S&T Policy Directions for Green Growth in Korea

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ABSTRACT

To achieve the "low carbon green growth" vision, the first step is securing core technologies. Therefore, S&T policy direction for green technology development is urgently needed. As of 2008, investment in green technology (GT) development hovered around 10% of the government's total R&D budget. Thus, the Korean government developed a plan to increase that percentage to 15%, by 2013. To develop reasonable investment strategies for green technology development, targeted strategies that reflect technology and market changes by green technology area are needed. However, the overall planning and coordination of national GT development is currently split among, approximately, 10 government ministries. To establish an efficient green technology development system, the so-called "Green Technology R&D Council" should be launched in collaboration with the Presidential Committee on Green Growth and the National Science and Technology Council.

Furthermore, to build a solid foundation for commercializing the outcomes of GT development projects and promote GT transfer, the government should undertake two initiatives. First, the government should reinforce GT R&D performance management, by establishing a GT R&D performance management and evaluation system. Second, the government should implement the "customized packaged support for promoting green technology business rights and commercialization" and present "e-marketplace for market-oriented green technologies".

Creating a pan-ministerial policy for GT development policy would necessitate restructuring the HR(Human Resources) development system, which is currently separated by technology area. Based upon mid/long-term HR supply and demand forecasts, the government should design differentiated HR development projects, continuously evaluate those projects, and reflect the evaluation results in future policy development. Finally, to create new GT-related industries, the "Green TCS (Testing, Certification, and Standards) System" needs to

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be implemented. For objective evaluation and diffusion of R&D results by green technology area, a common standardization plan for testing, analysis, and measurement, like the "Green TCS", should be developed and integrated.

KEYWORDS: green growth, green technology (GT), GT commercialization, green TCS System

1. INTRODUCTION

The international society is now faced with a crisis in both environment and resources. As mankind is now being threatened by meteorological disasters and destruction in ecosystem, the Stern Report (2006)[1] of the U.K. predicts the annual economic loss caused by climate change could reach 5~20% of the global GDP, if the current highly energy-consuming system continues. In responding to these challenges, advanced countries have already concentrated their attention on efficiently utilizing resources and minimizing environmental pollution.

As the 10th largest energy consuming country in the world, Korea is dependent on imports for 97% of its total energy consumption. The country is now ranked 9th in terms of CO2 emission, and its carbon emission level is recording 2.8% annual growth. Though Korea is being evaluated as the lowest among the OECD member economies in terms of Green Competitiveness Index, the country is actively exploring new growth engines, by pursuing "low carbon green growth".

In his commemorative speech on the nation's Independence Day in 2008, President Lee, Myoung-bak presented "low carbon green growth" as a new vision for the nation. The key contents of this "low carbon green growth" vision include i) achieving policy goals, like economic growth and job creation by securing key green technologies and turning these technologies into growth engines and ii) solving environmental issues, like global warming. Such development visions are well reflected in the "Twenty National Strategies of President Lee's administration".

In the journey to achieve the "low carbon green growth" vision, the first step should be securing core technologies. For this purpose, it is urgently needed to set the S&T policy direction for green technology development. To develop effective green technology development policies and strategies, a thorough review of various issues related to "low carbon green growth" within and outside of Korea should proceed. By reviewing the best practices of advanced countries that started the pursuit of green growth policy earlier than Korea, and by fully understanding socioeconomic opportunities stemming from green growth, as well as technological challenges in this process, the Korean government needs to systemize and elaborate its strategic direction and pursue systematic green technology development, technology transfer and commercialization by developing and implementing leading S&T policies in the public sector.

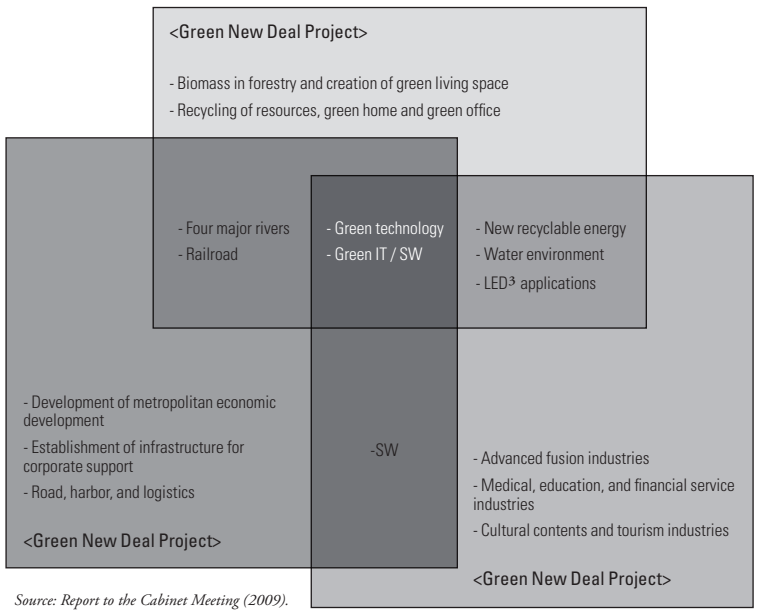
[1] Office of Climate Change. "The Stern Review on the Economics of Climate Change." UK. 2006.

2. CURRENT STATUS OF GREEN TECHNOLOGY R&D PLAN

Green New Deal Project (Jan. 6. 2009)[2]

Green New Deal policy is aimed at creating jobs by building a green economy. It is, both, a short-term temporary measure in response to the recent economic recession and a mid/long-term policy to secure growth engines. Green New Deal Project is composed of i) Korean-style 'New Deal' projects, ii) new growth engine projects which have high relevance with green growth and high impact on growth and job creation, and iii) other green projects with high job creation impact.

