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A Study on The Comparison of Domestic and Foreign Plastic-Free Certification Systems

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ABSTRACT: Regulations on plastic use are being strengthened worldwide, and consumer concerns about plastic waste are also increasing. A certification system for plastic-free products will show consumers that they trust the use of plastic, protect the environment, and show companies that strive for sustainability. Accordingly, this study compared domestic and overseas plastic-free certification systems to identify similarities and differences, and then looked for alternatives to the insufficient elements of the certification system based on the analysis results. Through this, this study presented improvement directions for efficiently implementing the domestic plastic-free certification system and compared the results.

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KEYWORDS: Plastic-free, Certification system, Less Plastic, Conventional Plastic, Petro-Plastic-free, On-site audit, Test analysis

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1. INTRODUCTION

1.1 Background and objective

Plastics are lighter and cheaper than other materials, and can be produced in various forms. In addition, plastics are durable and resistant to low temperatures, so plastics do not decompose, and are widely used in various fields, and their production volume continues to increase every year. Plastics have become an essential part of human life and can be found wherever humans have been. Recently, due to the COVID-19 pandemic, excessive use and consumption of disposable plastics has led to a sharp increase in plastic waste. Plastics do not easily rot or decompose, causing various environmental pollution such as marine pollution and river/stream pollution.

And plastics have caused climate change due to greenhouse gas emissions. According to GRID-Arendal-Arendal, Climate Impacts of Plastics (2024), about 94% of the total greenhouse gas emissions (about 2 billion tons CO_2 eq) during the production and disposal of plastics occur during the production of plastic raw materials and the production of products. It is estimated that greenhouse gas emissions during the production and disposal of plastics account for about 3.8~4.5% of global greenhouse gas emissions. If plastic production triples in 2060, it is expected to increase by about 6 billion tons CO_2 eq, which is included in 10% of global greenhouse gases. [1]

Plastics have also become a threat to human health. Plastic waste does not decompose and becomes microplastics, which are ingested by animals, or flow into the ocean, where they are eaten by marine animals and accumulate, eventually returning to humans and harming human health.[2]

Table1. Current status of petroleum-based plastic waste disposal (linear economy)[1]

National	Landfill and Speculation	Incineration	Energy Recovery	Recycling
World	79%	12%		9%
Europe (2021)	23%	42%		35%
U.S. (2018)	75%	16%		9%
Canada (2020)	87%	4%		9%
Japan (2020)	6%	8%	65%	21%
Korea (2021)	5%	22%	46%	27%

So, in order to reduce the use of plastic, each country is making efforts to recycle discarded plastic. Plastic recycling varies by country, with Europe at 35%, Korea at 27%, and Japan at 21%, but globally it is only 9%.[3] As an alternative, methods are being used to reduce the use of plastic or use alternative products because plastic recycling is not high. For example, instead of disposable products such as plastic bags, disposable paper cups, and straws, eco-bags, multi-purpose cups, and paper straws are used. Or, "Plastic-free products" that do not contain plastic are purchased.

The demand for Plastic-free products will increase in the future, which will lead to the need for Plastic-free certification. This study was initiated to examine the Plastic-free certification currently in operation and to compare and analyze domestic and foreign certification body to improve domestic Plastic-free certification.

1.2 Scope and Methods

The certification systems to be analyzed in this study were selected as the Plastic-free certification systems of the International Sustainable Certification Institute (IGSC) in Korea, Flustix GmbH (Flustix) overseas, and Plastic Free Certification (PFC), and the research method was as follows.

Through the review of each selected certification system,

First, the definition of plastic, scope of certified products, certification procedures, etc. were compared and analyzed for each certification,

Second, the characteristics of each certification system were compared and analyzed to identify similarities and differences with the certification system,

Third, based on the analysis results, alternatives were found for the insufficient elements of the certification system, and through this, research directions for efficiently implementing the certification system and directions for improvement in the method of applying the certification system were suggested.

2. ANALYZE OF DOMESTIC AND FOREIGN PLASTIC-FREE CERTIFICATION SYSTEMS

2.1 Introducing the Plastic-free Certification System

Here, we will learn about the development background and features of the programs of the certification bodies (IGSC, Flustix, PFC) that are implementing the plastic-free certification system.

