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Environmental Technology Development and Distribution Policies

1. Introduction

In the Korean Act on Environmental Technology Development and Support in Korea, environmental technology is defined as "technology necessary for preserving and managing the environment including the enhancement of assimilative capacity, suppressing and removing causes of environmental damages on humans and nature, preventing and reducing environmental pollution, and recovering polluted and destroyed environment. The definition does not mention the cost of technology, but focuses on preventing and reducing damages on the environment and humans. However, contemporary environmental technology means in two ways. One is environmental technology as a means of protecting people's health and the natural environment by solving environmental problems resulting from industrial activities. This means not only reduce of the environmental pollution, but also sustainable development possiblly by securing the environment for future generations. This is environmental technology defined by law. Another is the environmental technology as a basic element that determines the success of the environmental industry, which has grown newly. The civil society's demand for the presevation and pleasance of the environment is a driving force behind the growth of the environmental industry. The environmental industry is already seen as one of the new industry that lead the 21st century. For the continuous growth of the environmental industry, it is obvious that we obviously need outstanding environmental technologies. The environment management is strengthened and expanding in Korean environmental markets are also exploding in neighboring Asian countries including China. All these brighten the future of the environmental industry.

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Ministry of Environment · Korea Environment Institute
Republic of Korea

In the 1980s, Korean environmental technology was much inferior to that of developed countries such as the U.S. and Germany. At that time, people were more interested in economic growth than in environment protection. In addition, environmental problems were not global issues. However, since the late 1980's, political and economic progress has quickened democratization and increased national income, which has greatly changed the people's awareness of environment. The accident of the pollution of the Nakdong River with phenol in 1991 was an important turning point that engraved the importance of environmental problems in people's mind. Through the accident, there was a social consensus that advanced environmental technology must be secured first to solve environmental problems. Since then, environmental technologies began developing actively. "G-7 Environmental Technology Development Project" was launched in 1992, and the Act on Environmental Technology Development and Support was established to provide legal support for environmental technology development in Korea. Although government had supported, the Act accelerated environmental technology development and currently it is the legal ground of all governmental policies for environmental technology development and distribution.

In this background, environmental technology development policies in Korea have been executed with two objectives, namely, the environmental preservation and the promotion of the environmental industry. The governmental programs are aimed for developing the various policies to promote the development of the environmental industry and to secure advanced environmental technologies with high efficicncy. Various interest groups participate in making policies on environmental technology development. They include environmental technology specialists, environmental corporations, general corporations as consumers, policy makers in the government, the press and NGOs. This study briefly introduces the overall environmental technology development in Korea and a detailed explanation about the meanings of the three major policies. Three policies include "the next-generation core environmental technology development project," which is a technology development program aimed at becoming a country with advanced environmental technology, "the new environmental technology verification system," which is to certify the applicability of technologies owned by environmental corporations as well as environmental technologies developed

- 1989 Clean energy development project (MOCIE)
- 1992 G7 Environmental technology development project (MOE)
- 1992 G7 New energy development project (MOCIE)
- 1995 Clean production technology (MOCIE)
- 1997 Critical technology development project (MOST): Greenhouse gas reduction technology, water resource development technology
- 1999 40 environmental NRL(National Research Laboratory) (MOST)
- 2000 Frontier project(MOST): Industrial waste technology, sustainable water development technology
- 2001 Core environmental technology development project for next generation (MOE)

<Figure 1> History of major environmental technology development projects in Korea (Source: Next-generation environmental technology development projects, July 2002)

from various sources including "the next-generation core environmental technology development project," and "the local centers for environmental technology development" system, which is to solve environmental problems that arises in regional level and to give local businesses consultation on environmental problems.

2. Environmental technology development project

2.1 Characteristics of demands for technoly

(1) Characteristics of social demands

Korea has a small territory and high population density. Korea is however the 10th largest economy in the world due to rapid industrialization, which is why Korea suffers from various environmental problems. Thus, the development policies of the environmental technology also related closely to the social conditions of Korea. The social conditions relate to the demand for environmental technologies are as follows.

① Concentration of population in urban areas: Korean population is concentrated into urban areas so densely that its urbanization rate is as high as 90%. In particular, the Seoul Metropolitan Area is suffering from serious air pollution and heat island effect caused by exhaust gas from vehicles and lack of water resources. There are also environmental issues related to living environment such as the noise, lack of green areas and disposal of wastes.

② Large-scale industrial complexes: Korea has consistently promoted policies for developing industrial complexes to accommodate manufacturing facilities in specific areas and, as a consequence, large-scale industrial complexes are scattered around the country. Industrial complexes separate manufacturing facilities causing pollution from residential areas, protecting people from direct damages of pollution. However, the excessive environmental load upon specific areas causes another environmental problem. Representative industrial complexes in Korea include the petrochemical industrial complexes in Ulsan and Yeocheon and several industrial complexes around the Seoul Metropolitan Area.

③ Geographical conditions: Korea is surrounded by the sea on the three sides and 70% of the land is covered with mountains and forests. Because the size of usable land, namely, flat fields is small, the population or industrial activities are concentrated on the specific areas and this aggravates environmental pollution. On the other hand, this has been a reason for the fine preservation of the natural ecosystem. The sea itself forms a beautiful landscape and the quality control of river water flowing into the sea is also an important task. Moreover, large-scale land reclamation projects are being executed to expand the land and they are triggering concerns over tidal flat.

④ International environmental problems: As a heavy energy-consuming country, Korea copes with the problem of global climate change. In addition, we need to deal with environmental problems common to neighboring countries China and Japan such as long-range transboundary pollutants and to prevent the pollution of the Yellow Sea.

In this way, various environmental problems are related closely to the social and geographical conditions, which are unique to Korea. Accordingly, technology development policies have to reflect the characteristics of Korea, and such characteristics are appropriately reflected in the government's mid- and long-term strategies for environmental technology development.

