected to their own financial benefit.

2.3 The Need for a "Carbon Reduction = Wealth Creation " Paradigm

The core premise of the Eco Money Report is to redefine carbon reduction not as a mere environmental obligation, but as an opportunity for individuals to build personal assets. By designing a structure in which tangible financial rewards flow back to consumers as they reduce their carbon emissions, the system aims to make eco-friendly consumption something people experience, in everyday life, as an economically rational choice.

Chapter 3: Proposed Idea — The Eco Money Report System

The Eco Money Report is an integrated platform that automatically measures carbon emissions based on individual consumption data and provides financial rewards for carbon reduction. The system consists of four core functional modules.

3.1 Data Collection: Integration with E-Receipts

The Eco Money Report is built on integration with electronic receipt (e-receipt) data from card companies and retailers as its core foundation. When a consumer makes a card payment or receives an e-receipt, the relevant data is automatically collected, allowing their full consumption history to be analyzed without any manual input. For example, when users purchase airline tickets or travel by rail, the corresponding transportation mode is automatically identified, allowing the appropriate carbon emission factor to be applied immediately.

3.2 Carbon Conversion and Classification

Collected consumption data is converted into carbon emissions based on category-specific carbon emission factors. High-carbon consumption items include the use of food delivery apps, purchases of imported or processed foods, and the use of plastic bags, while low-carbon consumption items include shopping at local food direct-sale stores, using reusable shopping bags, and purchasing zero-waste products. By comparing these two categories, the consumer's actual carbon reduction is calculated.

3.3 Monthly Carbon Consumption Report

Each month, a personalized "My Carbon Consumption Report" is automatically generated and delivered through the app or web interface. Rather than simply listing numbers, this report is designed to visualize both the amount of money saved (financial benefit) and the amount of carbon reduced (environmental benefit) together, allowing consumers to experience both forms of benefit at once. For example, the system presents abstract carbon metrics in the form of familiar comparisons, such as, "Your transportation-related carbon emissions decreased by 115 kg in November, equivalent to planting 17 trees." Gamification elements such as "My Carbon Reduction Ranking" and "This Month's Reduction Goal Achievement Rate" are also introduced to sustain ongoing user engagement.

3.4 Linking to Financial Incentives

Carbon reduction performance is converted into "Eco Money Points," which translate into tangible financial benefits. Depending on the reduction rate, users receive differentiated points, cashback, or preferential interest rates. Accumulated points can be used across a range of financial activities, including redemption with partner financial institutions, application toward preferential savings interest rates, and access to eco-friendly investment products. The core of the system lies in establishing a structure in which carbon neutrality translates directly into financial benefit, thereby encouraging voluntary consumer participation.

Chapter 4: Implementation Method and Phased Action Plan

Phase 1 — Building the Data Collection Infrastructure

A real-time integration system will be established with e-receipt data from card companies and retailers. The moment a consumer makes a payment, the e-receipt is automatically scanned, and product-level certification marks and classification information are verified. For purchases of eco-certified products, the carbon savings relative to conventional products will be immediately converted into points.

Phase 2 — Development and Operation of a Personal Carbon Report Platform

An app- and web-based personal carbon report visualization platform will be developed. The system also incorporates intuitive and engaging feedback factors, such as "My Carbon Reduction Ranking" and "Number of Trees Equivalent to My Carbon Savings," enabling consumers to monitor changes in their behavior in real time. The platform will also support individual goal-setting features to encourage self-directed participation.

Phase 3 — Operation of the Incentive System

Through partnerships with financial institutions, the channels through which Eco Money Points can be used will be diversified. Points can be converted into cash-equivalent cashback, preferential savings interest rates, or eco-friendly investment products, allowing consumers to choose rewards that align with their own financial preferences.

Phase 4 — Expansion of the Regional and Corporate Ecosystem

By linking the system with local currencies and municipal point programs, the platform will simultaneously promote local economic activation and carbon reduction. The system establishes a dual rewards structure under which users receive both local government reward points and Eco Money points when purchasing zero waste products at local markets using local currency. In doing so, the system encourages environmentally responsible consumption to create a virtuous cycle that strengthens the local economy.