FIGURE 1. GREEN NEW DEAL PROJECT AND ITS RELATIONS WITH OTHER PROJECTS



Source: Report to the Cabinet Meeting (2009).

Key areas selected include i) green SOC project, ii) low carbon high efficiency industrial technology development, and iii) environmentally-friendly green life and, in these areas, 27 sub-projects under 9 core projects are being implemented. For this purpose, the following 3 implementation strategies have been set up; i) job creation through selection and focus, ii) efficient role split between central government and private sector, and iii) speedy implementation of green life.

[2] Report to the Cabinet Meeting (2009)

TABLE 1 Key Projects of Green New Deal Project

Biotechnology	Nanotechnology
1. Reviving the four major rivers and refurbishing their surroundings	Refurbish disaster risk districts, "Clean Korea", greening of river areas
2. Establishing green transportation network	Build transfer facilities, express bus system, and nation-wide bicycling road network
3. Establishing IT infrastructure for green country	Build integrated national building energy management system, promote the use of e-documents, and computerize under-ground facilities
4. Securing alternative water resources and	Enter overseas dam construction business, develop desalination technology, recycle sewage treatment water construction environmentally-friendly mid/small-scale dams
5. Distributing green cars and clean energies	Secure technological independence in plug-in hybrid cars, develop and pilot distribute bio-ethanol technologies
6. Expand recycling of resources	Transform biomass and livestock excretion into resources, and maintain and develop landfills
7. Expand the use of forestry biomass	Utilize forestry biomass, prevent forestry disasters, recover damaged forestry, and construct agricultural and fishery theme parks
8. Diffusing energy-saving green home, green office and green school	Replace LED in public sector, build test-bed for IT technologies, and develop green home doctors
9. Creating clean green living space	Pursue green building, construct eco-road, and recycle idling facilities

Source: Report to the Cabinet Meeting (2009).

Master Plan for Green Technology R&D (Jan. 13. 2009)[4]

Master Plan for Green Technology R&D is aimed at improving Korea's green S&T capabilities to the level of advanced countries, creating jobs by strengthening the competitiveness of green industries, and joining the ranks of advanced countries in the environmental sustainability index.

This plan, not only covers the traditional green technologies that utilize environmentally-friendly resources like recyclable energy and clean energy, but also encompasses fused green technologies, which pursue the fusion of existing and new technologies or industries in the areas of IT (Information Technology), BT (Biology Technology), and NT (Nano Technology). The Korean government plans to increase R&D investment in green technologies by more than two times by 2012, and concentrate its investment on 27 key development technologies that were selected according to their contribution to economic growth and strategic importance. Basic development strategies to realize this plan include i) promote the fusion of green technologies, ii) expand the scope of basic originative research to green technologies, iii) pursue greening of existing industries and transforming them into new growth engines, and iv) build green technology infrastructure.

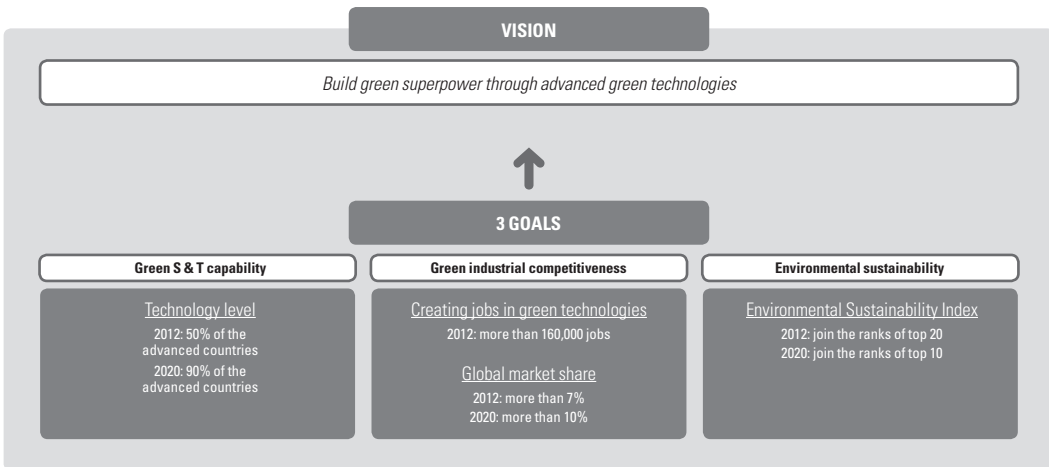
27 key technologies selected by the Master Plan for Green Technology R&D include i) forecasting technologies in climate change, ii) energy technologies related to solar cell, bio-energy and nuclear

[3] LED: Light-emitting diodes

[4] National Science and Technology Council (2009).

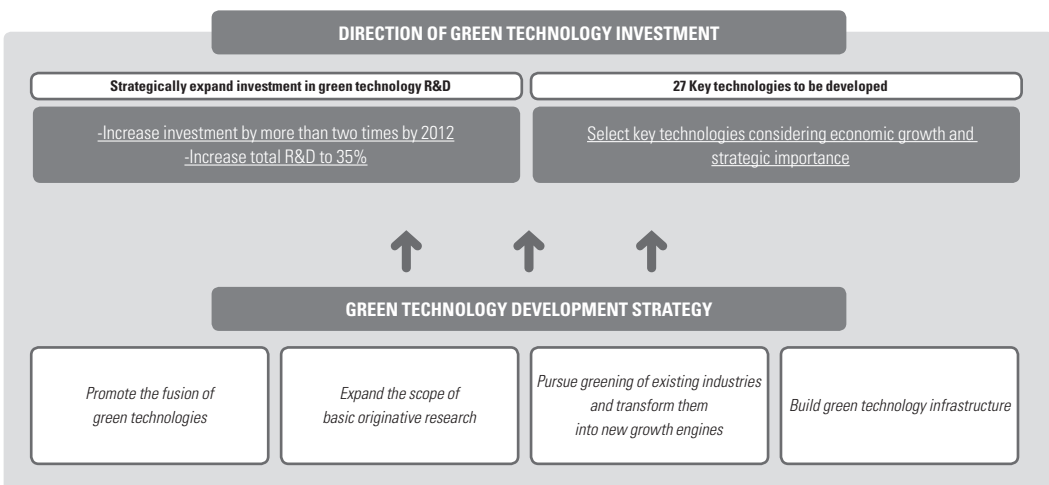
power generation, iii) higher efficiency technologies to help efficient use of existing energy sources, iv) post-treatment technologies to realize low carbon and minimize environmental pollution, and v) virtual technologies for pollution-free industrial economy.