(2) Changes in technology paradigms

Social demands for technologies are directly related to specific environmental problems but, on the other hand, they are closely connected to social values, namely, people's consciousness of the environment. For example, if people's awareness of environmental problems is low and

social capacity is poor, efforts are concentrated on the reduction of the discharge of pollutants from their sources. Thus, technologies are required for solving visible environmental problems caused by such as dust and COD and these efforts are usually made after pollution. Like this, environmental technologies before 1990 were usually for end-of-pipe technology. However, end-of-pipe technologies were criticized for their limitations in the improvement of efficiency, high marginal costs, irrecoverable environmental damages by pollutants that cannot be solved with post-management technologies, etc.

With these criticisms and the advance of technologies, pollution prevention technologies began being emphasized from the 1990s. Because it is impossible or take much cost and time to identify the effects of numerous pollutants on human health and environmental impacts, international society is changing its direction to prevent the pollution at the sources. Pollution prevention technologies have been spot-lighted in connection with clean technologies or manufacturing process technologies since the 1990s. Because pollution prevention technologies require detailed knowledge about each manufacturing process as well as know-how of various technologies other than those in the environmental area, they promoted the participation of manufacturers and specialists in other areas.

While pollution prevention technologies were emphasized, discussions was made on the nature of environment management means, namely,

<Table 1> Change in the paradigm of environmental technology by period

Period	1980s	1990s	2000s
Paradigm	· Dispose pollutants efficiently and manage pollution sources	· Pollution prevention (minimize the discharge of pollutants and recycle them)	· Establish total environment-friendly society · Manage receptor-centered environment
Goal of technology development	· with environmental regulations (solve current environmental problems)	· Cope with regulations and save resources (strengthen environmental competitiveness)	· Resolve environmental pollution load · Preserve and restore natural ecosystem
Major characteristics of technology development	· End-of-pipe technology (waste treatment)	· ?Cleaner production technology · Environment-friendly products	· Restore and revive the environment · Forecast and cope with long-term environment changes
Major technologies	· Hazardous gas removal technology · Dust collection technology · Waste water /sewage treatment technology · Water purification technology	· Low-pollution manufacturing process technology (minimize the discharge of pollutants from manufacturing process and recycle them) · Use low-pollution materials	· Soil and groundwater remediation, ecosystem restoration technology · Environment monitoring and detect · Environmental risk assessment and
Characteristics of technology	· Characteristics of technology	· State-of-the-art engineering technology	· Science-based technology · Fusion technology
Academic area	· Environment/chemical engineering, mechanics, electronics	· Environment/chemical engineering, mechanics, electronics, life science, new material	· Life science, health and medicine, new material, nano-tech, information, electronics and communication, etc.

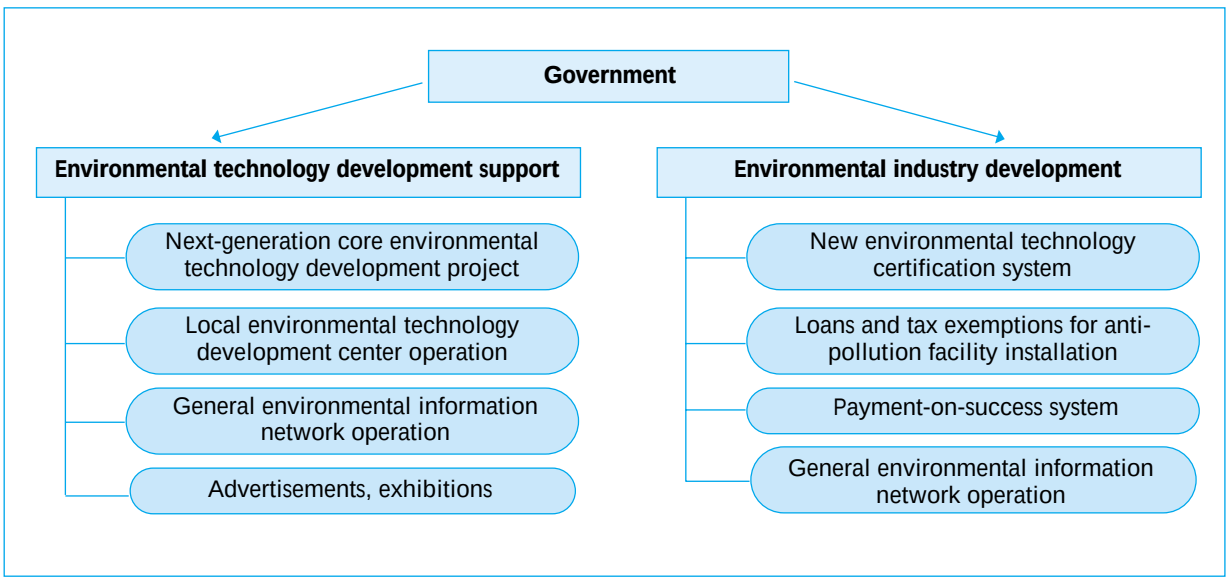
SOURCE: THE MINISTRY OF ENVIRONMENT, 10-YEAR COMPREHENSIVE PLAN FOR NEXT-GENERATION SOURCE ENVIRONMENTAL TECHNOLOGY DEVELOPMENT, 2002

whether existing environmental standards including pollutants under control are harmless to the human body or the natural ecosystem and, these discussions convinced people of the importance of measuring the harmful effects of pollutants. In addition, as new health risks such as environmental hormones were found, there were public opinions that overall inspections are necessary for all chemicals. Moreover, since international agreements such as POPs Convention and United Nations Framework Convention on Climate Change are coming into effect, new technologies need to be developed. The recovery and preservation of natural ecosystem were also recognized as important tasks. Entering upon the 2000s, these discussions grows more active but the development of relevant environmental technologies are hardly possible without governmental support because they require high-level scientific knowledge, analysis and cost. <Table 1> shows the trends and characteristics of environmental technologies by different periods.

2.2 Environmental technology development system

Governmental policies for promoting environmental technology development are largely divided into environmental technology development and environmental industry development.

First, environmental technology development projects are programs to develop and supply environmental technologies demanded by society or manufacturers and a representative project is the government-led "next-generation core environmental technology development project." In addition, the program to operate and support "local ecnters for developing environmental technology" with the objective of solving environmental problems of local regions can be considered as an environmental technology development program in the broad sense. Environmental industry development policies include direct and indirect support to environmental corporations, e.g. give extra points to public tenders for new environmental technologies, the operation of web sites providing information on environmental technologies and the hosting of exhibitions promoting environmental technologies. In addition, special loans and tax exemptions for the installation of environmental facilities by general manufacturers may expand the size of the environment market. These are diagramed in <Figure 2>.