Chapter 5: Expected Effects and Potential for Expansion

5.1 Environmental Effects

Once the Eco Money Report is fully introduced and operational, it can be expected to produce a tangible reduction in carbon emissions at the individual consumption stage. As consumers become aware of carbon emission information at the moment of each purchasing decision and form habits of choosing low-carbon alternatives, this will, over the long term, lead to the broader spread of a sustainable consumption culture. In addition, a consumption data driven carbon reduction system can also contribute to quantifying carbon emission reductions in the consumption sector, which have been difficult to measure using conventional policy approaches.

5.2 Economic Effects

The expansion of eco-friendly consumption increases market demand for Korea's domestic green industries and creates economic ripple effects that promote the growth of related companies. It also opens the possibility of forming a new "green credit" market based on financial data. A new paradigm in which a consumer's carbon reduction history is recognized as a form of financial credit asset would mark a turning point in extending the scope of climate finance into the everyday lives of ordinary citizens.

5.3 Social Effects

The most important social effect is a shift in public perception of the climate crisis. When carbon reduction is experienced not as a vague environmental obligation but as something that is financially rewarding, more citizens will voluntarily participate in eco-friendly consumption. The experience of directly seeing one's carbon reduction performance translated into financial benefit serves as a powerful motivator, helping individuals recognize the climate crisis as "their own issue."

5.4 Technical Scalability

By combining AI-based consumption pattern analysis with blockchain-based data transparency technologies in the future, the Eco Money Report can evolve into a more sophisticated and reliable carbon-tracking platform. In the long term, growth into a global carbon finance platform is a fully viable scenario. If developed into an innovative system that connects cross-border carbon credit trading with individual consumption data, this

model could contribute to the global climate finance ecosystem, extending well beyond Korea.

Conclusion

The Eco Money Report is a proposal that integrates two objectives, carbon reduction and asset building, within a single system. Rather than treating carbon neutrality as an obligation that requires people to accept inconvenience, this system seeks to drive sustainable behavioral change by designing a structure in which changes in everyday consumption habits translate directly into personal financial benefit.

By measuring carbon emissions based on individual consumption data and converting reduction outcomes into financial rewards, this system represents a feasible model that combines principles of behavioral economics with fintech technology. It has the potential to address the limitations of existing carbon neutrality policies and to drive voluntary participation across a diverse range of consumers, including the MZ generation.

In this era of climate crisis, what we need is a bridge that makes carbon neutrality part of "my everyday life." The Eco Money Report can serve as that link. Rather than simply promoting carbon reduction as a slogan, this report ultimately aims to propose a new way of life that integrates sustainable consumption habits with financial habits.

I. Introduction

1. The Rise in Plastic Usage and Environmental Problems
2. The State of Plastic Recycling in Korea and the Problems with Thermal Recycling
3. The Need for a Transition to a Circular Economy

II. Body

1. Proposed Solution 1: Introduction of the AI-Based Sorting System "Atron"
2. Proposed Solution 2: A Roadmap for the Phased Elimination of Thermal Recycling

III. Conclusion

IV. References

Recycling

06

Lee Yeon-seon / Ewha Womans University

Phasing Out Thermal Recycling of Plastics



AI 선별 시스템 도입

인력 대비 처리량 증가 (2-4배)

인건비 절감 및 노동환경 개선

99.3%

국내 AI 선별 시스템 도입 사례

창원시
수퍼빈의 AI 자동 수거기를 설치해 투명 PET를 인식, 분리, 압축

양천구
수퍼빈의 AI 시각 인식 기능을 이용해 투명 PET병과 캔을 분리

성남시
에이트테크의 선별 로봇 '에이트론'을 분리센터에 설치하여
하루 최대 1.8톤의 플라스틱 선별이 가능하도록 함

| Introduction

1. The Rise in Plastic Usage and Environmental Problems

Plastic is widely used across modern industry and everyday life due to its light weight, durability, and low production cost. However, behind this convenience lie serious environmental problems. Plastic is produced from fossil fuels and emits greenhouse gases throughout its entire lifecycle, including production, distribution, and disposal. It also takes more than 500 years to decompose in the natural environment, persisting in oceans and soil for extended periods and causing adverse effects on ecosystems and human health.