2.1.1 IGSC's Plastic-Free

As the number of related companies and products increases due to the spread of environmental and value consumption, the demand for related certification systems has arisen. Existing overseas certifications have high costs and complex certification standards for large companies. IGSC created sustainable certification due to the need for certification that can be used domestically, and it is characterized by low costs and certification that is tailored to domestic conditions.

IGSC's Plastic-free certification is characterized by providing 100% raw material information and allowing biodegradation/composting certification. And tests related to plastic component analysis are analyzed using FTIR, Raman or scanning electron microscopy, and pyrolysis GC/MS.

Table2. IGSC Plastic-free Certification Overview

Item	Contents
Operating Authority	Institute of Global Sustainability Certification (IGSC)
Year of implementation	2021
Related standards	ISO 17065
Scope	Products, packaging, semi-finished products
Certification type	Plastic free for Product
Validity period	1 year
Test Analysis	Qualitative analysis
Features	Korea's first Plastic-free certification
Certification Marks	

2.1.2 Flustix's Plastic-Free

Flustix believes that reducing the amount of plastic waste not only contributes to the protection of the environment, water, biodiversity and oceans, but also significantly reduces greenhouse gas emissions associated with production. Therefore, it considers reducing the use of plastic in the consumer sector important, and certifies products, packaging and entire products with low or ideally no plastic content. The certification standard clearly describes the criteria for plastic, and has the characteristic of allowing the use of a certification mark according to the content of plastic included. In addition, the certification procedure does not conduct an on-site audit, and samples are sent directly to the testing lab by the customer. In addition, there are two types of tests related to the analysis of plastic components, and the analysis is performed using a combination of FTIR and other analytical equipment (TGA, DSC, Mass Spectrometry, Raman) or thermal desorption gas chromatography/mass spectrometry (TED-GC/MS).

Table 3. Flustix Plastic-free Certification Overview

Item	Contents
Operating Authority	Flustix GmbH
Year of implementation	2020
Related standards	-
Scope	Products, packaging, semi-finished products
Certification type	Less Plastic – Total Product, Packaging, Product
Validity period	5years
Test Analysis	Quantitative analysis
Features	Packaging is allowed to contain up to 5% plastic Product is allowed to contain up to 2% plastic
Certification Marks	

2.1.3 PFC's Plastic-free

In July 2018, during a training session on compostable materials for environmental associations, Giuseppe Sarua Cinquegrana, an expert on the subject,

shared the idea of creating a system that would accompany and reinforce the plastic-free path. This insight led to the creation of a team of 12 people with a strong interest in environmental protection, activists and experts from various strategic fields, which led to the creation of PFC's Plastic-Free certification.

Currently, PFC provides certification under three Plastic-Free certification systems (management systems, products and events) and supports restaurants, hotels, food companies and certification bodies on five continents.

The Plastic-Free product certification system is divided into Plastic-Free and Conventional Plastic-Free, with Conventional Plastic-Free allowing bio-based materials. PFC's Plastic-Free certification procedure is characterized by on-site audits after a document review, but no testing or analysis.

Table4. PFC Plastic-free Certification Overview

Item	Contents
Operating Authority	Plastic Free Certification(PFC)
Year of implementation	2022
Related standards	-
Scope	Products, packaging, semi-finished products
Certification type	Plastic free Product, Conventional Plastic-free
Validity period	1year
Test Analysis	-
Features	Plastic-free certification system (Management system, Products, Events)
Certification Marks	

2.2 Analysis of Plastic-free Certification Systems

Here, we provide a comparative analysis of the certification systems of three certification bodies: IGSC, Flustix, and PFC. Each body sets its own plastic-free standards based on international regulations and standards such as ISO, EC, and EU regulations, and establishes certification processes and selects testing and auditing methods based on each body's plastic definition and plastic-free standards.

We examine the plastic definition, certification type and standard scope, certification criteria, certification process, and on-site audit and testing methods in each body's certification system.

2.2.1 Plastic definition

The definitions of plastics by each certification body are shown in Table 5. IGSC and Flustix do not include a definition of bio-based composition materials, but PFC includes a definition of bio-based composition materials.

2.2.2 Certification Types and Standard Scope

The certification types and standard scopes of each certification body are as shown in Table 6.