FIGURE 2. VISION AND GOALS OF THE MASTER PLAN FOR GREEN TECHNOLOGY R&D



Source: National Science and Technology Council (2009).

FIGURE 3. DIRECTION AND DEVELOPMENT STRATEGIES OF GREEN TECHNOLOGY INVESTMENT



Source: National Science and Technology Council (2009).

TABLE 2 27 Key Green Technologies to be Developed

Forecasting technology	- Climate change forecasting and modeling development - Technologies to analyze the impact of climate change and to apply the analysis results
Higher efficiency technology	- Integrated coal gasification combined cycle (IGGC) - High efficiency low pollution vehicle technology - Intelligent transportation/logistics technology - Building eco-space and urban recycling technology - Environmentally-friendly low energy architectural technology - Green process technology considering environmental load and energy consumption forecasting rate - Lighting LED and green IT technology - Technology to improve electricity IT and efficiency of electronic appliances - High efficiency secondary cell technology
Pollution free industrial economy	- Virtual technology
Energy source technology	- High efficiency low cost silicon-based solar cell technology - Mass production of non-silicon-based solar cell and core originative technology - Bio-energy production element technology and system - Renovated light water reactor design and construction - Environmentally friendly nuclear nonproliferation fast reactor and nuclear cycling system development - Fusion reactor design and construction technology - High efficiency hydrogen production and storage technology - Next generation high efficiency fuel cell technology - Environmentally-friendly plant growth catalyst technology
Post-treatment technology	- Carbon capture/storage/treatment technology - Non-CO2 treatment technology - Water system quality evaluation and management technology - Technology to secure alternative water resources - Technology to reduce and recycle wastes and convert them into energy - Toxic materials monitoring and environmental cleaning technology

Source: National Science and Technology Council (2009).

Master Plan for New Growth Engines (March 26. 2009)[5]

In January 2009, the government announced the "vision and development strategy for new growth engines" and finalized 17 growth engines in 3 areas. Those seventeen growth engines are industrial areas, which will be materialized in 3 years, and thus, lead the nation's economy. The government plans to induce more active participation of the private sector by relating these growth engines to "Green New Deal" and "Green Technology R&D Project".

Last May, the "Master Plan for New Growth Engine" was announced as a plan to cultivate and develop new growth engines. According to this plan, over the next 5 years, total 24.5 trillion won will be invested in securing 17 growth engines in the fields of green technology industries, advanced

[5] Ministry of Knowledge and Economy (2009).

fusion technologies, and high value added services. These fields reflect the key areas of the government investment. It also shows the government's strategic choice in advancing the existing industrial structure. The seventeen new growth engines include more than 200 sub-projects, of which green technology industry will focus on developing high-risk, originative technologies and creating initial markets, considering green technology industry is still in its infancy. In the field of green technology industry, a total of 79 sub-projects will be identified and 6.7 trillion won will be invested.

TABLE 3 17 New Growth Engines in 3 Areas

Area	New growth engines	Rationale of selection	Category
Green technology industry	1. New recyclable energy	Capability to solve climate change and energy crisis; huge market potential	Long/mid/ short-term
	2. Carbon reduction energy	Respond to climate change and resource crisis; Korea's high potential	Mid/ long-term
	3. High water treatment	Relation with green growth; promising future market	Mid-term
	4. LED application	Energy saving and market potential	Mid-term
	5. Green transportation system	Down-stream/up-stream industrial impact and promising global market	Mid-term
	6. Advanced green city	Improving life quality and creating jobs	Short-term
Advanced fusion industry	7. Broadcasting/ telecom fusion industry	Domestic IT competitiveness and new market creation	Short-term
	8. IT fusion system	Improving competitiveness of major industries (shipbuilding)	Short-term
	9. Robot application	Down-stream/up-stream industrial impact and promising global market	Long-term
	10. New materials/ nano fusion	Creating industries essential to other industries and new industries	Long-term
	11. Bio- pharmaceuticals/ medical equipment	Promising global market and creating new industries	Long-term
	12. High value added food industry	Resolving future food resources and pursuing high value added	Mid-term
High value added service industry	13. Global healthcare	Creating jobs and new business models	Short-term
	14. Global education	Creating jobs and new business models	Mid-term

Source: Ministry of Knowledge and Economy (2009).