<Figure 2> Schematic diagram of environmental technology development system

2.3 Next-generation core environmental technology development project

The "next-generation core environmental technology development project" is one of the representative environmental technology development projects implemented by the Korean government. A total of 1 trillion Won will be invested in the project from 2001 to 2010. To reflect changes in social demands for environmental technologies and the progress of environmental technologies as mentioned above, the project is composed of three stages. As of 2005, the second stage is in progress. In this section, we will examine in detail the "next-generation core environmental technology development project."

2.3.1. Program design

■ History

Since the program is a long-term R&D project that will continue on until 2010, it is important to establish detailed plan on the ultimate goal of the project, objectives for each stage, implementation strategies, required technologies, guideline for budget allocation, and technology map for 10 year period. For this, a task force team was formed in 2001, and the team drew up "a 10-year comprehensive developmnt plan for the next-generation core environmental technology" after about one year preparation period.

<Table 2> Formation and roles of committees

Classification	Status and roles
Planning committee	- Consist of sspecialists from industry, universities, research institutes, NGOs and the government, and give advices on the directions of planning. - Give advice on sub-committee activities (derive key tasks, prepare TRM, set the detailed goals of technology development) - Make decisions on major issues related to planning (setting strategic goals, planning methods and procedures, examine the results of planning, etc.)
Technology committee	- Consist of around 10 specialists in specific area (elect the chairperson and executive secretary) - Identify key technology areas through analyzing technology demands and markets - Set key programs and derive technologies in need - Prepare reports on the technology roadmap

The technology roadmap needed for the comprehensive plan was drawn up by seven "technology committees" composed of 10 experts in each area. In addition, a "planning committee" was formed with representatives from the government, universities, research institutes, corporations, the press and NGOs. When the plans were drafted, the public's opinions were collected through public hearings and the plans were finalized through the government's internal revision.

■ Program design procedure

The comprehensive plan began with the basic objective of realizing national long-term environmental visions and supporting sustainable development by integrating the environment and economy without overlapping with the basic direction of other governmental agencies. Under the principles, we conducted a survey of policy makers, researchers, NGOs and corporations on demands for technologies and, based on the results, the meeting of the technology committee

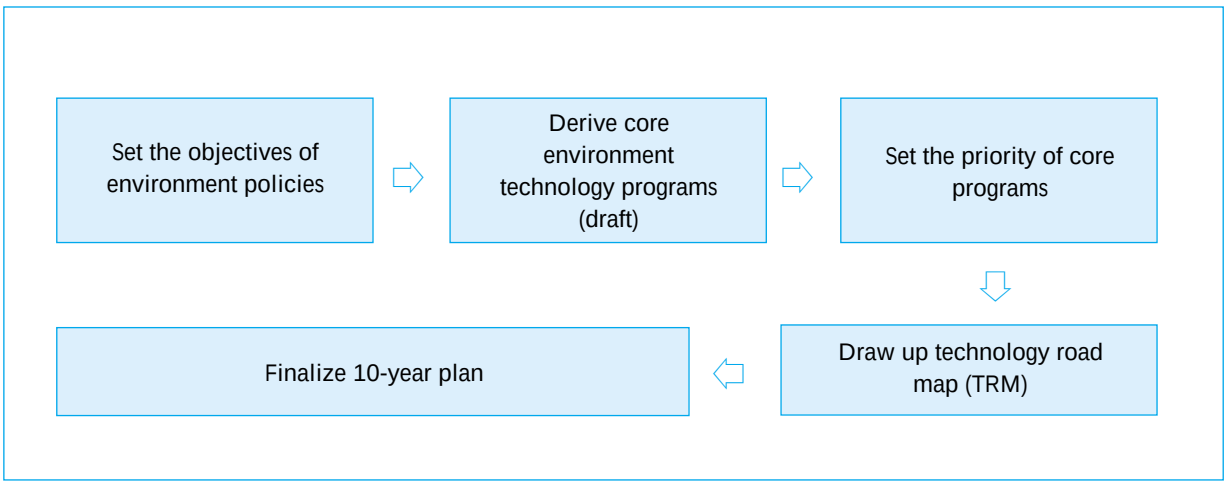
was held and major environmental issues were derived. Using the results, the research team developed draft core programs, and reviewed and finalized programs in the technology committee. A questionnaire survey was conducted using AHP (Analytic Hierarchy Process) method to reflect specialists' qualitative opinions in deciding the priority of the goals of multi-dimensional policies in the decision of the priority of core programs. In this project, mutual comparison was made between draft core programs and their priority was decided through statistical processing of the results of mutual comparison.

Based on core programs (draft) with priority decided, a 10-year technology map was drawn by the technology committee and finalized through public hearings and reflection of people's opinions. The complicated process was taken because the project is of large scale up to 1 trillion Won and would result in the foundation of environmental technology development policies in Korea. In the process, important matters were reviewed by as many experts and general public as possible and actually many experts participated in the process. <Figure 3> shows the process of program design explained above.

2.3.2. Outline of the project

■Objectives

The ultimate objectives of the proposed project until 2010 are summarized into five; First, securing technologies for managing pollution related to air, water and wastes on the level of



<Figure 3> Schematic diagram of program design procedure

developed countries. The second objective is improving technologies for recovering ecosystem, pollution prevention, preserving global environment and improving health environment to meet 80% of the level of developed countries. The third one is creating 10 or more world-best products through technology development. Fourth, independent environmental risk assessment methods and environmental risk management models will be developed. The last objective is the securith of future core technologies. The government forecasts that with successive achievement of these ambitious objectives, Korea will be one of the five major countries in the world in terms of environmental technology in the year of 2010.