The certification types of each body are divided into 1 for IGSC, 3 for Flustix, and 2 for PFC. In particular, Flustix is divided into finished products including products and packaging. The standard scopes of each body are the same, and Flustix includes low-plastic consumer goods. In addition, the standard scope of PFC includes detailed descriptions such as not including food and beverage products, showing differences from IGSC and Flustix.

Table 5. Definition of plastic by certification body

Certification Body	Plastic definition
IGSC	"A group of all synthetic or natural organic materials, including resins, resinoids, polymers, cellulose derivatives, casein materials and proteins". It includes descriptions of biodegradability and oxidative degradability, but does not include descriptions or definitions of bio-based plastics.
Flustix	Plastics are substances composed of polymers [as defined in Article 3(5) of Regulation (EC) No. 1907/2006 of the European Parliament and of the Council], to which additives or other substances may be added, and which may act as the main structural component of the final product. [5] However, natural polymers that have not been chemically modified are excluded. And elastomers, thermoplastics and thermosetting plastics are also included. It does not include descriptions or definitions of biodegradable plastics and oxidative degradable plastics.
PFC	Conventional Plastic is defined in place of the definition of Plastic. Conventional Plastic defines fossil fuel-based materials, including commercial plastics polyethylene (PE), polypropylene (PP), polyurethane, polyethylene terephthalate (PET), polystyrene (PS), and PVC, while Conventional Plastic-free refers to materials in which at least 80% of the mass of each individual component is composed of bio-based materials.

Table 6. Certification type and standard scope by certification body

Certification Body	Certification Type	Standard scope
IGSC	Plastic-Free for product	Products, Packaging Semi-finished products
Flustix	LESS PLASTICS-Total Product LESS PLASTICS-Product LESS PLASTICS-Packaging	Products, Packaging, Semi-finished products Low-plastic consumer goods
PFC	Plastic Free Conventional Plastic Free	Products, Packaging, Semi-finished products

2.2.3 Certification criteria

The certification criteria of each certification bodies are as shown in Table 7. IGSC's certification criteria are defined more simply than Flustix and PFC, and if a small amount of plastic is included, it deviates from the certification criteria, making it difficult to utilize in a wide range.

Table7. Certification criteria by certification body

Certification Body	Certification Type	Certification criteria
IGSC	Plastic-Free for product	Defined as a product without plastic-related components.
Flustix	LESS PLASTICS - Total Product	Packaging and products are those that contain the relevant maximum limits for small quantities of plastic as defined in the " LESS PLASTICS – Packaging " standard and in the " LESS PLASTICS – Product " standard.
	LESS PLASTICS - Product	Refers to cases where microplastics are contained up to 2%.
	LESS PLASTICS - Packaging	Packaging refers to cases where the packaging contains microplastics up to 5% of the total weight of the consumer product, semi-finished product or packaging.
PFC	Plastic Free	Anything other than plastic, such as glass, wood, metal, or fiber.
	Conventional Plastic Free	Materials that are composed of at least 80% bio-based mass of each individual component. (For disposable items, the required bio-based ratio is 90%.)

2.2.4 Certification Process

Each certification body's certification program has its own certification process, and the Plastic Free certification process of IGSC, Flustix, and PFC is as shown in Table 8 from application to certificate issuance.

Table 8. Certification process of each certification body

Item	IGSC	Flustix	PFC
Application Submit	O	O	O
Contracts	O		O
Send Invoice	O	O	O
Pre-reviews	O		O
On-site Audit	O		O
Corrective action for Nonconformity	O	O	O
Test analysis	O	O	
Certificate issuance	O	O	O

IGSC is a certification body that has received ISO17065 recognition from an American accreditation body and has a standardized certification process as shown in the table above. Flustix does not conduct on-site audits compared to IGSC, and the test analysis samples are directly sent to the testing lab by the requester. PFC has the same certification process as IGSC, but shows a difference in that it does not conduct test analysis.

2.2.4.1 Required Documents

Once the application is submitted, the certification body will request the customer to submit the documents required for certification. Table 9 shows the required documents for each certification body.

IGSC and PFC allow the use of bio-based plastics, so biodegradation certificates/composting certificates must be submitted when necessary. And Flustix will accept the test results if the customer submits them. Since PFC does not conduct testing and analysis, PFC has more requirements for documents than other certification bodies. MSDS (Material Safety Data Sheets), Product Technical Specification sheet, and Product recycling statement are included in the required documents only for PFC.