According to the OECD Global Plastics Outlook, global plastic consumption is projected to continue rising, reaching approximately 1.2 billion tonnes by 2060. As such, plastic waste generation is expected to increase to approximately 1 billion tonnes, and greenhouse gas emissions from plastics are projected to reach approximately 2 billion tonnes. Furthermore, by 2060, plastics are projected to account for approximately 6 billion tonnes of greenhouse gas emissions, representing about 10% of it.

In this sense, the plastics problem is not merely a waste issue, but is emerging as a core challenge of the carbon-neutral era, directly linked to the climate crisis.

2. The State of Plastic Recycling in Korea and the Problems with Thermal Recycling

Although Korea is known as a country for recording one of the highest recycling rates in the world, a closer look at its actual recycling structure reveals heavy reliance on thermal recycling. The rate of domestic waste plastic treatment methods is as follows: direct incineration 33.3%, landfill 4.6%, material recycling 22.7%, and thermal recycling 39.3%.

Thermal recycling refers to the use of waste plastic as an alternative fuel in power generation facilities, cement plants, and boilers. Thermal recycling has traditionally been classified as a form of recycling because it recovers energy by utilizing the high calorific value of waste plastics. However, it has been criticized for being little different from incineration in practice. In particular, thermal recycling presents the following problems:

- Significant greenhouse gas emissions during the incineration of plastic fuel
- The potential generation of harmful substances such as fine particulate matter and dioxins
- A simple energy-recovery method that does not actually circulate resources
- In many international contexts, it is not recognized as recycling at all

In fact, the incineration of approximately 2.6 million tonnes of plastic waste, including waste treated through thermal recycling, emitted an estimated 5.2 million tonnes of carbon dioxide in 2020. Also, the EU classifies thermal recycling not as recycling but as "energy recovery." While Korea's plastic recycling rate is officially recorded at 75.5%, the proportion accounted for by thermal recycling is so high that, when converted to EU standards, the effective recycling rate is only about 27%. This demonstrates that Korea's recycling statistics do not adequately reflect actual circular resource use, and has given rise to controversy over a form of greenwashing.

3. The Need for a Transition to a Circular Economy

The conventional linear economy is based on mass production, consumption, and disposal. Thermal recycling, in that it converts waste plastic into solid fuel for ultimate incineration, is itself closer to a linear economy structure. A circular economy, by contrast, is a structure that continuously circulates resources through resource conservation, recycling, and remanufacturing. Through material recycling and chemical recycling, plastic can be reused as raw material, thereby reducing both waste generation and greenhouse gas emissions. However, material recycling also faces the following limitations:

- Quality degradation through repeated recycling
- Issues related to mixed materials and contamination
- A lack of sorting and washing infrastructure
- High collection and processing costs

Therefore, rather than simply increasing the recycling rate, sorting technologies and institutional improvements for securing high-quality recycled raw materials must be advanced in tandem. Particularly, achieving net zero will require moving away from a structure centered on thermal recycling and toward a circular economy system centered on material and chemical recycling.

| Body

1. Proposed Solution 1: Introduction of the AI-Based Sorting System "Atron"

1) The Need for an AI-Based Sorting System

Expanding material recycling requires accurate sorting of waste plastics. Existing manual sorting methods are limited in both accuracy and throughput, and contamination and mixed-material issues make it difficult to secure high-quality recycled raw materials.

The introduction of an AI-based automated sorting system is needed to address this challenge.

2) Overview of the Atron System

Atron is an AI-based waste-sorting robot developed by the Korean company AETECH (에이트테크). Using hyperspectral camera technology and near-infrared spectral analysis, it can automatically classify various types of waste, including PET bottles, PE, PP, PS, and cans. Atron has the following features:

- Capable of sorting 9 categories of recyclable waste into up to 50 sub-categories based on color and intended use
- Can sort up to 96 items of waste per minute
- Increases sorting volume by 2–3 times compared to existing methods
- Achieves a classification accuracy of over 95%
- Increases processing throughput by 2–4 times compared to manual labor
- Reduces labor costs and improves working conditions

A.Tech also became the first Korean company to win the World Intellectual Property Organization (WIPO)'s "Global Awards 2024," gaining international recognition for its technological capabilities. The actual cost of introducing the system is reported to be approximately 270 million KRW.

