This comprehensive review report is a document provided for expert consultation on diverse and valuable technologies and ideas from the public for Carbon Neutrality

Overall Review Report on a Public Technology Proposal for Achieving Carbon Neutrality

Proposal name: Commercialization of zero-discharge, odorless composting and odor and greenhouse gas control technology using Cylindrical Airtight Fermenters

Proposed by : G&L Co., Ltd. Sung-hee Kim

2023. 04. 03.

Presidential Commission on
2050 Carbon Neutrality and Green Growth

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Contents of Public Technology Proposal

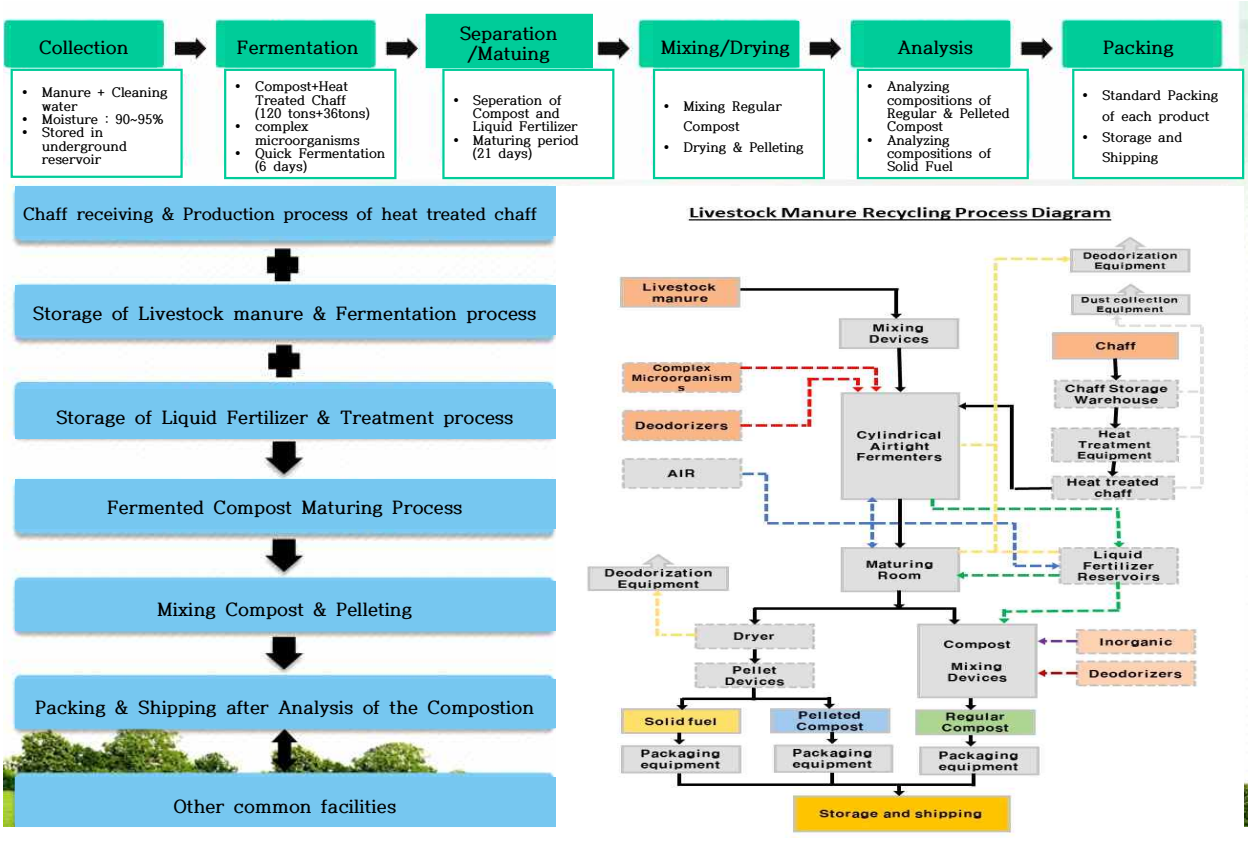
Public Technology Proposal

1. Proposal name: Odor and greenhouse gas control technology for zero-discharge, odorless composting using Cylindrical Airtight Fermenters