The project was executed in three stages and each stage has its goals. The first stage, which is until 2003, secures technologies for imminent environmental problems and develops basic technologies for risk assessment. Stage 2, which is until 2007, develops key technologies for risk assessment and monitoring as well as competitive environmental technology products by improving

technologies developed in stage 1. Stage 3, which is until 2010, secures future core technologies and unique technologies for assessing harmful environmental effects and monitoring infinitesimal quantities of pollutants, which are the ultimate objectives of the project.

■ Research fund investment plan

The total amount of research funds for the present project is 1,435 billion Won, 1,000 billion Won by the government and 435 billion Won by private corporations. The government already funded 195 billion Won in stage 1 until 2003, and plans funding 460 billion Won in stage 2 and 345 billion Won in stage 3.

<Table 3> Technology development goals in each stage of the next-generation core environmental technology development project

Technology	Stage 1 (2001 ~ 2003)	Stage 2 (2004 ~ 2007)	Stage 3 (2008 ~ 2010)
Monitoring	◓	◕	●
Assessment	◔	◓	◕
Treatment	◓	◕	●
Prevention	◔	◓	◕
Management	◔	◓	◕

Note) ○: Low-level technology, ◔: Elementary technology, ◓: Partial technological innovation, ◕: Independent technological innovation, ● : World-class technological innovation

SOURCE: THE MINISTRY OF ENVIRONMENT, TEN-YEAR COMPREHENSIVE PLAN FOR NEXT-GENERATION SOURCE ENVIRONMENTAL TECHNOLOGY DEVELOPMENT, 2002

<Table 4> Investment plan for the next-generation core environmental technology development project in stages

	Stage		1 (2001 ~ 2003)	2 (2004 ~ 2007)	3 (2008 ~ 2010)
Funds (billion Won)	Total	1,435	280	660	495
	Government	1,000	195	460	345
	Private Corp.	435	85	200	150

■ Project promotion system

The next-generation core environmental technology development project is managed by the Ministry of Environment and the Environmental Technology Promotion Institute. The Ministry of Environment charges basic planning and overall evaluation but it does not manage individual tasks. The project is managed by the Environmental Technology Promotion Institute, which executes specific tasks commissioned by the Ministry of Environment. Major management tasks include the reception and evaluation of task applications evaluated by external specialists, contracting, task evaluation, advertising for commercialization of developed technologies, etc.

2.3.3. Major contents and results in the project

■ Stage 1 (2001~2003)

During stage 1, 30 key tasks in 12 unit projects were selected as in <Table 5> and executed for three years (2001~2003). By large classification, there were 1 unit project for air quality, 2 for cleaner production and clean products, 2 for ecosystem recovery, 2 for water quality, 1 for waste management, 1 for risk assessment, 1 for monitoring and 1 for life environment and 1 for high efficiency of environmental policies. Key tasks related to these unit projects were finalized by reflecting the opinions of many experts and NGOs in making the general plans explained above.

During stage 1, a total of 460 research tasks were selected and executed. The number of research tasks was 219 in 2001 and increased to 317 in 2002 and 340 in 2003. In addition, investment in researches also increased every year from 79 billion Won (50 billion Won by the government) in 2001 to 79 billion Won (70 billion Won by the government) in 2002 and 101.6 billion Won (75 billion Won by the

<Table 5> Key tasks by unit project in the next-generation core environmental technology development project

Unit project (large classification)	Key tasks (medium classification)
1. Clean and safe air	Technology to control fine dust Technology to control ozone/smog Technology to control harmful air pollutants
2. Goods made from environmentally-friendly materials	Develop materials in substitute for substances causing environmental pollution Develop materials and products with high-efficiency pollutants removal
3. Environment-friendly manufacturing process	Optimization technology to reduce the discharge of pollutants Processing technology to remove harmful substances and to recycle useful ones
4. Soil and underground water recovery and management	Technology to recover and manage urban and industrial areas Technology to recover and manage polluted landfill areas Technology to recover and manage areas around abandoned mines
5. Ecosystem recovery and management	Technology to recover destroyed natural ecosystem Technology to use and manage ecological environment
6. High-quality drinking water	Technology to improve the efficiency and quality of water purification Technology for optimal management of water supply and sewer system Technology to secure and manage high-quality water supply sources
7. Advancement of sewage and waste water treatment	Technology to treat sewage and waste water Environment-friendly technology to treat and manage discharged water
8. Environment-friendly waste recycling	Technology to reduce, recycle and manage wastes Technology to convert wastes into resources Technology to treat and dispose harmful wastes
9. Risk assessment	Key technologies for risk assessment Technology to assess environment control technologies
10. Measuring and analyzing devices and equipment	High-precision sensor technology Environmental pollution measuring and analyzing equipment technology Remote monitoring technology
11. Creating comfortable living environment	Technology to assess and manage noise and vibration Technology to prevent and reduce noise and vibration Technology for soundproofing and vibration-isolation
12. High efficiency of environmental policies	Technology to cope with and solve international environmental problems Technology for environmental education and advertisement

<Table 6> Number of research tasks and research funds during stage 1

Year	Number of research tasks			Research funds (billion Won)		
	Total	New tasks	Continued tasks	Total	Governmen investment	Private investment
Total	-	460	-	280	195	85
2001	219	219	-	79	50	29.1
2002	317	131	186	99.3	70	29.3
2003	340	110	230	101.6	75	26.6

government) in 2003, so a total of 280 billion Won was funded for three years. The government invested 195 billion Won (around 70%) and private sectors did 85 billion Won.

Despite three years' short period, a large number of dissertations, patents and commercialized products were achieved. From the research activities, 277 industrial property (patent) applications were made. This is 0.6 per research task, suggesting quite high achievement. This result is considered an important indicator proving that these researches are commercially practical. Still 1,173 research papers were published in journals or presented in conferences, suggesting also academic significance of the research outcomes. As indicated by the number of patent applications, some practical results from stage 1 were directly commercialized. Technological contracts of 5.6 billion Won, constructions of 5.6 billion Won, domestic sales of 1.6 billion Won and export of 6.4 billion Won were achieved using the results of 45 research tasks. Considering that these data are as of December 2003, excluding the outcomes of tasks that finished at the end of 2003, and that commercialized technologies will increase their market shares, actually much more visible results were produced through the first stage.