3) Detailed Implementation Plan

(1) Mandatory Automation of Local Government Sorting Facilities

- 2027: Mandate the introduction of AI sorting robots at sorting facilities in the Seoul metropolitan area and major metropolitan regions
- 2030: Achieve automation in over 50% of local government sorting facilities nationwide

(2) Improvement of the EPR System Based on Measured Data

Using actual measurement data from the Atron sorting robots, Extended Producer Responsibility (EPR) fees will be differentiated according to recyclability.

- Impose higher fees on products made of composite materials that are difficult to recycle
- Encourage reduced production of highly contaminated plastic products

(3) Expansion of AI-Linked Unmanned Collection Machines

- 2027: Expand the installation of unmanned PET collection machines at large retail stores and local government facilities
- After 2027: Introduce a consumer incentive system

This would increase consumer participation in recycling and minimize contamination at the collection stage.

2. Proposed Solution 2: A Roadmap for the Phased Elimination of Thermal Recycling

1) Policy Direction

Thermal recycling should be phased out of the recycling category, and a circular economy system centered on material and chemical recycling should be established. To this end, this paper proposes a phased phase-out roadmap from 2026 to 2030.

2) Phased Roadmap

Phase 1: Legal and Institutional Reform

- Narrow the scope of recognized plastic recycling to physical and chemical recycling only
- Reclassify thermal recycling as energy recovery
- Reset recycling rate targets based on criteria that exclude thermal recycling
- Set a target of achieving an actual recycling rate of 40%

Phase 2: Operate Transition Period

A three-year transition period will be provided to ease the impact on industry.

- Allow only facilities that achieve a heat recovery efficiency of at least 70%.
- Strengthen emission standards for thermal recycling facilities
- Impose a waste disposal levy
- Reflect energy recovery as a separate criterion in ESG assessments.
- Consider introducing a plastic tax
- Apply the same regulations to plastics used in cement plants

Phase 3: Support for Recycling Industry Transition

- Expand R&D investment in chemical recycling technologies
- Provide incentives for companies that use recycled plastics
- Offer preferential treatment to companies using 30% or more recycled plastics
- Expand government priority procurement programs

Phase 4: Achievement of Final Goals

- Complete the phased elimination of thermal recycling
- Establish a system centered on material and chemical recycling
- Achieve a plastic recycling rate of 40%

| Conclusion

The two proposed solutions each carry significant expected benefits. First, the introduction of the AI-based sorting system Atron can substantially improve both the efficiency and accuracy of the recycling process. By overcoming the limitations of existing manual sorting methods, it can expand the production of high-quality recycled raw materials. This can drive the growth of the recycled plastics market and strengthen the competitiveness of the circular economy industry. Moreover, sorting automation is expected to improve working conditions and reduce labor costs, while also contributing to the creation of new green jobs in areas such as quality inspection of recycled raw materials and process management.

Second, the roadmap for the phased elimination of thermal recycling can play an important role in achieving meaningful greenhouse gas reductions and building a recycling system that aligns with international standards. By reducing the emissions of carbon dioxide and harmful substances generated during thermal recycling, environmental pollution can be mitigated, and the resource circularity can be increased through the transition to a system centered on material and chemical recycling. Furthermore, this is expected to help resolve greenwashing issues and improve the credibility of Korea's recycling statistics, thereby strengthening Korea's responsiveness to international plastics agreements and global environmental policy.

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I. Introduction

- a. Opening
- b. What Is the Emissions Trading Scheme?

II. Body

- a. Limitations of the Emissions Trading Scheme
- b. The Need to Reduce Scope 3 Emissions
- c. Emissions Trading Scheme: Expansion of Scope 3 [Detailed Roadmap]
- d. Expected Effects