2. Proposer: G&L Co., Ltd. Sung-hee Kim

3. Contents of Proposal

- The technology utilizes cylindrical airtight fermenters to prevent the external release of odor and greenhouse gases generated during the composting process, contributing to odor and greenhouse gas control in composting processes. The technology features optimized thermophilic aerobic fermentation conditions, allowing for short-term fermentation within a period of 7 days for the first stage and 21 days for the second stage. Odors and greenhouse gases can be captured and processed in deodorization facilities. With the technology of zero-discharge livestock manure resource utilization, it is possible to convert livestock manure and cleaning water into resources without the pretreatment of solid-liquid separation. It is a zero-discharge system where there is no external discharge of leachate during the process. It produces high-quality organic fertilizers and converts them into solid fuel by pelletizing the organic fertilizers.



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Comprehensive advisory opinion from professional institutions

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1. Greenhouse gas emissions status

- The environmental issues, including the odor problem caused by the livestock industry, are constraining the growth of the industry and causing social conflicts. In addition, with the emergence of global warming as an international issue and the concrete formulation of domestic greenhouse gas reduction targets for the livestock sector towards achieving net-zero emissions by 2050, the livestock industry is also facing challenges in addressing greenhouse gas emissions issues.
- Greenhouse gas emissions in the livestock sector primarily originate from enteric fermentation in livestock and the livestock manure management process. Additionally, the release of ammonia (NH3), a major contributor to odor, has been increasing along with the rise in livestock population.
- The greenhouse gas emissions from enteric fermentation in livestock have increased from 3.38 million tons in 2000 to 4.74 million tons in 2020. Similarly, the greenhouse gas emissions from livestock manure management have increased from 3.87 million tons in the same period to 4.99 million tons.
- As of 2018, the ammonia (NH3) emissions from the livestock industry were estimated to be around 230,000 tons.
- For sustainable development of the livestock industry, it is necessary not only to enhance its competitiveness but also to achieve an environmentally-friendly transformation, including the mitigation of odor issues and reduction of greenhouse gas emissions. This transformation aims to harmonize the livestock industry with the environment while ensuring its continued growth and development.
- Livestock manure treatment facilities are often perceived as representative nuisance in local communities, and they face challenges related to complaints and issues arising from odor emissions.
- If this technology is applied to the renovation and construction of aging livestock manure treatment facilities, it can be expected to not only reduce complaints related to odor emissions but also achieve a reduction in greenhouse gas emissions

2. Policy aspects

- In the "2050 Agri-Food Carbon Neutrality Implementation Plan" (2021) by the Ministry of Agriculture, Food and Rural Affairs, the detailed strategies related to livestock manure treatment emphasize expanding the proportion of purification treatment for livestock manure and increasing non-agricultural utilization such as bioenergy production as key measures to reduce greenhouse gas emissions.
- It is projected that greenhouse gas emissions from livestock manure treatment processes will be reduced by 35.0% by 2050, and the proportion of agricultural utilization (purification treatment and energy conversion) will expand from 33% in 2030 to 34% in 2040 and further increase to 35% by 2050.
- As the expansion of non-agricultural utilization, such as purification treatment and energy conversion, takes place in livestock manure management, it is crucial to achieve greenhouse gas emission reduction in the livestock sector by reducing greenhouse gas emissions in the process of livestock manure liquid-solid separation processes(resource utilization), which currently account for a significant portion. and it is necessary to introduce and utilize new technologies to improve livestock manure treatment.

- This technology not only contributes to greenhouse gas reduction but also addresses the long-standing issue of odor problems. Therefore, it is necessary to integrate and implement it in conjunction with the "Livestock Environmental Improvement Measures" for comprehensive improvement of the livestock sector's environmental impact.
- Furthermore, there is a need to expand the establishment of outsourced treatment facilities on a regional basis and increase the promotion of pilot R&D for next-generation livestock manure treatment.

3. Technology Trend Analysis

- Vertical composting devices are useful for small-scale and low-volume treatment purposes or for research purposes to assess changes in characteristics during the composting process.
- Livestock manure composting facilities require appropriate equipment that suits the specific livestock species, available space, treatment capacity, and surrounding environment. No vertical composting devices can meet all of these conditions.
- In the livestock manure treatment sector, the greenhouse gases emitted are primarily methane (CH4) and nitrous oxide (N2O). The "2021 National Greenhouse Gas Inventory Report" applies Tier 1 methodology to estimate greenhouse gas emissions from livestock manure management.