3. PROGRESS IN GREEN TECHNOLOGY R&D

Investment Performance in 2009

By ministry, the investment plan in green technology R&D shows the following rankings; the Ministry of Knowledge and Economy (45.8%, 894.8 billion won), the Ministry of Education, Science and Technology (25.3%, 494.4 billion won), the Ministry of Land, Transport, and Maritime Affairs (11.4%, 2232.3 billion won), and the Ministry of Environment (8.5%, 165.4 billion won). The Ministry of Knowledge and Economy focuses on developing green IT and green energy technologies, while the Ministry of Education, Science and Technology actively supports the development

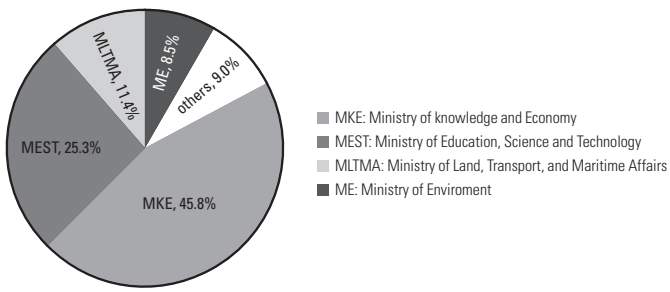
of green, basic originative technologies by universities and government-funded research institutes and the development of specialized research manpower in the relevant areas. The Ministry of Land, Transport, and Maritime Affairs has developed its investment plan focused on building eco-space and developing intelligent transportation and logistics technologies. In the meantime, the Ministry of Environment is focused on developing post-treatment technologies like reducing and recycling wastes.

TABLE 4 Summary of Green Technology Investment in 2009

Total R&D investment	Green technology R&D investment
12,343.7 billion won	1,954.7 billion won
(12.2%)	(35.0%)

Source: The Presidential Committee on Green Growth. "National Strategy and 5-Year Plan for Green Growth.", 2009.

FIGURE 4. RATIO OF GREEN TECHNOLOGY INVESTMENT BY MINISTRY IN 2009 (%)



Source: Ibid.

Progress by Ministry [6]

Ministry of Education, Science and Technology: According to the investment plan, the Ministry plans to invest 49.2% of its total R&D budget in energy technologies, including joint development of international nuclear fusion reactor and nuclear technology development project. The Ministry also plans to focus its investment on 14 basic and originative technologies, out of 27 total technologies, to pursue the development of basic and originative technologies that can break through the limitation of existing technologies and create new green industries. (e.g. developing originative technologies for next generation high efficiency solar cell, developing flexible solid-type film cell)

In terms of infrastructure building, to operate government-funded research institutes as the Mecca of green growth, the Ministry is concentrating its investment on strategic "Top Brand Project" (5.8 billion won) and "Degree and Research Center" (7 billion won), jointly formed by universities and government-funded research institutes. The Ministry also pursues innovative low carbon green urbanization in hub cities under the leadership of "Basic Science Research Center", by forming the "International Science and Business Belt" (7 billion won) (e.g. pursue joint research by attracting world renowned science brains and research centers).

[6] The Presidential Committee on Green Growth. "Plan for Green Technology R&D Implementation.", 2009

In the area of developing human resources and pursuing international joint research, the Ministry has invested 30.2 billion won for WCU (World Class University) Project and 35 billion won for BK21 (Brain Korea 21) Project, in order to develop research manpower specialized in green technologies. To form and operate specialized programs, the Ministry plans to increase the number of "SRCs"[7] and "ERCs"[8] in green technology research, from 7 in 2008 to 14 in 2012, open new programs for developing fusion-specialized manpower (2009), and run "Specialized Graduate School Programs" (2 billion won). In addition, the Ministry is operating the "Global Lab" Project, as well as the green technology cooperation program between Korea, China and Japan to further strengthen international cooperation in green basic and originative technologies.

Ministry of Knowledge and Economy: In R&D, the Ministry is pursuing greening of strategic technologies, green IT, and technology development in energy resources in 14 industrial source areas. Specifically, in the area of greening strategic technologies, the Ministry is focusing its investment on clean manufacturing-based technologies, green car originative technologies, high efficiency materials and environmentally-friendly bio-materials. In regards to green IT, investment is being concentrated on LED lighting, low power consuming semiconductor and display, energy savings using RFID/USN, and IT-based fusion technology. In energy and resources area, the Ministry is concentrating its investment on resources development, energy efficiency improvement, green house gas reduction and energy source technologies covering electric power, nuclear energy, and new recyclable energy.

When it comes to building infrastructure, RIC (Regional Innovation Center) project and regional strategic industry promotion project are being operated and pursued mainly in green technology areas.

In the area of developing talents and promoting international joint research, efforts are being concentrated on developing green technology manpower that can support green IT and green energy industrial policies, and continuously pursuing international joint technology development with advanced countries in green technology.

Ministry of Environment: In R&D, 67% of the Ministry's budget is being invested in post-treatment technologies, including technologies to reduce and recycles wastes and turn them into energy, water system quality evaluation & management technology, and technology to secure alternative water resources.

The Ministry is investing 150.8 billion won in 14 projects, including the "Next Generation Key Environmental Technology Development Project", and the "Environmental Healthiness Research Project". To support market-oriented green technology R&D for low carbon green growth, the Ministry is providing concentrated support for new investment in commercialization of green technology development (81 billion won in 2009), which includes low energy cyclical urban sewage treatment technology, feasibility study on underground carbon storage and soil bank complex, technology development for cleaning polluted soil with toxic heavy metals, and technology development for resource recycling.

To enhance systematic research in future-oriented basic and originative technologies, the Ministry is concentrating its investment on technologies that promote green industries including, new

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[7] SRC: Science Research Center

[8] ERC: Engineering Research Center

environmental fusion technology development project (38.8 billion won). Research on preserving and managing bio-resources, in preparation for the competition to secure bio-sovereignty and environmental basic and originative fusion technologies based on IT, BT, and NT, falls into this category. The Ministry is also making investments to strengthen R&D support in 3 key areas for discovering and developing new growth engines, which include biomass/wasters, water industry and pollution-free or low pollution cars.

In the area of infrastructure building, the Ministry is investing 13.5 billion won in expanding research infrastructure to strengthen environmental research capabilities focused on low carbon green growth.