III. Conclusion

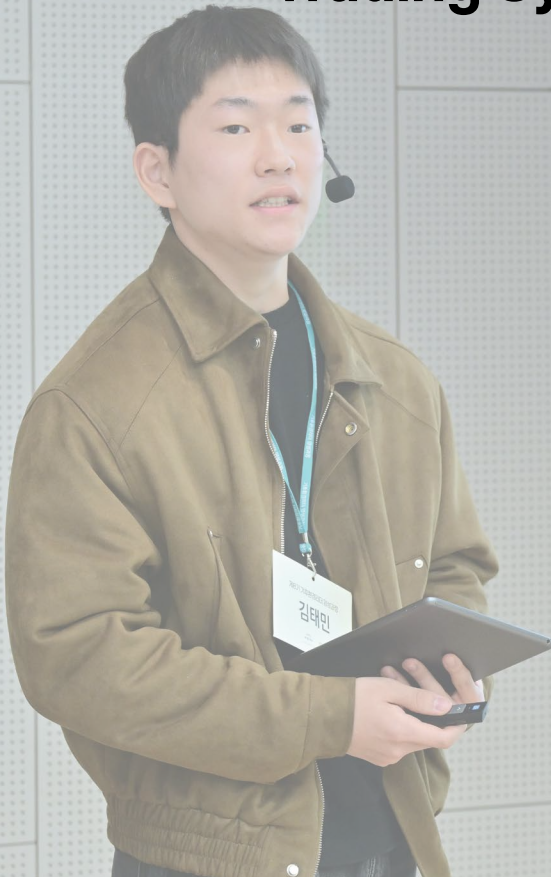
IV. References

Policy

07

Kim Tae-min / Chonnam National University (Gwangju)

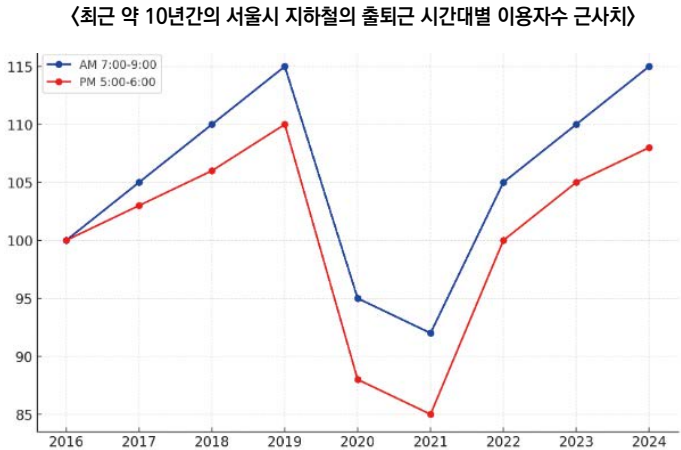
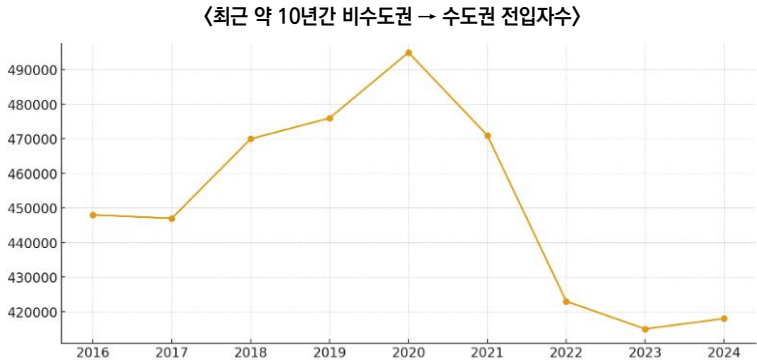
Expanding the Emissions Trading System Target to Scope 3



Introduction

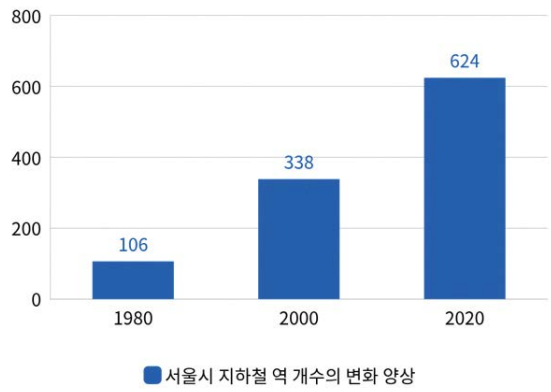
a. Opening

Most people have likely heard that young Koreans are increasingly relocating from non-metropolitan regions to the Seoul metropolitan area to seek employment. According to statistical data, over the past decade, the population moving from non-metropolitan to metropolitan areas has averaged around 400,000 people per year, meaning that between 2016 and 2024 alone, nearly 4 million people moved into the Seoul metropolitan area.