Table 9. Required documents for each certification body

Item	IGSC	Flustix	PFC
Application	O	O	O
DOC	O		O
Business Registration Certificate	O	O	O
Composition table	O	O	O
Biodegradation/ Composting Certificate	O		O
Management System Document	O		O
MSDS (Material Safety Data Sheets)			O
Product Technical Specification sheet			O
Product recycling statement			O

2.2.4.2 On-site audit

On-site audits are a very important part of the certification process. It is important because the auditor can directly observe the facility, management, and products of the factory and test for cross-contamination. Here, IGSC and PFC conduct on-site audits, but Flustix does not conduct on-site audits. IGSC has two qualified auditors visit the manufacturing plant and thoroughly review quality control, material management, process manufacturing facility management, test reports, and certification-related documents, and check for cross-contamination that may occur during the process. If a non-conformance occurs during the on-site audit, a non-conformance report is issued and the customer must submit a non-conformance corrective action report. In addition, samples to be tested are sampled during the on-site audit and sent to a testing lab. On the other hand, Flustix does not conduct on-site audits, but conducts experimental tests and relies on test results and document reviews, which is different from the other two certification bodies. PFC has a similar certification process to IGSC from application to certificate issuance, and conducts on-site audits.

2.2.4.3 Test Analysis and Test Equipment

IGSC and Flustix will request test samples to an ISO 17025 accredited testing and analysis organization.

IGSC determines the presence or absence of plastic through qualitative analysis using FTIR, Raman, scanning electron microscopy, and pyrolysis GC/MS equipment for plastic detection.

Flustix can confirm the presence or absence of plastic and the content in two ways for plastic detection.

The first method can analyze plastic in two steps by combining at least one of FT-IR and TGA, DSC, Mass Spectrometry, and Raman Spectroscopy analysis equipment.

The second method is thermal desorption gas chromatography/mass spectrometry, which can separate and identify volatile organic compounds from plastic samples after thermal desorption using gas chromatography and mass spectrometry.

IGSC determines plastic detection through qualitative analysis, but in order to expand the scope of certification, Flustix's quantitative analysis method should be included.

Table 10. Description of the analysis equipment

Equipment name	Description
Infrared Spectroscopy (FTIR)	Analyze infrared absorption to identify specific functional groups within solid materials.
Thermogravimetric Analysis (TGA)	Quantify the content of organic and inorganic components by measuring weight loss while increasing temperature.
Differential Scanning Calorimetry	Use dynamic heat flow differential calorimetry after pre-separation of internal coatings (using

(DSC)	CUEN separation solution).
Mass Spectrometer (MS)	Identify and quantify molecules within solid materials based on mass and charge.
Raman Spectroscopy (Raman)	Investigate Raman scattering of Raza light to identify molecular structure and chemical composition.

2.3 Comparison of plastic-free certification systems

Each Plastic Free certification body had differences in the type of certification, standard scope, certification criteria, and certification process as described above. Table 11 compares the certification systems of each certification body according to certification type, certification criteria, test analysis, and on-site audit.

Table 11. Comparison of certification systems of each certification body

Item		**IGSC**	**Flustix**	**PFC**
Plastic-free (Cert. Type)	**Product**	O	O	O
	Packaging	O	O	O
	Total Product	X	O	X
Test Analysis		O	O	X
Criteria		Y/N (Qualitative)	Max 5 % (Quantitative)	Y/N (Qualitative)
Conventional Plastic-free (Cert. Type)	**Product**	X	X	O
	Packaging	X	X	O
	Material	X	X	O
Test Analysis		X	X	X
Criteria		X	X	80 % (Quantitative)
Certificate Validity		1 year	5 years	1 year
On-site Audit		O	X	O

3. CERTIFICATION SYSTEM REVISION AND EVALUATION

3.1 Limitations of the certification system and ways to improve it

Through a comparison of the certification systems of each certification body, we were able to identify the current status and limitations of the domestic IGSC certification system. First, the biggest feature of IGSC's Plastic Free certification is that, although it is a private certification system, it is operated by a certification body that has gone through the accreditation process according to the ISO 17065 standard and satisfies the requirements for conformity assessment - product, process, and service certification bodies. However, there are the following limitations, and we have sought improvement measures accordingly.