- When applying Tier 1 methodology, methane (CH4) emissions are calculated by multiplying the livestock population by emission factors specific to each livestock category. Therefore, changes in methane (CH4) emissions based on different livestock manure treatment facilities or methods are not considered under Tier 1 methodology.
- For nitrous oxide (N2O), emissions are estimated by calculating the nitrogen emissions based on the livestock manure emissions and nitrogen content within the manure, taking into account the livestock population for each species.Then, specific emission factors for nitrous oxide based on the livestock manure treatment facilities are applied to estimate the N2O emissions. Livestock manure treatment facilities can be categorized into liquid manure management facilities, solid manure management facilities, and other types of facilities.
- For the current greenhouse gas inventory reporting, the emission factors for nitrous oxide (N2O) for livestock manure treatment facilities are categorized into three types only: liquid manure management facilities (0.001 kg N2O-N/kg N), solid manure management facilities (0.02 kg N2O-N/kg N), and other types of facilities (0.005 kg N2O-N/kg N). There are various methods for solid manure management, but the current greenhouse gas inventory calculation does not differentiate between composting methods. Solid manure management is assigned a higher emission factor compared to liquid manure management or other types of facilities.
- However, the technology is considered to be a technology that can be applied to the emission factor of 0.005 for aerobic treatment (forced aeration systems) according to the 2006 IPCC guidelines and the 2019 IPCC guidelines, as it is a composting method using forced aeration with microorganisms.
- There is a need to further differentiate and apply the livestock manure treatment methods outlined in the 2006 IPCC Guidelines or 2019 IPCC Guidelines when estimating greenhouse gas emissions from the livestock manure treatment processes.
- In addition, for this technology to be utilized in estimating greenhouse gas emissions, a transition from the current Tier 1 methodology to Tier 2 or Tier 3 is required, which requires a national greenhouse gas emission factor registry.

- Registration of nationally specific greenhouse gas emission factors for the specific facility types involved in livestock manure treatment processes is necessary.
- Currently, national approved greenhouse gas emission and absorption factors related to livestock manure treatment exist, specifically for the "average annual nitrogen emissions from pig manure," which was registered in 2022. However, national-specific greenhouse gas emission factors for individual livestock manure treatment facilities have not been registered.
- Currently, methane (CH4) emissions are estimated based on livestock population for each species (Tier 1). However, to apply methane (CH4) emissions by livestock manure treatment facilities, a transition from Tier 1 to Tier 2 or Tier 3 is required.
- To register national-specific greenhouse gas emission factors for this technology, additional empirical analysis and the implementation of the technology in facilities are necessary.

4. Economic Feasibility Study

- An economic analysis considering the initial installation costs is necessary. Additional supplementary data is required to conduct an economic evaluation for this technology. (the cost-benefit analysis, etc.)
- In particular, it is necessary to provide information on the extent to which the use of stainless steel materials affects the initial facility costs compared to the conventional materials. Additionally, it is important to present the costs related to the procurement and installation of stainless steel materials, depreciation considering content research, labor, microorganisms, and other operational expenses.
- It is also important to consider the cost increases. There may be costs associated with the use of stainless steel materials, such as material prices, construction expenses for containment and aeration, environmental facilities (odor control equipment), as well as costs related to the production process of heat treated chaff and the purchase of chaff.
- It is also necessary to consider cost reduction factors. There may be cost reduction factors such as increased service life of internal equipment (e.g., stainless steel (SUS304) 40-80 years compared to carbon steel structures 3-5 years, approximately 10 times longer), shortened production period through short-term fermentation (1 month compared to the previous period, approximately 50% reduction), and savings in purchasing sawdust.
- For further clarification, it is necessary to provide detailed calculations and evidence for the production cost. The production cost per unit (20kg) is as follows: Currently : Ranges from 3,600 to 4,550 won, New method : 2,340 won. It is expected that the equipment cost will be higher compared to the existing facility, but the production cost is lower (taking into account facility depreciation expenses).
- Livestock manure treatment facilities are prone to corrosion of equipment and machinery due to ammonia exposure. Additional evidence or case studies are needed to support the claim of the durability and lifespan of stainless steel materials in livestock manure treatment facilities.
- For example, 36 tons of heat treated chaff are required for every 120 tons of manure. Therefore, it is necessary to review whether chaff can be supplied stably throughout the year for the production and injection of heat treated chaff.