■ Stage 2 (2004~2007)

Despite many visible results during stage 1, there were opinions to change the promotion strategies to secure future core technologies in 2010, the ultimate goal of the "next-generation core environmental technology development project." Because tasks were selected and supported from bottom up, original technologies were secured to some degree. Thus, stage 2 was required to switch to a system that facilitates the development of future core technologies. The characteristics of research tasks in stage 2 are as follows. First, the 12 unit projects were simplified into three. Second, the bottom-up system in the previous stage was changed to the top-down one to secure core environmental technologies. Lastly, Eco-STAR Project was introduced to pick up and support large-scale tasks of high marketability and possibility of success.

Tthree unit projects are future core technology

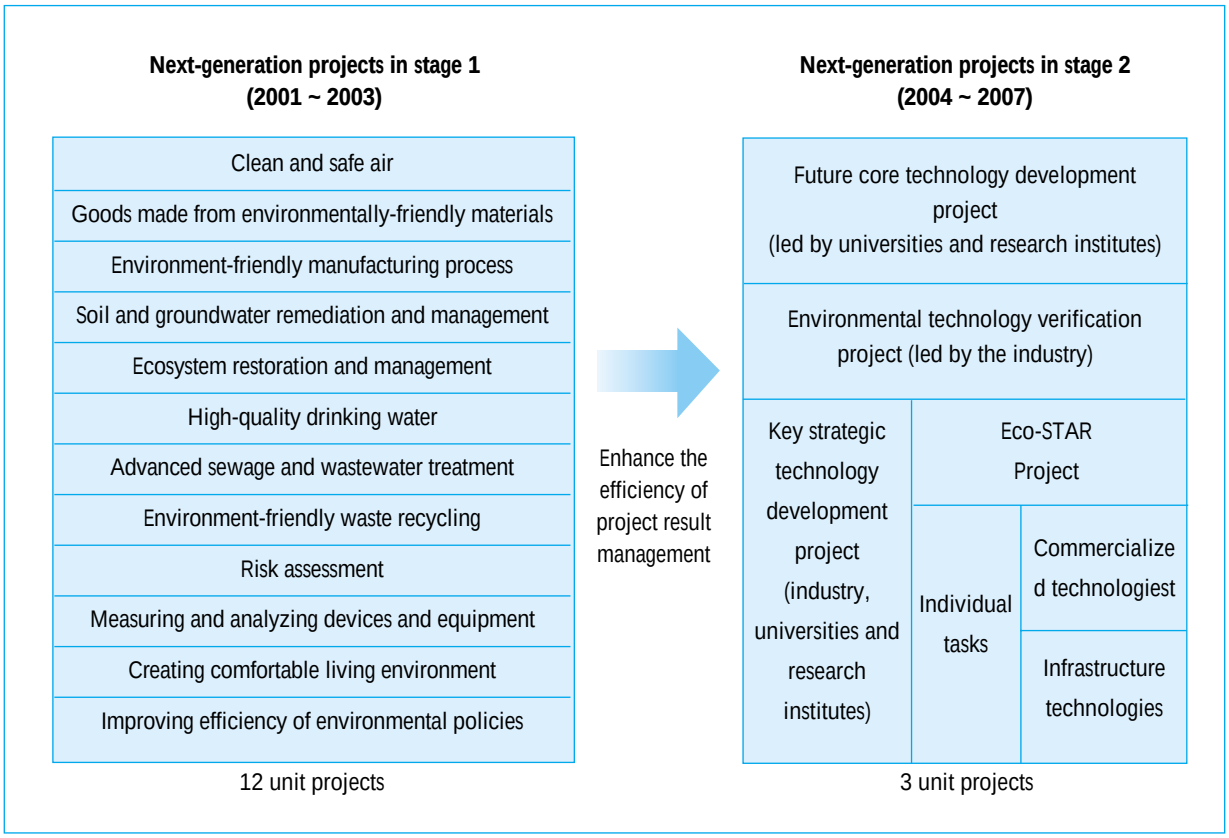
<Table 7> Visible results of projects in stage 1 (2001~2003, as of December 2003)

	Technological contract		Industrial property		Publication in journals and presentation in conferences
	No. of tasks	Contract amount (billion Won)	Application	Registration	1,173
No. of cases	45	5.6	207	70	

development project, environmental technology verification project, and key strategic technology development. The characteristics of each unit project are as follows.

① Future core technology development project: Future source technology means the concepts of technology that can reduce environmental load drastically. Although the possibility of success is low, if such a technology is developed, its effect is enormous. Because it is difficult to catch up with developed countries' technological level and market competitiveness, we need to develop innovative technologies by introducing new concepts. For this, future core technology is selected as one of three unit projects and 10% of the total amount of research funds is invested in this project.

② Environmental technology verification project: Considering Korean environmental corporations with relatively few experiences in process design, this project aims at selecting technologies based on the possibility of commercialization in two years among those successful in small-scale development, scale up them, and verify their performance. Even though a technology is successful in laboratory, it generally requires engineering data to enlarge the equipment for commercial use. Because the size of Korean environmental corporations are usually small, they hardly bear the risk of enlarging the equipment and, as a result, developed technologies are occasionally kept unused. On the other hand, technology users require the verification of technologies in scaled-up equipment. Thus, the enlargement is an obstacle in commercializing developed technologies. To support the need on the governmental dimension, the verification project was selected as one of three unit projects in stage 2, and 20% of the total amount of research funds is invested in this project. This project is led by companies with a lot of experiences in equipment design.



<Figure 4> Comparison of unit projects between stage 1 and stage 2

③ Key strategic technology development project: This project is to attain the goals by area in environmental technology road map (TRM) presented in the general plans, and is composed of individual tasks for each area and Eco-STAR Project. Individual tasks are supported by the object of securing key environmental technologies by area, and Eco-STAR Project is to find tasks with high marketability and possibility of commercialization and operate them in the form of business project. Compared to other projects, Eco-STAR Project requires composite technologies, various participants and a large scale. Eco-STAR Project organizes the project team in the top-down method and transfers the full authority to the director of the team, guaranteeing researchers the maximum autonomy. Ten project teams will be operated and currently two teams - pollution-free/low-pollution automobile project team and water treatment advancement project team - have been selected. The pollution-free/low-pollution automobile project team aims for developing automobile technologies for low pollutant discharge and the water treatment advancement project team aims developing advanced sewage/wastewater treatment and water purification technologies. Each project is supported dring 5~7 years and with 5 billion Won each year. The contents and objectives of research in the selected project teams are as follows.