First, the IGSC certification system does not have specific definitions of terms. The terms biodegradation and oxidative biodegradation are defined in the certification standard, but the definition of bio-based plastic (biodegradable plastic, oxidative biodegradable plastic, bio-based plastic) is not expressed. In order to add certification types and scopes, definitions of terms should be added.

Second, it is necessary to add certification types and establish certification criteria. The certification system aims to reduce plastic. It is necessary to gradually add certification types to satisfy the certification criteria for products and packaging that reduce plastic and confirm the certification criteria.

Lastly, it is necessary to expand the testing and analysis methods. The domestic IGSC's test analysis was limited to qualitative analysis. It is necessary to introduce test analysis methods from other certification companies to enable qualitative and quantitative analysis.

Table12. Revision of the existing certification system and the revised certification system

Item	Original	Revision
Terms and definitions	Biodegradable [Oxo-, Oxy- or Oxobio-] degradable	Biodegradable [Oxo-, Oxy- or Oxobio-] degradable -Bio-based plastics -Biodegradable plastics -Oxidative biodegradable plastics -Bio-based plastics -Petro-Plastic
Certification Type	Plastic free for Product	Plastic-free Product Plastic-free Packaging Petro-Plastic-free Product Petro-Plastic-free Packaging
Test Items	Qualitative analysis	Qualitative analysis Quantitative analysis
Analysis equipment	FTIR Raman scanning electron microscopy pyrolysis GC/MS	FTIR DSC Mass Spectrometry Raman Spectroscopy TED-GC/MS

3.2 Certification system revision

The revision was carried out based on improvement measures through domestic and overseas certification systems, and the results are as shown in Table 12.

3.2.1 Definition of terms

Table13. Definition of terms

Item	Definition
Bio-based plastics	Refers to biodegradable plastics, oxidative biodegradable plastics, and bio-based plastics. [7]
Biodegradable plastics	Refers to plastics containing more than 70% of so-called biomass derived from plants such as corn.
Oxido-biodegradable plastics	Refers to polymers that undergo primary oxidative decomposition under heat, sunlight, etc., and then undergo biodegradation.
Bio-based plastics	Refers to plastics containing a certain amount or more of biomass.
Petro-Plastic	Refers to fossil fuel-based materials including commercial plastics such as polyethylene (PE), polypropylene (PP), polyurethane, polyethylene terephthalate (PET), polystyrene (PS), and PVC.

3.2.2 Addition of plastic-free certification types and certification criteria

The following four types of plastic-free certification were added and certification criteria were established.

3.2.3 Addition of test analysis method

The test analysis for plastic detection added the following two methods.

The first method can analyze plastics in two steps, combined with at least one of FT-IR and TGA, DSC, Mass Spectrometry, and Raman Spectroscopy analysis equipment.

The second method is thermal desorption gas chromatography/mass spectrometry, which can separate and identify volatile organic compounds from plastic samples by thermal desorption and then using gas chromatography and mass spectrometry.

Table14. Plastic Free Certification Type

Certification Type	Certification criteria
Plastic-free Product	Refers to products made of all materials other than plastic, such as glass, wood, metal, and fibers.
Plastic-free Packaging	Refers to packaging materials made of all materials other than plastic, such as glass, wood, metal, and fibers.
Petro-Plastic-free Product	Refers to products not made of petroleum-based plastic materials (however, plastic components may be permitted up to 3%, see DIN EN 643_2014).
Petro-Plastic-free Packaging	Refers to packaging materials not made of petroleum-based plastic materials (however, plastic components may be permitted up to 3%, see DIN EN 643_2014).

3.3 Application and Evaluation of Revised Certification System

In order to compare the revised certification system with the existing certification system, IGSC's Plastic Free certification was conducted on "recycled paper cups." When the certification process was completed, the document submission and on-site evaluation results were satisfactory, and this evaluation began with sample analysis. The samples were commissioned to an authorized testing lab, and the results are as follows.

3.3.1 Test results and certification results of the existing certification system

The FT-IR results of the product confirmed the presence of plastic, but it was difficult to confirm the exact type of plastic. The TGA analysis results showed that the polymer decomposed from 450°C, and the decomposed content was approximately 1%, confirming that the plastic content was less than 1%.