5. Environmental technology status

- It is necessary to review the economics and usability aspects in comparison to the integrated biogasification of livestock manure that is currently underway.
- In the case of composting, there is an ongoing imbalance between decreasing demand for compost and excessive supply. To prevent water and soil pollution caused by excessive application of compost, pollution source management and environmental standards are being strengthened, leading to a situation where reduction becomes inevitable.
- Feed production is also facing a contraction in demand due to concerns over livestock diseases such as African swine fever in 2019, leading to restrictions on the use of food waste as animal feed. Additionally, there is a growing demand from animal right groups calling for restrictions on the use of food waste as animal feed, driven by changing societal awareness regarding animal well-being. This also contributes to the inevitable need for reduction in feed production.
- The Biogas Production and Utilization Promotion Act, which was enacted in December 2022, requires the conversion of technology to biogasification plants that can integrate organic waste such as food waste, manure, and sewage sludge, and the improvement of operational efficiency. This is to ensure the stable treatment of organic waste, which has been treated by composting and feeding, and to build a circular system for energy reproduction.
- The use of animal manure to produce organic fertilizer and to pelletize it into solid fuel can increase the diversity of its use, but the CAPEX will increase when the facility is built, which may lead to lower profitability. Therefore, it is necessary to establish a countermeasure plan.
- The technology of livestock manure resource recovery through composting has evolved from small-scale operations without specialized equipment, which were commonly used in individual farms, to automated large-scale facilities.
- Recently developed composting facilities have improved odor control and fermentation efficiency, allowing for the processing of larger quantities of livestock manure within the same scale of operation.
- In particular, with the decrease in agricultural land and the continuous increase in odor-related complaints, there is a growing need for technologies that enable high-quality compost production and odor control.

6. Environmental improvement effects

- The utilization of Cylindrical Airtight Fermenters allows for direct capture of high-concentration odors, minimizing their external release. Additionally, the technology enables the simultaneous processing of livestock manure into compost and pellets, reducing the emission of pollutants when the compost is not utilized. These factors contribute to environmental improvement and the potential for carbon neutrality compared to conventional methods.
- After a comprehensive review of the odor control technology and concentration presented in this technology, it is concluded that it offers better odor control and environmental improvement compared to existing open recycling facilities.

- The quality of the compost meets the compost standards of the Fertilizer Management Act. In addition, during the livestock manure treatment process, the moisture is evaporated into the air by the absorption of chaff and the heat generated during fermentation, thus aiding in the prevention of water pollution.
- The vertical composting system is recognized for its greenhouse gas reduction and odor mitigation effects during operation compared to horizontal conventional composting systems. However, it may not have a significant impact during the input or output phases.
- Out of the three ammonia measurements conducted, one of them complied with the environmental standards. However, periodic measurements are necessary to obtain consistent results. Based on the measurement results alone, two out of the three measurements did not meet the standards.
- Although facility maintenance is challenging, the reduction in greenhouse gas emissions compared to conventional horizontal composting systems is recognized.

7. Domestic and international patent status

- Since the 1980s, as the livestock industry has scaled up, become specialized, and centralized, a large volume of livestock manure has been generated, leading to increased interest in livestock manure management. With strengthened enforcement and regulations regarding livestock manure emissions, effective management of livestock manure has been recognized as a prerequisite for the development of the livestock industry.
- Furthermore, since 2012, the dumping of livestock manure into the ocean has been completely prohibited. Instead, livestock manure is now being managed through methods such as incineration, landfilling, and utilization as fertilizer. Among these methods, utilizing livestock manure as fertilizer is preferred as the most environmentally friendly approach. In South Korea, more than 90% of livestock manure is being converted into compost or liquid fertilizer and returned to agricultural fields for recycling.
- Therefore, the technology for converting livestock manure into fertilizer plays a crucial role in formulating policies for livestock manure resource utilization and environmental conservation. Continuous technological development is actively taking place in this field.
- An analysis of the patent application status related to livestock manure resource utilization technology reveals a continuous increase in the number of patent applications, indicating advancements in the related technologies.
- The livestock manure treatment technology was dominated by purification treatment technology from the 1970s to the early 1990s. After that, patents were applied with an emphasis on composting and liquid fertilizer technology.
- Recently, there has been a significant focus on composting technologies related to carbon neutrality and reducing carbon emissions. Continuous and active technological development in this direction is ongoing, and this trend is also evident in the patent applications.