In the areas of talent development and international joint research, the Ministry is investing 1.1 billion won to develop manpower specialized in environmental technologies and the needs of the market, as a way to respond to global environmental changes. To export advanced domestic environmental technologies, the Ministry is striving to diversify overseas markets and develop commercialization technologies to be applied to the local markets.

Ministry of Land, Transport, and Maritime Affairs: In R&D, the Ministry is focusing its efforts on driving low carbon green growth through fusion and combination of advanced technologies such as IT, BT, and NT in construction, transportation and maritime. About 81.6% of the total investment is being concentrated on high efficiency technologies in relation to eco-space formation and urban recycling technology, low pollution vehicles, intelligent transportation and logistics power system. A total of 222.3 billion won is being invested in 20 projects, including "Future Urban Railroad Technology" (50.3 billion won) and "Maritime Observation Infrastructure" (43.5 billion won).

TABLE 5 Focus Areas of Green Technology Development Investment by the Ministry of Land, Transport, and Maritime Affairs

Focus areas	Key implementation strategy
Advanced technology	Develop technology to construct advanced future green cities through forecasting/responding to climate change, restoring environment, and improving energy efficiency
Transportation	Build the foundation for low carbon green growth by developing technologies for high efficiency/environmentally-friendly future railroad system and intelligent transportation and logistics
Maritime	Focus on developing environmental technologies in relation to new recyclable energy, responding to climate change, and developing maritime environmental technologies

Source: Ministry of Land, Transport, and Maritime Affairs (2009).

Ministry of Food, Agriculture, Forestry and Fisheries: In R&D, the Ministry is concentrating its support on field application technologies that ensure environmental soundness and economic profitability during agricultural and fishery production and processing stages. These field applications include i) forecasting technologies (forecasting climate change in agricultural and fishery production environment and the analysis of the impact of climate change on production and income) and technologies to respond to climate change, new animal and plant pests, and infectious diseases common

to humans and animals, ii) eco-system restoration technology for sustainable agriculture and fishery and high efficiency technology (environmentally-friendly agricultural and fishery materials, environmentally-friendly process and product) to save energy and resources (fertilizer and pesticide).

The Ministry is also expanding its investment in advanced application of fused or combined technologies and industrialization to drive new growth engines by "upgrading and transforming existing technologies in agriculture, fishery and forestry industries into green technology". Turning agricultural, fishery and forestry wastes (excrements, waste wood) into resources, developing technologies using biomass, developing advanced green house construction technologies and specifications, developing closed-type nutriculture, and applying LED and other advanced materials to vertical farming are all included in this category.

As an infrastructure-building effort, the Ministry is supporting the construction of agricultural and fishery plants, which incorporate advanced greenhouse complex and building-type agricultural and fishery complex that utilize reclaimed land, like Saemangeum[9].

In the areas of developing talents and promoting international joint research, the Ministry is striving to develop advanced epidemiologic, diagnostic and prevention methods of animal diseases caused by climate and environmental changes through 6-county coordination. The Ministry is also conducting a study on a monitoring and quarantine system of major pests induced from Southeast Asia due to changes in the pathway of typhoon and climate change, which covers 15 countries in the Asian region.

Rural Development Administration: In R&D, to "create agricultural industry as a new growth engine by developing strategic green agricultural technologies" and to drive agricultural industry as an axis of green growth, the Administration is concentrating its efforts on i) responding to climate change and realizing low carbon agriculture, ii) realizing sustainable environmentally-friendly natural circulation organic agriculture, iii) Korean-style resource cycling organic agricultural technology, technologies to replace chemical fertilizers and pesticides, technologies to turn by-products into resources, technologies to support urban life agriculture, landscape and green village construction, and iv) strategic R&D necessary for creating future agriculture and food industries.

In infrastructure building, the Administration is providing policy support to gain public consent on food safety, globalization of the Korean cuisine, and gardening therapy. The Administration is also strengthening its efforts to build infrastructure for agricultural industry, including intelligent robot and system engineering and vertical farming.

In the area of talent development and international joint research, to make inroads into the overseas agricultural markets, the Administration is striving to enhance the value of national brands and build overseas infrastructure through talent development and international technology cooperation considering local circumstances. In addition, the Administration is working to enhance the national image and expand exchange of resources through overseas technology transfer and joint research while striving to create jobs for the youth, by enhancing global talent and implementing overseas internship program.

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[9] Saemangeum Reclamation Project creates lands of 40,100ha as constructing of total 33km sea dike in Gunsan, Gimje and Buan of Jeollabuk-do (Land: 28,300ha freshwater lake:11,800ha).

Korea Forest Service: In R&D, the Agency is focused on developing technologies to secure forest carbon sinks, technologies to measure and evaluate forest carbon fluctuation, technologies for long-term monitoring of forest ecosystem and climate change impact analysis, technology for evaluating the impact of forestry disasters caused by climate change, and technology to promote the use of wood-based biomass and wood materials. The Agency is also focused on securing, systematically preserving, and managing useful forest bio resources home and abroad.

As infrastructure building efforts, the Agency is constructing wood-based bio energy plants (supercritical water treatment) and building a greenhouse gas statistics system and a database of forest genetic resources.

In the area of talent development and international joint research, the Agency is supporting the following projects; developing methods for early selection of superior tree families for forest growth using metabolic substances (Calgary University in Canada), a study on forest destruction caused by air pollution (Geo-Ecosystem Research Institute of Mongolia), identifying characteristics of reoccurring backfire and developing fire management techniques (Kyoto University Disaster Prevention Research Institute in Japan), research on pine wilt disease prevention (Japanese Forestry Research Institute), research on methods of forestry carbon accounting and emission factor and activities (Japanese Forestry Research Institute), and monitoring of pilot development of tree and grass species to prevent deforestation (Chinese Academy of Forestry Science).