The certification criteria of the existing certification system were that the product did not contain any plastic-related components, and the plastic material was detected, satisfying the certification conditions. Therefore, this product did not obtain Plastic Free certification.

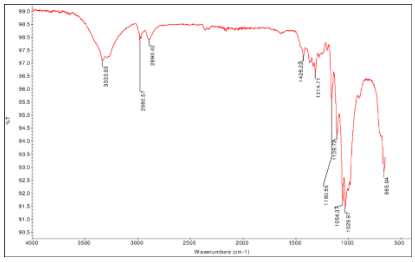

Figure 1. FT-IR results

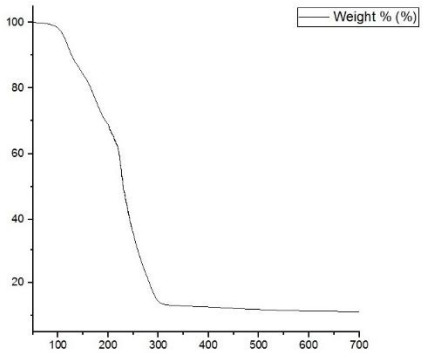

Figure 2. TGA results

3.3.2 Test results and certification results of the revised certification system

The FT-IR results of the product confirmed the presence of plastic, but it was difficult to confirm the exact type of plastic. The TGA analysis results showed that the polymer decomposed from 450°C, and the decomposed content was approximately 1%, confirming that the plastic content was less than 1%. The product was filtered by removing the paper component through preprocessing, and the plastic component and size of the component remaining in the filter were confirmed through μFT-IR.

Table 15. Microplastic analysis results

Item	20 ㎛-50 ㎛	50 ㎛-100 ㎛	100 ㎛-500 ㎛	500 ㎛-	Total (Item)
Polypropylene (PP)	-	7	8	1	**16**
Polyethylene (PE)	-	6	9	1	**16**
Polystyrene (PS)	5	-	-	-	**5**
Total (size)	**5**	**13**	**17**	**2**	**37**

The solids content of a product is determined as follows:

$$G = \frac{(F - LF) \times 100}{\mathrm{P}}$$

Here

G: Solids content of the product (%)

F: Weight of the filter containing solids in the product

LF: Empty weight of the filter

P: Initial weight of the product

The analysis results showed that the solid content was 0.1% when calculated as the plastic content. The Petro-Plastic-free Product certification standard allows a maximum of 3% plastic content. Therefore, this product obtained the Petro-Plastic-free Product certification.

3.3.3 Comparison of certification results between existing and revised certification systems

As a result of the test analysis, the plastic content of the existing certification system was roughly confirmed to be about 1%, but the content difference was confirmed to be 0.9% with the test method of the revised certification system, which was 0.1%. In addition, “Recycled paper cups” did not meet the certification criteria under the existing certification system, but they were able to obtain certification under the revised certification system by meeting the certification criteria.

4. RESULT

As a result of re-evaluating the existing certification system with the revised certification system, there was a difference in that the existing certification system could not obtain certification, but the revised certification system obtained Petro-Plastic Free Product certification. The trace amount of plastic detected in the test analysis did not satisfy the certification conditions in the existing certification system, but in the revised certification system, the presence and content of plastic could be calculated using testing equipment. The plastic content satisfied the standard of 3% or less, so it was possible to obtain certification.

In summary, through a comparison of domestic and international certification systems, the necessity of defining terms, adding certification types, establishing certification criteria, and expanding testing and analysis methods was confirmed for the IGSC certification system. Based on this, the

revised certification system was evaluated and certification was obtained, enabling evaluation of various products.

5. CONCLUSION

In this study, first, the Plastic Free certification systems of IGSC, Flustix, and PFC were analyzed and compared through a literature review. Through comparisons between each certification body, the limitations and improvement measures of IGSC's Plastic Free certification were examined, and the certification system was finally revised and applied to products that had not previously received certification, and the evaluation results were compared. The conclusions are as follows;

First, the IGSC certification system was revised by comparing it with overseas certification systems.

Second, the certification of products that had limitations in the existing certification system was made possible through the revised certification system, thereby expanding the scope of certification.

In the future, similar certification systems will be discovered, compared, and analyzed, and improvements will be continuously made to make them efficient and usable.

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