8. Intellectual property protection strategies

- The composting technology for livestock manure is not a field with a low number of patent applications. However, it has been confirmed that the proposing company of this technology has already filed numerous patent applications and secured rights.
- Upon examining the patents of the proposing company for this technology, it has been found that they have consistently filed patent applications for related technologies from 2004 to 2015. It has also been confirmed that they have obtained seven registered patents and secured rights in the field.
- However, upon examining the patents filed by the proposing company for this technology, it has been found that no patent applications have been filed for related technologies after the 2015 application (KR10-2016-0113951 Improved Fermentation Residue Discharge Device for Livestock Manure Resourceization). It appears that no patents have been filed internationally as well.
- Therefore, if the proposing company intends to commercialize the related technology, it is advisable to build a patent portfolio by consistently filing patent applications for the relevant technology. This will help secure the scope of rights and protection.
- The analysis of overseas patent trends for the related technology reveals active patent filings in Japan, the United States, and Europe. Therefore, if the proposing company plans to enter other foreign markets, it is deemed necessary to secure rights through overseas patent filings.

9. Patent utilization potential

- The patent applied by the company proposing this technology that is considered to be relevant to this proposed technology is Korean Registration Patent No. 10-1183744 (Method and Apparatus for Manufacturing Compost and Liquid Fertilizer without Discharge of Livestock Wastewater from Livestock Manure Waste Including Livestock Bedding Straw in a Cylindrical or Polygonal Closed Fermentation Tank with Moisture Regulator). The company has paid the 11th year registration fee (2022.7.22) and has secured its rights in a registered maintenance status.
- In addition to the aforementioned registered patent, the proposing company holds six other registered patents related to the relevant technology (KR10-0699176B1, KR10-0818496B1, KR10-0852873B1, KR10-0841551B1, KR10-0960166B1, KR10-0989013B1). All six patents have had their registration fees paid and are currently maintained, securing rights.
- Having seven registered patents related to the proposed technology, the proposing company is expected to benefit from holding multiple patents in technology transfer and licensing agreements.

- However, the patent KR10-0699176B1 (heat treatment device of chaff) expires on October 2024, and the patent KR10-0818496B1 (heat treatment device of chaff) expires on August 2026. There are patents that have a short remaining validity period.
- Therefore, it is recommended that the proposing company continues to pursue business development by consistently filing patent applications for related technologies. Building a strong patent portfolio will help secure rights and facilitate business expansion.

10. Business commercialization strategies

- It is deemed feasible to apply the proposed technology to private livestock manure resource utilization (composting, pelletization) businesses, excluding public livestock manure treatment facilities.
- However, it is considered efficient to develop a business implementation strategy by incorporating the latest technological trends, such as the proposed Environmental Technology Certification (2009), Green Technology Certification (2010), and relevant patents (2007, 2008, 2010, 2012), to further upgrade the technology and reflect current advancements.
- The technology has been recognized for its objective performance by obtaining certifications from the Ministry of Environment for Environmental Technology and the Ministry of Agriculture, Food and Rural Affairs for Green Technology.
- Unlike similar composting facilities that use sawdust, this technology utilizes chaff with heat treatment. It allows for a stable supply of chaff and is advantageous for areas with a high generation of swine manure, resulting in a higher operational efficiency.
- Exploring and utilizing the R&D support programs related to this technology provided by the Ministry of Environment, Small and Medium Business Administration, and other relevant organizations would be beneficial.
- Participating in the livestock manure resource utilization projects selected annually by the Ministry of Agriculture, Food and Rural Affairs can provide opportunities to receive financial support from the national and local governments.
- The demand for this technology is anticipated in Southeast Asian regions with a high cultivation of rice and a significant number of pig farming. Support for overseas projects in these regions can be sought through programs such as ODA and EDCF.
- It is necessary to show whether the technology was previously supported by a patent application in 2005 and recognized as a new technology in 2006, and what the new technology is today, more than 10 years later.
- The initial installation cost is relatively high, and regular maintenance by experts is required for management and operation. Information regarding the advantages and disadvantages of the device is limited.
- To promote the adoption of vertical composting devices, it is necessary to consider the initial installation cost and the availability of specialized personnel for equipment operation and management.