As a result, ridership on the Seoul subway system has also been increasing, and in particular, the number of users during commuting hours has been steadily rising. This in turn suggests that the concentration of population in the Seoul metropolitan

area continues to intensify year after year, and that the use of private vehicles is also increasing.

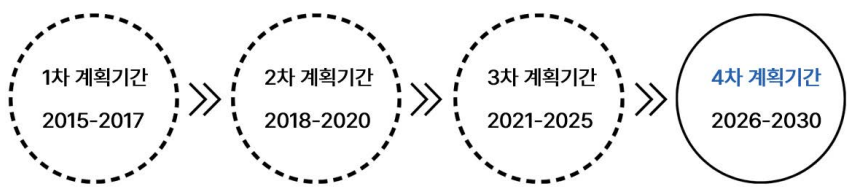


In addition, the number of subway lines and stations in Seoul has also been increasing. This implies that as residents' daily living areas expand, electricity consumption and traffic volume increase accordingly, and carbon emissions rise along with them. When this occurs, urban heat island effects and temperature inversions may occur, causing fine particulate matter to accumulate in specific areas. This can increase the risk of respiratory diseases and may even lead to severe air pollution similar to the London smog.

This proposal focuses on the Emissions Trading System(ETS) and explores ways that can incentivize companies to voluntarily reduce greenhouse gas emissions.

b. What Is the Emissions Trading Scheme?

The Emissions Trading Scheme(ETS) is a system in which the government allocates greenhouse gas emission allowances to companies, allowing them to emit within their allocated limits or to buy and sell allowances among themselves. The current status of Korea's ETS is as follows.



The scheme has been implemented in successive planning periods since 2015, and this year(2026) marks the start of the fourth planning period. Among its achievements to date, the most notable is that the ETS has become firmly established as a core instrument for Korea's national greenhouse gas reduction efforts.

| Body

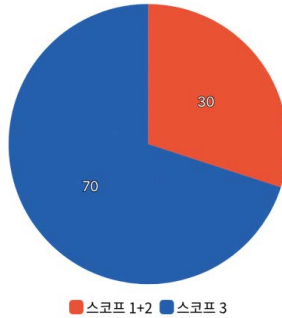
a. Limitations of the Emissions Trading Scheme

Although the Emissions Trading System(ETS) has demonstrably contributed to reducing greenhouse gas emissions, it also has clear limitations. In particular, auction-based allocation has remained at a very low level, with the effective auctioning ratio accounting for only 4% of total allowances. Thus, carbon allowance prices have also remained low. Consequently, many companies have found it more economical to purchase carbon allowances than to voluntarily invest in reducing their greenhouse gas emissions. Accordingly, growing concerns have been raised about whether the Emissions Trading System(ETS) is achieving its intended policy objectives. Also, the current ETS applies only to Scope 1 and Scope 2 emissions. To enhance the effectiveness of the system and further encourage companies to take voluntary climate action, this proposal argues that its regulatory scope should be expanded to Scope 3 emissions.

b. The Need to Reduce Scope 3 Emissions

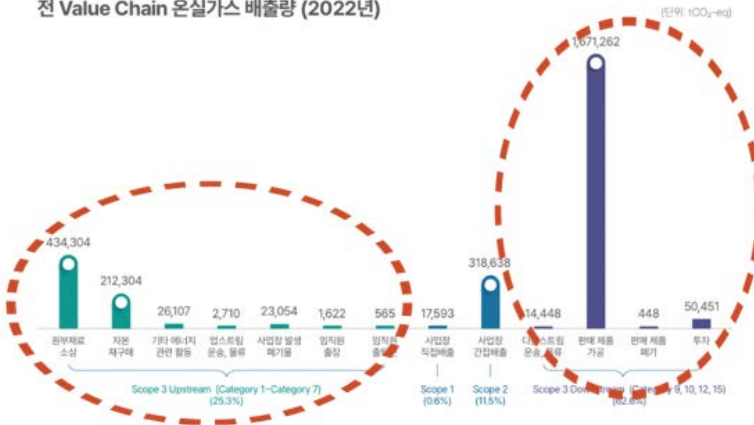
To begin with, Scope 1 refers to direct greenhouse gas emissions from sources owned or controlled by a company. Scope 2 refers to indirect greenhouse gas emissions arising from the electricity, steam, heating, or cooling that a company purchases or otherwise acquires and consumes. In contrast, Scope 3 emissions refer to indirect greenhouse gas emissions that occur throughout a company's value chain but are not included in its Scope 2 emissions. Consequently, they are considerably more difficult for companies to manage. Moreover, among all emissions generated across the value chain, Scope 3 emissions are the most challenging to measure and reduce.