Stage 2 is in its 2nd year. A total of 365 tasks were

<Table 8> Objectives and contents of Eco-STAR Projects

	Pollution-free/low-pollution automobile	Water treatment advancement project team
Objectives	- Reduce air pollution by developing and distributing technologies for low pollutant discharge from vehicles	- Localize advanced treatment technologies and enhance international competitiveness - Commercialize high-efficiency integrated sewage / waste water treatment and water purification technologies
Contents	- Reduce pollution by cars by 70% of the current level - Develop technologies to meet the permitted limit of discharge in Euro-5 for diesel vehicles - Develop technologies to meet the permitted limit of discharge in SULEV for natural gas and LPG vehicles	- Secure state-of-the-art sewage / waste water treatment technologies (up to the level of water in swimming pool based on BOD) - Remove harmful pollutants in sewage / waste water and water supply sources to be harmless or to meet the required standard - Reduce the use of chlorine by 50% in purifying and supplying water and reduce the turbidity of purified water below 0.1 NTU - Minimize the land size of water purification and sewage / waste water treatment plants - Reduce the generation of sewage / waste water sludge
Period	December 2004 ~ May 2011	December 2004 ~ May 2011
Government support (billion Won)	65	65

<Table 9> Number of research tasks and research funds during stage 2 (2004~2005)

	Number of research tasks			Research funds (billion Won)		
Year	Total	New tasks	Continued tasks	Total	Governmen investment	Private investment
Total	-		-	2,200	1,634	566
2004	365	199	166	1,016	750	266
2005	-	88	-	1,184	884	300

selected in 2004, 25 less than 2003 the last year of stage 1. In 2005, the number of new tasks went down to 88 because large-scale tasks were selected according to the promotion strategies of stage 2. For research, a total of 220 billion Won was funded during the two years and respectively 163.4 billion Won and 56.6 billion Won by the government and by private sectors. Compared to 280 billion Won for the three years of stage 1, investment in researches has increased significantly.

Results during the period of 2004~June 2005 (a year and six months) include 290 intellectual property(patent) applications and registrations, 1,588 research papers published in journals or presented in conferences, showing higher performance than stage 1. This means that tasks were selected and researches were managed more efficiently than stage 1 but, on the other hand, it shows that the results of stage 1 are becoming materialized. The number of the commercialized cases also increased. In 2004, 103 tasks made sales contracts with developed technologies, raising sales of 6.8 billion won based on contract amount, far exceeding the record of the three years in stage 1. This is also an important sign that the results of researches in stage 1 are commercially gradually spreading.

<Table 10> Visible results of projects in stage 2 (2004~June 2005)

	Technological contract (2001 ~ 2004)		Industrial property		Publication in journals and presentation in conferences
	No. of tasks	Contract amount (billion Won)	Application	Registration	1,588
No. of cases	148	12.4	171	119	

■ Major successful cases

Among technologies developed in the next-generation core environmental technology development project, a number of commercially successful cases are as follows.

① Indoor air purifier using photocatalyst

- Outline: Purify air using photocatalyst system instead of existing absorption system
- Characteristics: Efficiency in treating VOCs, CO and odor substances is two times higher than existing products
- Record: Sales of 15.5 billion won including air purifier export contracts with 22 European countries including the U.K., France and Switzerland amounting to 7 million dollars in three years

② Hazardous chemical detection system utilizing microbial fuel cells

- Outline: Detect hazardous chemicals in water in real time using microbial fuel cells
- Characteristics: Developed first in the world,

can detect hazardous chemicals in sewage and wastewater in real time

③ Ethanol-SCR process to remove NOx from point sources

- Outline: Denitrifying technology using ethanol instead of ammonia as a reducing agent
- Characteristics: Solve problems in the use of ammonia (odor, risk of explosion, etc.)
- Record: Sales of 13.5 billion won until 2004

④ Livestock excretion disposal as a resource with zero discharge

- Outline: Treat livestock excretion using TAO(Thermophillic Aerobic Oxidation) system, separate fermented solutions, and compost the fermented dry materials
- Characteristics: Produce liquid fertilizer and compost (bed soil) using TAO system technology
- Record: Applied to 10 companies discharging livestock excretions

⑤ Research on improving sewage treatment plants

- Outline: Use dPAO (denitrifying Phosphorus Accumulating Organisms) that feeds sewage efficiently through step-feed and removes nitrogen and phosphorus at the same time
- Characteristics: High nitrogen / phosphorus removal rate even at low ratio of organic matters / (nitrogen, phosphorus)
- Record: Applied to many urban sewage treatment plants

⑥ Research on melting system of new concept using brown gas

- Outline: Melt harmful materials such as ash and dust at high temperate of 1,450℃~1,500 ℃ using brown gas obtained by electrolysis of water and such materials that are isolated.
- Characteristic: As brown gas, pollution-free clean fuel, is used, there is no secondary discharge of pollutants, and the life of landfill areas is extended.
- Record: Export 5 billion Won to Japan and other countries

2.4. Operation of local development center for environmental technology

Environmental problems vary depending on each localities. For example, urban areas have air pollution caused by fine dust from cars while rural areas have problems such as livestock waste water and abandoned vinyl. Areas around industrial complexes problems such as chemicals and noise discharged by the complexes. If the government uses a uniform approach to different characteristic environmental problems in localities, such approach can be inefficient in solving local environmental problems. Thus, to solve environmental problems specific to a locality, an organization needes to be constructed including local universities, residents, administrative organs, research institutes and companies that are familiar with the characteristics of the locality. For this purpose, the government establishes "local environmental technology development centers" and provides financial supports to them.

"Ulsan development center for local environmental technology" and "Yeosu development center for local environmental technology" were founded first in December, 1998 and since then 8 centers were founded in 2000, 5 in 2001 and 1 in 2002, so a total of 16 centers are in operation at major universities in 14 cities and provinces throughout the country.