11. Overall opinion

- The proposing company of this technology is considered to have secured rights through multiple patent applications related to the technology. Therefore, it is expected that the patents held by the proposing company will be beneficial for commercialization.
- However, the field of composting technology for livestock manure is not one with a low number of patent applications. Therefore, it is important to consistently monitor patent applications related to the technology. If there are plans to enter foreign markets, it is advisable to consider applying for international patents to secure rights in those markets.
- Furthermore, there are some patents in the portfolio that have a limited remaining duration. If the proposing company intends to continue with commercialization efforts, it is advisable to consistently file patent applications for related technologies to build a strong patent portfolio. This will help secure the rights and support the commercialization of the technology.
- This technology is closely related to the "2050 Carbon Neutrality Scenario," "Carbon Neutrality and Green Growth Basic Act," and the "2050 Agricultural Carbon Neutrality Promotion Strategy." It is recognized as a necessary technology for achieving carbon neutrality goals in the livestock sector.
- Technologies such as using CH4 directly as a fuel source for fuel cells without converting it to hydrogen after separating CH4 in the process of biogasification, and developing technologies to capture and refine CO2 and convert it into high-value-added materials, can contribute to carbon neutrality by 2050.
- In the long term, this technology is not expected to remain at its current level but to progress further, extending to capture and utilize greenhouse gases in Cylindrical Airtight Fermenters. It has the potential to become a leading carbon-neutral technology in South Korea, but continuous development is necessary to achieve that position.
- The utilization of livestock manure allows for the simultaneous production of organic fertilizers and solid fuel pellets, enabling product diversification. The system directly captures and treats high-concentration odors during product production, resulting in low concerns regarding odor complaints.
- In terms of technology development, it is necessary to explore avenues for upgrading existing technologies and utilizing R&D support programs.
- The vertical composting device is already a commercialized technology and may not be considered as a new technology. However, it is recognized for its positive environmental impact through the treatment of livestock manure, reduction of greenhouse gases, and mitigation of odors. Therefore, increasing support for this technology is advisable, but it would also require the establishment of separate organizations or budgets for its management and operation.
- The characteristics of this technology include non-discharge methods to mitigate water pollution, odor reduction through sealed facilities, and a decrease in greenhouse gas emissions. Considering recent changes in the livestock industry, this technology is necessary and requires rapid implementation.

- If the economic feasibility of the technology is ensured, it is evaluated that through dissemination and business expansion, it will contribute to achieving the 2050 carbon neutrality goal in the livestock sector. However, it is noted that the current submitted data lacks sufficient information for evaluating the economic feasibility.
- The application of this technology as an alternative for livestock manure treatment can be considered in areas with severe odor complaints and water pollution caused by livestock manure in Korea. Exploring overseas expansion opportunities following the successful commercialization of this technology in domestic facilities would be beneficial.
- The initial equipment costs for the facility can be high due to the use of stainless steel materials to enhance durability. To facilitate the smooth dissemination of the facility, it would be beneficial to collaborate with government programs such as the "Livestock Manure Treatment Support Program" to alleviate the burden of initial equipment costs.
- The achievements of the technology include significant reduction in odor and greenhouse gas emissions, as indicated by the environmental impact assessment provided. However, it is noted that there were measurement errors during the first and second measurements due to a fire incident.
- The ammonia concentration measured during the third measurement was lower than the emission standard, but it was still measured at a similar level. Further analysis is needed for the odor measurements, and it appears that there is a need to explore options for improvement beyond the current level.
- It appears that an analysis of the cause of the fire and the establishment of measures to prevent recurrence are necessary, considering that ammonia emissions exceeding the allowable standards occurred for a period of one month or longer (from the first measurement to the second or even longer until the third measurement). Additionally, prompt verification and restoration are necessary in cases where the facility is not operating properly.
- Regarding the issue of complaints,it is important to note that even if there is no odor issue during regular operation, the occurrence of sudden odor emissions due to incidents like fires can still lead to complaints.