Other ministries:

TABLE 6 Key Action Plan by Ministry

Focus areas	Focus Areas	Key Implementation Strategy
Ministry of Culture, Sports, and Tourism	R&D	• Identify and develop core technologies related to virtual reality and virtual world (7.5 billion won) - By using virtual reality technologies, reduce socio-economic costs like energy consumption and environmental pollution and create new industries
	Infrastructure building	• Establish "Cultural Technology Research Institute" (0.5 billion won) - Fuse emotion, art and engineering by establishing a research institute in the field of virtual reality on the university campus and build the foundation for basic and originative technologies
Ministry for Health, Welfare and Family	R&D	• Improve life quality and build national health safety network by establishing an immediate response system to disease caused by climate and environmental changes - Identify causes of nation-wide pandemic diseases and develop technologies for diagnosis, prevention, and treatment of these diseases
	R&D	• Develop and implement "National Defense Green Innovation Technology Project"
		• Pursue the "Development of base technologies for environmentally-friendly/green energy"
		• Pursue the "Development of technologies for M&S based military operation and army build-up system"
		• Pursue the "Development of technologies for weaponry system based on low carbon/future energies" - Develop "Master plan and action plan for pursuing defense green technologies", develop an analysis paper on the level of green defense technologies, and research and analyze "foreign defense green market
	Talent development and international joint research	• Pursue the project of "developing experts in defense green technologies" - Support post-doctoral researchers in defense green technologies
		• Expand international joint research in green technology by activating international joint research - Actively identify/reflect agenda for international joint research or collaboration in basic research on defense

Korea Meteorological Administration	R&D	• Produce and supply high quality information on climate change science • Establish advanced forecasting system of a new paradigm pursuing the improvement of forecasting • accuracy through the interactions between weather forecasting model and observation system Build the basis for developing national standard climate change scenarios
	Infrastructure building	• Pursue industry/academia/research institute cooperation by cooperating with disaster research institutes • Attract and develop talents at the national meteorological research institutes - Attract and manage researchers to develop green technology base and policies
	Talent development and international joint research	• Develop ultra short-term forecasting system (McGill University, Canada) • International joint climate research (Russia, U.K., Australia, Japan, and Canada) • International ARGO project (Korea Ocean Research and Development Institute, National Fisheries Research and Development Institute)

Source: The Presidential Committee on Green Growth. "Plan for Green Technology R&D Implementation.", 2009.

4. INCREASE GOVERNMENT INVESTMENT IN GREEN TECHNOLOGY (GT) DEVELOPMENT AND ESTABLISH REASONABLE INVESTMENT STRATEGY

Increase Government Investment in Green Technology (GT) Development

As of 2008, investment in green technology development hovers around 10% of the government's total R&D budget. Thus, the Korean government has developed a plan to increase the ratio to 15% ,or 3.5 trillion won, by 2013. To achieve this goal, the share of R&D in existing funding sources should be expanded, and additional funding sources should be secured. For this purpose, the share of R&D in major funding sources such as Energy and Resources Project Special Account, Environmental Improvement Special Account and Power Industry Infrastructure Fund should be further expanded. The ratio of R&D in Energy and Resources Project Special Account needs to be increased from 11.5% in 2008 to 30%, by 2013, while that of Power Industry Infrastructure Fund should be expanded from 23.1% to 40%, during the same period of time.

In order to secure additional funding sources required for activating green technology development, the government needs to develop various measures including raising dedicated fund for green technology development by issuing government treasury bonds and utilizing technology fee collected from the existing national R&D projects..

In addition, the central government should develop measures to increase budget of the local governments to help them activate green technology development. Similarly, in order to promote investment tailored to the unique characteristics of the local provinces, the central government should set its R&D investment targets for regional green technology development. For this purpose, the central government needs to utilize systems such as grant, subsidy, and tax revenue allocation to local governments, incorporation of green technology development investment into the boundary of tax revenue allocation to local governments, and budget allocation according to the financial independence of local governments. The government should also come up with other measures like i) improving national subsidy system to support green technology development project, ii) applying differentiated subsidy rates depending on the project progress, and iii) newly launching special tax revenue allocation to support green technology development of local provinces.

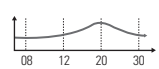
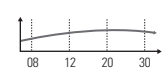
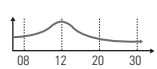
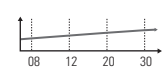
Develop Reasonable Investment Strategy for Green Technology Development

To develop reasonable investment strategies for green technology development, targeted strategies that reflect technology and market changes by green technology area are needed. The government is planning a concentrated investment in 38 total projects in 5 green technology areas by 2010. Specifically, they include 27 green technology projects for focused development: energy source technology (9), high efficiency energy technology (4), greening industry and space (5), environmental protection technology (8), pollution-free economic activities technology (1); 10 new green technology projects of individual ministries: energy source technology (1), high efficiency energy technology (2), environmental protection technology (6), pollution-free economic activity technology (1); and 6 new growth engine related projects: maritime energy technology development (1); and the remaining 5 projects are incorporated into similar projects among 27 key projects.

In addition, considering all the factors like the current investment size, technology level, and timing of commercialization, investment direction by technology should be presented based on the following four investment types.

The first type is concentrated investment over short-term. Silicon-based solar cell, renovated light water reactor, and lighting LED, which require immediate demonstration, distribution and timely market entry, all fall into this category. The second type is concentrated investment over a mid-term period. In general, technologies that need to secure the upper hand in the market by securing competitiveness over the mid-term fall into this category. Examples of these technologies include high efficiency low pollution vehicles, green process, secondary cell, Non-CO2 treatment, water system quality management, securing alternative resources, waste reduction, and virtual reality technology. The third one is a long-term concentrated investment. To develop world's leading technologies, concentrated investment is required over the long term. Technologies of this category include fast reactor, nuclear fusion reactor, hydrogen energy, environmentally-friendly plant growth, IGCC (Integrated Gasification Combined Cycle), urban reviving, environmentally-friendly architecture, intelligent power distribution network, CCS (Carbon Capture and Storage), and toxic substances. The fourth is long-term incremental investment. Technologies that need to secure basic and originative nature through continuous investment fall into this category, including climate change forecasting, impact evaluation and adaptation of climate change, non-silicon-based solar cell, bio energy, and intelligent transportation logistics.