Each center performs functioning such as investigating local environmental pollution phenomena, developing environmental technologies, supporting environmental technologies and education to local businesses and spreading new environmental technologies.

2.4.1. Current state of the operation of local development center for environmental technology

■ Functions and roles

The roles of local development centers for environmental technology are summarized into two. One is investigation and technology development to solve local environmental problems and the other is specialized environmental consulting for local corporations. Specifically, they investigate the causes of local environmental problems, look for solutions for the problems and develop technologies to solve

imminent problems. In addition, they develop environmental technologies demanded by local businesses, share environment information and provide advice on process diagnosis and improvement as well as on licenses and permits. Different from the Seoul Metropolitan Area, there are not many specialists and technicians in environment in localities. Thus, local small and medium businesses are usually in need of relatively easy technologies and small amount of information rather than advanced ones.

If local members take charge of local problems, they can get local residents' understanding and cooperation more easily and, in the long run, localities' environment management capacities are enhanced and similar environmental problems can be prevented earlier. Furthermore, local environmental problems tend to be extremely practical, experiences and know-how obtained from these problems can be useful in solving environmental problems in other areas as well as in developing countries in Asia and other regions which have similar localities.

■ Current state of installation

There are 16 "local development centers for environmental technology" around the country. It was installed first in 1998 in Ulsan and Yeosu where petrochemical industrial complexes were causing problems of odor and threatening residents' health by VOCs and other pollutants. Since then, it was installed in eight areas including Gangwon-do and Incheon in 2000, in five areas in 2001, and in Jeju in 2002 with very fine environmental condition. As of 2005, 16 centers are in operation across the country.

■ Method of operation

"local development centers for environmental technology" execute projects jointly with industries, universities, research institutes, NGOs and the government. The centers have the administration council and the research council. The administration council is membered by the director of the district environment management office, those from participating institutions, environmental groups and the representatives of local residents, and deliberates and resolve matters related to its projects and budgets. On the other hand, the research council is membered by specialists from universities, municipal and provincial health and environment research institutes, environment management office, corporations, etc. and performs tasks such as project planning and execution, technician training, and technological supporting for local corporations. There is a coordination meeting to prevent redundancy in selecting tasks among the centers, and research tasks are selected based on applicability to the corresponding locality. The Ministry of Environment is inducing competition among the centers by differentiating governmental support based on the results of operation every year.

<Table 11> Current state of local development centers for environmental technology

Total	1998	2000	2001	2002
16	2	8	5	1
	Ulsan, Yeosu	Gangwon, Incheon, Daegu, Gyeonggi, Siheung, Ansan, Chungnam, Daejeon	Chungbuk, Gyeongbuk, Gyeongnam, Jeonbuk, Gwangju	Jeju

■ Composition of funds

The funds of "local development center for environmental technology" are composed of supports from the central government, the local government and the organizations belonging to the center, and contributions by corporations participating in projects. However, because the centers were found to solve local environmental problems and give environment-related consultation to local companies, a large part of

<Table 12> Composition of funds of local development centers for environmental technology

Year	Total amount(A) (billion Won)	Support from central government(B) (billion Won)	Support from other organizations (billion Won)	Percentage of central government's support(B/A x 100, %)	Number of centers
2000	7.55	1.5	6.05	19.9	10
2001	7.96	2.5	5.49	31.4	15
2002	10.44	3.91	6.53	37.5	16
2003	11.8	4.8	7	40.7	16

the funds comes from local society, namely, the local government and corporations. In fact, support from the central government is merely 19.9~40.7% of their budgets.

2.3.2. Results of center operation

The basic objective of the installation and operation of the centers is to solve locally specified environmental problems through the participation of local society. Thus, it is quite different from the objective of the "next-generation core environmental technology development project" explained earlier. This is why technological support to corporations, information sharing with local society and technology education are emphasized in center operation. Although it is not easy to quantify the results of center operation, until 2004, they performed 858 research tasks, provided 2,100 cases of technological advice to 844 companies, executed regular education for residents and company staffs in charge of environmental affairs, contributing to the solution of local environmental problems and the improvement of environment management capacities.

Based on these results, two more centers are planned to be installed in the future and, for the long run, these centers will be settled as major environmental research and support organizations in their corresponding areas.

3. New environmental technology verification system

3.1. Objectives

Many of Korean environmental companies are small or medium businesses. Even if they develop excellent environmental technologies at their own expenses, it is not easy for them to get into the market due to their low marketing ability. This situation has a significant effect on their business, making them reluctant to develop new technologies and, for the long run, highly dependent on foreign environmental technologies and ultimately affecting the government's environmental policies negatively.

One of the biggest reasons that newly developed technologies are not admitted in the market is lack of confidence in the technologies. That is, if a new technology has not been used in the field, technology users are reluctant to buy it. To solve this problem, the government introduced a system that verifies the performance and field applicability of new technologies and certifies them and this is called "new environmental technology verification system." The system was introduced first in 1999 and has been recognized as effective and helpful to many domestic environmental companies.

3.2. Major policies

■ Conditions for verification

In order to be verified as a new environmental technology, it must pass both the 1st document-based examination and the 2nd field investigation by "the environmental technology evaluation committee" membered by specialists.

The first document-based examination is focused on the newness of the technology, seeing whether the technology is newly developed, and its performance. Thus, only when the technology is found to be new, its performance is also evaluated. In addition, before the final decision on the new technology, the field applicability and performance of the technology are confirmed in the practical respect. Test on field applicability is focused on whether the new technology is more efficient, safer in operation, and easier to maintain than existing ones. As the evaluated items indicate, the new environmental technology verification system tests not only the originality and performance of technologies but also their field applicability. Thus, once a technology is verified, the technology is recognized as immediately applicable in the field.

The term of a new technology verification is three years in principle but the verified term of technology which is applied in the field successfully can be extended by extra three years through examination. However, if any defect is found during field application, the verification can be revoked for the reliability of the system.

On the other hand, in order to promote the utilization of excellent new environmental technologies developed by small and medium businesses, the government supports 50% of expenses for the verification of new environmental technologies (around 40 million won on the average per case).