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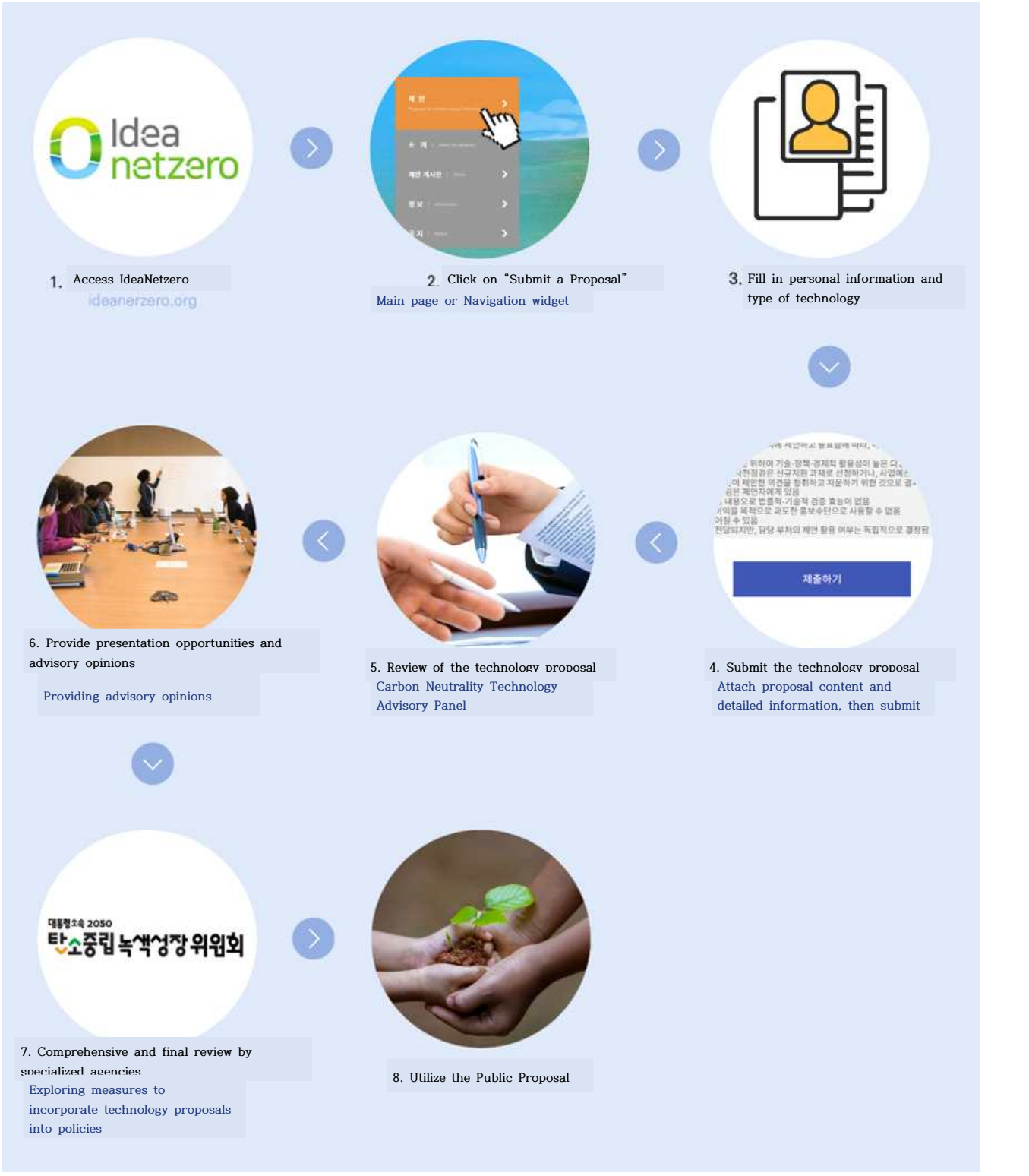
Public Technology Proposal Application and Implementation Process