FIGURE 5. INVESTMENT DIRECTION BY TECHNOLOGY BASED ON FOUR INVESTMENT TYPES

Investment Type	Investment Curve	Investment Type	Investment Curve
Short-term Concentrated		Long-term Concentrated	
Mid-term Concentrated		Long-term Incremental	

Source: Presidential Committee on Green Growth . "National Strategy and 5-Year Plan for Green Growth.", 2009.

5. BUILD EFFICIENT GREEN TECHNOLOGY DEVELOPMENT SYSTEM

Strengthen R&D Coordination to Improve Efficiency of Green Technology Development

To establish an efficient green technology development system, the so-called "Green Technology R&D Council", the highest-level coordinating body in green technology development, should be launched. In line with this, a system should be established to continuously review national green growth strategy and its alignment with 5-year development plan during the planning and implementation stages of green technology development. This means the overall planning and coordination function of national green technology development efforts currently being split among more than 10 government ministries should be established at the Green Technology R&D Council through collaboration with the Presidential Committee on Green Growth and the National Science and Technology Council. The Presidential Committee on Green Growth should be responsible for reviewing strategic linkages between national green growth plan and green technology development plan of individual ministries. Meanwhile, the Green Technology Committee, under the National Science and Technology Council (NSTC), should play the role of a coordinator, coordinating structuring and contents of green technology development plan of individual ministries. For this purpose, the Green Technology Committee, under the NSTC, should be elevated from a special sub-committee to the status of a specialized committee.

Establish Effective Coordination and Support System for Green Technology Development

For effective pan-ministerial coordination of national green technology development efforts, the tentatively-called "Green Technology R&D Board" should be formed and operated as a working-level body. Since this organization plays the role of a working-level supporter of the Green Technology R&D Council, it will help strengthen information exchange and cooperation at the working level between managing organizations. It will also help implement integrated operation of green technology R&D management information of each ministry by building networks among staffs of R&D institutes in charge of green technology under each ministry.

For mid/long-term, the tentatively-called "Green Technology Policy Center" should be established as a body dedicated to developing and coordinating national green technology R&D strategy. This center can be operated as an affiliate body of existing relevant research centers, which are neutral to the interests of their governing ministries, and not as a stand-alone organization. This center can be responsible for domestic and foreign technology trend analysis and technology forecasting in green technology, developing national green technology development plan and strategy, analysis of government's green technology R&D projects, and supporting green technology development coordination function.

6. STRENGTHEN THE BASIS FOR COMMERCIALIZATION OF THE RESULTS OF GREEN TECHNOLOGY DEVELOPMENT PROJECTS

Strengthen Government's Performance Management System of Green Technology (GT) R&D Projects

As the first step in building the foundation for commercializing the outcomes of green technology

development projects, the government should reinforce a GT R&D performance management system. As a means to implement this idea, the GT R&D performance management and evaluation system should be established.

First of all, in order to "establish R&D performance management system of green technologies", R&D performance should be monitored to check the progress and understand any bottlenecks, through due diligence, in the field. Based on annual progress reports, an R&D performance database should be established and the commercialization performance should be reflected in the selection of green R&D projects by allocating more than 10% of the total scores to commercialization performance. Especially, in case of application development projects led by universities or government-funded research institutes, among the evaluation criteria, the portion of registered patents and technology transfer should be expanded and performance management based on commercialization results should be pursed. Furthermore, a technology history system should be introduced to systematically analyze the entire life cycle of technologies by building a database of the whole history of technology development, and online patent management should be established and operated.

As the next step, in the process of "establishing green technology R&D performance evaluation system", GT R&D performance should be evaluated against the targets and the evaluation criteria should be redefined to better reflect commercialization results. In addition, commercialization progress and results should be tracked for a certain period of time (i.e. 3 years) after the completion of the project. Moreover, by providing preferential support for high performing companies in green technology commercialization when they pursue R&D projects or develop overseas markets, incentives for promoting green technology commercialization can be strengthened.

Build the Foundation for Promoting Green Technology Transfer and Commercialization

As another initiative to build a solid foundation for commercializing the outcome of green technology development, the government should focus on building the foundation for promoting green technology transfer and commercialization. For this purpose, investment should be expanded from 10.6 billion won, as of 2009, to 15.2 billion won, by 2013.

As a means to achieve this target, the government can implement the "customized packaged support for promoting green technology business rights and commercialization" and present "e-marketplace for market-oriented green technologies".

To be able to implement the "customized packaged support for promoting green technology business rights and commercialization", the government should research patent technology trends, build the foundation for patent map analysis, and provide seed capital for commercialization. When it comes to patent application and deliberation of green technologies, patent rights should be secured early on through the express track of deliberation and judgment, and a full packaged support should be provided for international patent registration, patent technology valuation and demo product manufacturing. In addition, for companies holding green patents, technology financing should be provided through "patent technology valuation guarantee system", and mentoring service on knowledge property rights should be offered to develop small but strong companies holding green technology knowledge properties. Regarding the issue of patent disputes, one-stop service covering intellectual property rights, laws, and accounting should be available to R&D implementing organizations through a counseling center for intellectual property rights. To prevent patent disputes, in advance, a monitoring system should be established and joint discussion channels should be operated by technology area.