〈대다수 기업에 배출하는 온실가스배출량의 종류별 차지하는 비중〉



According to a study by Deloitte, Scope 3 emissions account for approximately 70% of total greenhouse gas emissions for most companies.

전 Value Chain 온실가스 배출량 (2022년)



Further evidence can be found in data published by SK Siltron(2022), which show that Scope 3 emissions were substantially higher than Scope 1 and Scope 2 emissions. This means that the importance of prioritizing reductions in Scope 3 emissions.

Scope 3 emissions can be classified into a total of 15 categories. Among these, this paper focuses on efforts to reduce emissions related to employee commuting.

구매한 상품 및 서비스	2. 자본재	3. 연료 및 에너지 활동
4. 업스트림 운송 및 유통	5. 영업에서 발생한 폐기물	6. 투자
7. 출장	8. 종업원 통근	9. 업스트림 리스자산
10. 다운스트림 운송 및 유통	11. 판매된 제품의 가공	12. 판매된 제품의 사용
13. 제품의 수명종료시 처리	14. 다운스트림 리스 자산	15. 프랜차이즈

c. Emissions Trading Scheme: Expansion of Scope 3 [Detailed Roadmap]

1st Stage: Government-Led Survey of Residential and Workplace Locations for Commuting Employees

Given the question about whether such a project could be carried out by private companies, I conducted a survey of 30 respondents via personal social media, and found that approximately 73% expressed sensitivity around disclosing their residential information. Based on this, the government was selected as the implementing body. Furthermore, this survey would be modeled on the Population and Housing Census conducted at the end of last year (October 2025).

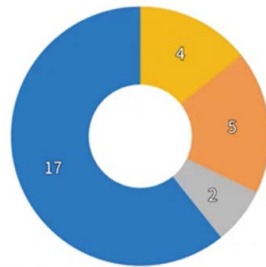
대외활동에서 진행하는 Net Zero[넷제로] 아이디어 제안 프로젝트에서 '탄소배출권 거래제, 스코프3까지 연장선으로'라는 해결책을 제시하였으나
→ 상용화 단계에서 개인정보 관련 피드백을 받았습니다.

이에 따라 피드백에 대한 해결책을 도출하기 위해 의견 수렴차 투표를 진행하오니 다들 한번씩 부탁드립니다 🙏

(스캠이나 이를 악용하는 기업이 아닌)
어느 한 기업에서 SNS 메시지를 통해 여러분의 현 거주지와 소속된 직장(학생의 경우, 재학중인 학교)을 알려달라고 요청합니다.

여러분은 알려주실건가요? 🤔

[거주지의 경우, 구체적인 N동 N호가 아닌 OO아파트
→ 대략적인 주소파악이 가능한 수준]



- 모두 알려준다.
- 모두 알려주지 않는다.
- 부분적으로 [거주지]만 알려준다.
- 부분적으로 [직장]만 알려준다.

2nd Stage: Converting the Distance Between Residence and Workplace into Quantitative Data

Distance Between Residence and Workplace	Quantitative Conversion Data	Carbon Emissions (tCO ₂)
less than 10km	Section 1	Remarks
10km to less than 20km	Section 2	Remarks
20km to less than 30km	Section 3	Remarks
30km to less than 40km	Section 4	Remarks
45km to less than 60km	Section 5	Remarks
60km to less than 75km	Section 6	Remarks
more than 75km	Section 7	Remarks

3rd Stage: Expanding the ETS to Scope 3, Based on Distance-Banded Allocation Using Quantitative Data

Based on distance estimates from Naver Map, the shortest route between Seoul and Seongnam is approximately 27km, while the longest route between Seoul and Pyeongtaek is approximately 75km. Taking this into account, the 27–75 km range is considered as the median line. Distances exceeding this range will reflect commuting patterns within the Seoul metropolitan area, while shorter distances will also account for commuting patterns in regional areas. However, carbon emissions from employee commuting represent a relatively small share of Scope 3 emissions. Therefore, this category should be incorporated into the ETS, while simultaneously providing incentives, in order to encourage voluntary reduction efforts by companies.