Public Technology Proposal Implementation Process

1. How to apply for a Public Technology Proposal



1. Access IdeaNetzero
ideanerzero.org

2. Click on "Submit a Proposal"
Main page or Navigation widget

3. Fill in personal information and type of technology

4. Submit the technology proposal
Attach proposal content and detailed information, then submit

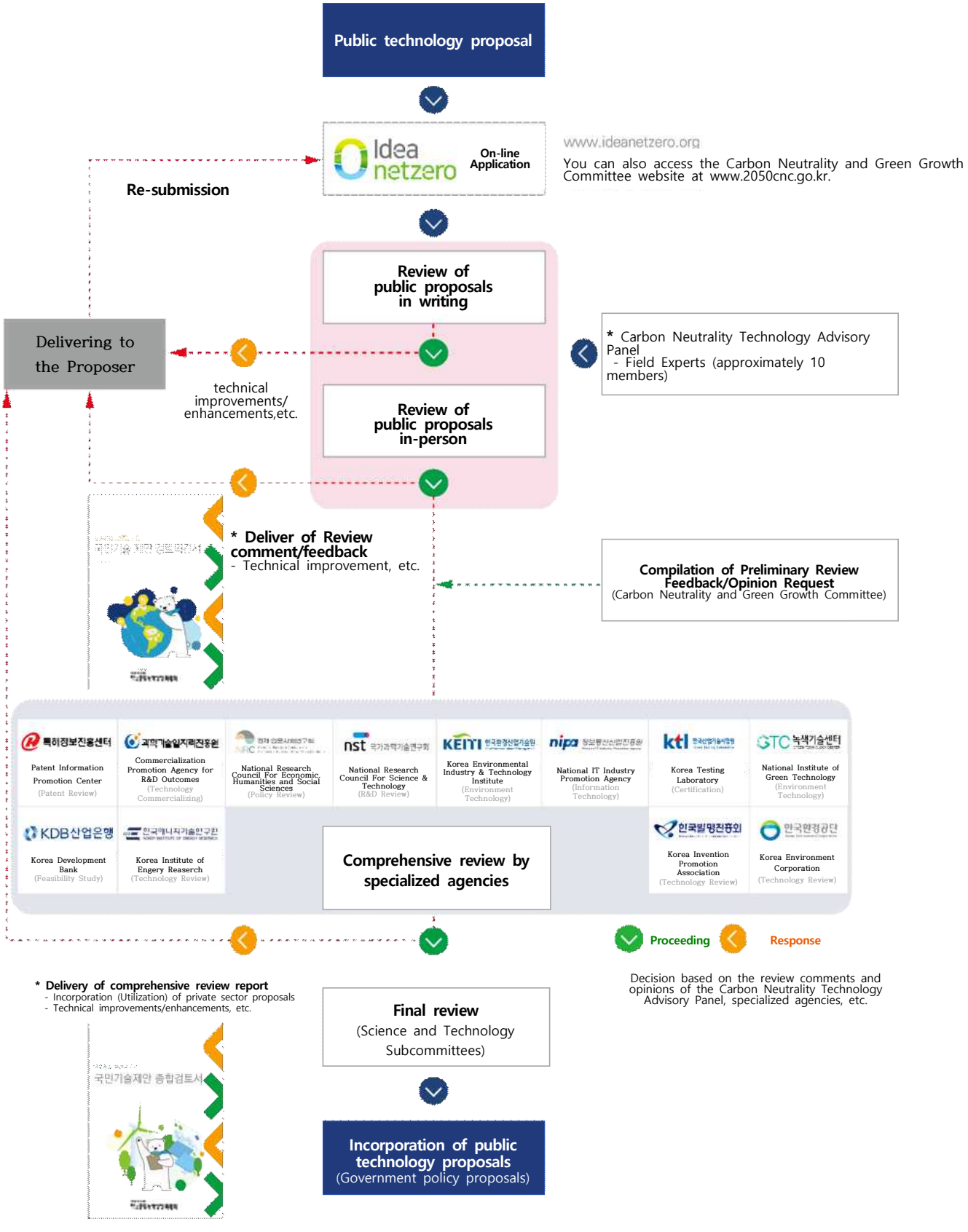
5. Review of the technology proposal
Carbon Neutrality Technology Advisory Panel

6. Provide presentation opportunities and advisory opinions
Providing advisory opinions

7. Comprehensive and final review by specialized agencies
Exploring measures to incorporate technology proposals into policies

8. Utilize the Public Proposal

2. Public technology proposal implementation framework



Overall review report on a Public technology proposal for achieving carbon neutrality

2050 Carbon Neutrality & Green Growth Commission