■ Supports to new environmental technologies

If a new environmental technology is verified by the system, selling its products is in an advantageous position. Besides, government supports the verified technology in the various respects as follows.

First, verified new environmental technologies are given extra points in bids for all environmental facility constructions and designs executed by the government and public organizations. The range of extra points is decided by Minister of Environment and is around 1~2% of the total score.

Second, advertisement and public awareness of new environmental technologies, companies with a verified new technology can use ET Mark (New Environmental Technology Mark) on facilities or products, to which the new technology was applied.

Third, payment-on-success system is executed for environmental facilities. This system was introduced as technology consumers are not active in buying new environmental technologies, worrying that they may fail to apply the technology the field despite the government's official verification. Under the system, an environment facility is installed first at the expense of the new technology developer and when the success of technology is confirmed the buyer pays the price. This system is helpful for both new technology developers and consumers. For early settlement of the system, the government is promoting model projects for six facilities including livestock waste water treatment system as of December 2004.

Fourth, exhibitions are held regularly and promotive books are published to promote the distribution of new environmental technologies. In addition, new environmental technology forum have been being held every year since 2000 and information on new technologies and their developers is provided to the public through the Internet (www.konetic.or.kr).

3.3. Results of the new technology verification system

3.3.1. Number of new technology verification issued

Since 1998 and until the end of 2005, a total of 74 new technologies have been verified. Most of the technologies are concentrated into water treatment and waste disposal. By year, 1 verification was issued in 2000, 11 in 2001, 14 in 2002, 8 in 2003, 25 in 2004 and 15 in 2005, showing a steady increase in the number of verified new technologies.

3.3.2. Record of field distribution

The number of field applications of verified new environmental technologies is increasing every

year. It was 5 in 1999 the beginning stage of the system but increased significantly to 384 in 2004. The amount was also merely 8.3 billion Won in 1999 but rose to 234.6 billion Won in 2004, increasing by 28 times in six years. This is basically thanks to the government's effort to distribute new environmental technologies and the primary reason for the growth is probably market consumers' confidence in new environmental technologies.

<Table 13> Number of certified new environmental technology by year

Year	1998	1999	2000	2001	2002	2003	2004	2005
No. of certified technologies	0	0	1	11	14	8	25	15

<Table 14> Field distribution of new environmental technologies

Year	Total	1999	2000	2001	2002	2003	2004
No. of field applications	1,065	5	47	140	239	250	384
Amount (billion Won)	1,039.7	8.3	176.1	142.5	196.3	281.9	234.6

SOURCE: SURVEY DATA OF ENVIRONMENT MANAGEMENT CORPORATION (FEBRUARY 2005)

4. Conclusion

The present paper reviewed current governmental systems for environmental technology development and distribution. Two objectives of the government's environmental technology policies are improving the environment through continuos development of outstanding environmental technologies and promoting the environment market using the developed technologies. The global environment market has already emerged and grown and major markets are being formed in China and other regions. However, the two goals are not much attainable because of the low level of environmental technologies and the small size of environmental corporations in Korea. For this reason, environmental technology development was emphasized all the more and the government came to execute relevant policies.

The general directions of the Korean government's policies are largely summarized into the expansion of R&D investment for environmental technology development and the promotion of the environment market. In this framework, we can understand technology development programs represented by the "next-generation core environmental technology development project" and "local development centers for environmental technology" to solve locality-specific environmental problems, and the "new environmental technology verification system" for developing new environmental technologies and environmental corporations. The history of environmental technology development projects is short in Korea. Nevertheless, many visible results have been attained through the government's powerful driving force and investment and efforts by distinguished environmental technology personnel and more policies will be executed to

be a developed country in environmental technology.

Lastly, experiences obtained from executing environmental technology development policies are summarized as follows.

First, the government's powerful leadership is necessary at the beginning of environmental technology development. It is because small environmental businesses lack abilities to develop new technologies and ordinary enterprises are not active in investing in environmental technology development. Thus, until the environment market grows to a certain size, the government's intervention is effective for technology development and market formation.

Second, public support is important. Because environmental technologies are not for manufacturing, they cannot produce visible results immediately and often quantified results are not much meaningful. Because of these characteristics, without the support of civil society, it may be extremely difficult to secure government budgets.

Third, environmental technology development projects must reflect national demands as well as international demands for special environmental technologies, and forecast future demands. Precise estimation of demands makes the efficient distribution and execution of budgets possible, contributes to the environmental solutions, and secures easily relevant budgets in the future. For accurate forecast of technology demand, specialists in broad areas must participate and relevant information should be shared through a sharing system.

Fourth, the environment market should be activated. Without the environment market, technologies are useless no matter how great they are. Such a situation even raises the opinion that environmental technology development is unnecessary. Thus, it is important to create market environment for developed environmental technologies to be utilized actively and this requires governmental intervention and support. For example, the size of the environment market can be extended by tightening environmental regulations, providing loans and tax exemption for the installation of treatment facilities, expanding the government's purchase of environment-friendly goods, etc. Therefore, the higher effectiveness of the environmental technology development policies, development policies need to be supported by gearing with policies for activating the environment market.

Fifth, policies for promoting environmental corporations are also important. Because environmental businesses play main roled in forecasting demands for environmental technologies, developing them and selling them, they need to grow up to a certain level for the long-term development of the environmental industry. However, because most beginning environmental companies are small in size, they have difficulties in getting into the market. A representative example is that new developed technologies are not trusted in the market. The "new environmental technology verification system" is one of major policies to solve the problem. What is more, it is desirable for the government to promote various policies in order to enhance environmental companies' own management and research capabilities

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Ministry of Environment
Government Complex Gwacheon, Jungangdong 1, Gwacheon-si,
Gyeonggi-do, 427-729, Republic of Korea
Tel. (822) 2110-6550 Fax. (822) 504-9206

Korea Environment Institute
613-2 Bulgwang-Dong, Eunpyeong-Gu, Seoul, 122-706 Korea
Tel. (822) 380-7777 Fax. (822) 380-7799

Written by Dr. Sung-Yong Gong(KEI)

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