3rd-1 Stage: Launching a Minimum Viable Policy and Improving It Incrementally Through Active Communication with Employees and Companies

As with other fields, the climate sector involves an enormous number of variables that must be taken into account. It is therefore unrealistic to expect a perfect policy from the outset. Instead, it is essential to continuously refine the policy through active engagement

and communication with the public.

d. Expected Effects

This proposal can be expected to produce two main effects.

(1) The formation of a virtuous industrial cycle promoting electric vehicle adoption.

From a company's perspective, reducing Scope 3 emissions is challenging because emissions associated with employees' use of public transportation for commuting are difficult to control. In contrast, companies can control employees' use of private vehicles.

Under this proposal, conversion data based on carbon emissions would be applied to Scope 3 emissions. In addition to commuting distance, the government would impose disincentives on engine vehicles and provide incentives for electric vehicles. Companies would then encourage employees who commute by private vehicle to purchase electric vehicles instead of internal combustion engine vehicles through corporate partnership benefits. Then, demand for electric vehicles is expected to increase, while demand for internal combustion engine vehicles declines. In response to this shift, automobile manufacturers such as Hyundai would likely expand electric vehicle production as part of their ESG strategies. This could serve as a starting point for establishing a virtuous industrial cycle that promotes carbon emission reductions.

주행시 1km당 탄소배출량은 석유차 - 154g / 전기차 0g
서울 외곽에 지어진 경기도 | 인구 총 1,400만명
이들 중 30%가 석유차를 하루에 왕복 80km(중간값)씩 365일 운행한다고 가정했을때.(출퇴근 한에서)

계산식

$$14,000,000_{\text{만명}} \times 0.3 \times 80_{\text{km}} \times 365_{\text{일}} \times 154_{\text{g}} \\ = 18,886,560,000,000 \text{ (약 1,800만톤)}$$

(2) If even 30% of existing gasoline/diesel vehicles were converted to electric vehicles, or if commuting patterns shifted toward public transportation, this could enable an annual reduction of approximately 18 million tonnes of greenhouse gas emissions.

Conclusion

If the ETS is expanded to cover Scope 3 emissions in this way, it will create an environment in which companies have no choice but to voluntarily move toward reducing their carbon emissions. Furthermore, as public transportation usage increases, this would bring us closer to achieving genuine carbon neutrality goals. Finally, it is hoped that this project will give readers an opportunity to think a little more about "Scope 3" going forward.

References

Reference data on the number of people moving from non-metropolitan to metropolitan areas over the past approximately 10 years: [file:///C:/Users/msi/Downloads/Population Migration in the Seoul Metropolitan Area Over the Past 20 Years.pdf](file:///C:/Users/msi/Downloads/Population%20Migration%20in%20the%20Seoul%20Metropolitan%20Area%20Over%20the%20Past%2020%20Years.pdf)

Reference data on approximate Seoul subway commuting-hour ridership over the past approximately 10 years: <https://english.seoul.go.kr/public-transport-usage-surged-by-330-million-last-year-with-daytime-travel-up-by-14/>

Reference data on the implementation status of the Emissions Trading Scheme: [file:///C:/Users/msi/Downloads/250122_10th Anniversary of the ETS_1. \(Ministry of Environment\) Achievements of the Greenhouse Gas ETS and Future Policy Directions.pdf](file:///C:/Users/msi/Downloads/250122_10th%20Anniversary%20of%20the%20ETS_1.%20(Ministry%20of%20Environment)%20Achievements%20of%20the%20Greenhouse%20Gas%20ETS%20and%20Future%20Policy%20Directions.pdf)

Reference data from the market research firm Deloitte: <https://m.blog.naver.com/bsmk0325/223277618920>

Reference data on SK Siltron's 2022 value chain greenhouse gas emissions statistics: <https://blog.naver.com/esginfluencer/223237254699>

Proposals from Future Generations for a Net-Zero Future