In addition, the government should work on a plan to implement "e-marketplace for market-oriented green technologies", an expanded concept of the existing cyber marketplace that supports technology transfer and transactions. For this purpose, one-stop service system should be established by linking various existing support systems while providing various services, like review of green technology experts, producing technology PR videos, and holding technology briefing meetings. In the same context, overseas integrated IT system on environmental technologies and cyber overseas environmental exhibition system should be established for effective promotion of domestic green technologies in overseas markets. Moreover, based on the concept of "open-style technology innovation system", the success rate of R&D commercialization and investment efficiency should be enhanced, and an innovative business model of "transaction first and development later" should be developed. Taking a step further, through alliances with overseas open-style technology brokerage sites like NineSigma, the government should be able to provide technology demand information and matching service, help domestic green technology make inroads into overseas markets, support identification and commercialization of promising foreign technologies, and build infrastructure-like support organizations covering the entire life cycle of green technologies.

By holding the tentatively-called "Green Technology Fair" in 2011, the government should be able to provide total service including information on green technology outcome with potential for technology utilization and commercialization, corporate demand for green technology, and arrangement of financial support. As this fair is expected to provide rich information on green technologies and the evaluation results of excellent green technologies with patent rights registered through business negotiations and exhibitions, green technology transactions will be activated.

Lastly, to help early commercialization of green technology outcome, a pan-ministerial implementation system led by the Green Growth Committee should be reinforced through following activities; i) continuous review of national green growth strategy and its linkage with 5-year plan during the stages prior to commercialization, ii) coordination of commercialization policies of different ministries, and iii) designation and operation of dedicated organizations responsible for supporting green technology commercialization through green technology pilot projects and test bed projects.

7. BUILD-UP INFRASTRUCTURE FOR GREEN TECHNOLOGY DEVELOPMENT

Restructure Manpower Development Project by Green Technology Area

A talent development policy for green growth is often intermingled or overlapped with existing policies for cultivating talent in science and engineering or for new growth engines. In fact, a systematic understanding of the current status of green technology industries or their long-term prospect is missing. Moreover, R&D strategy is geared toward the technological outcome at the final stage. As result, a systematic talent development starting from the undergraduate level is not in place. Under these circumstances, the long-term direction of talent development policy is urgently needed. Due to the talent development policy focused on the roles and responsibilities of individual ministries, the government is now faced with challenges in developing high caliber manpower necessary for the era of fusion technology. Therefore, through linkages between human resources development efforts of different technological disciplines, HR(Human Resources) development policy should be considered as a national strategy. Since there is a strong call for pan-ministerial policy in pursuing green technology development from the perspective of technology fusion, one of the most important pol-

icy initiatives at this moment is to restructure the HR development system, which is, currently, being separately pursued by each technology area. For this purpose, it is necessary to establish a mid/long-term human resources supply and demand system, which considers different stages of industrialization in different green technologies. Based on the supply and demand forecasts, the government should design differentiated HR development projects by different stages of industrialization, strive to continuously evaluate the quantitative and qualitative fit of the developed talents with the industry, and reflect the evaluation results into the policy development.

Bring Up Core Research Manpower as a Foundation for Future

Green technology is high value added technology, whose essence is the fusion of new and traditional technologies. Considering that most of green technologies still remain at the early stage of R&D, the most important factor at this moment is the development of core researchers who will lead the future development. This implies the development of talents who capable of overcoming limitations of existing green technologies and achieving creative fusion of technologies. At the same time, a close linkage should be pursued between fusion technology R&D and HR development policy, as a way to explore new development areas. Based on the linkage between education and research, it is necessary to launch educational institutions specialized in green technology fusion in order to supply talents required by the fast-evolving area of technology fusion.

However, as was reviewed beforehand, the size of HR development project is meager, as compared with the current size of the R&D investment. As result, the size of HR development projects is relatively small and interdisciplinary programs linking education and research are not plentiful. Moreover, as green technology R&D has long been geared toward the delivery of final technological outcome, curriculum restructuring is urgently needed to systematically develop human resources for future-oriented green technology R&D.

Specifically, the government should, first, develop core research manpower through special-purpose graduate programs to increase manpower specialized in strategic areas. In this process, strengths in green technology of each university should be identified and graduate programs with systematic curriculum for green technology development should be launched and promoted. Among more than 3,800 university-affiliated research centers, those who have green technology potential, as well as new research centers, can be designated as green technology specialized R&D centers, and they can used as space for training of novice researchers of green technology through research faculty and post-doctoral programs.

Second, it is necessary to link education and research by activating cooperation between universities and research institutes. Specifically, more joint graduate programs by green technology area should be launched and operated between universities and government-funded research institutes. When excellent research resources and capabilities are combined, it will help establish cooperation models that link education and R&D.

Third, by providing support for leading research centers by green technology area, the government can leverage these research centers as hubs of joint research and talent development for green technology fusion research. By supplying high caliber researchers in science, engineering, basic medicine and pharmacy to these research centers, the government can expedite R&D in green technology fusion and facilitate the development of core researchers by technology area.

Fourth, it is necessary to promote globalization of green R&D manpower. Through the WCU (World Class University)[10] and the WCI (World Class Institute) programs, the government should be able to offer green technology-related majors and departments, attract high caliber foreign tal-

ents, promote world-class green technology research, and train the future generations in academic pursuits. In addition, through international joint green technology research efforts such as "Global Research Lab" and "ITER (International Thermonuclear Experimental Reactor)"[11], the government should be able to expand opportunities to acquire green technology competencies.

Implement the Program to Build the "Green TCS (Testing, Certification, and Standards) System"

To create green technology-related new industries, the tentatively-called program to build "Green TCS (Testing, Certification, and Standards) System" needs to be implemented. For objective evaluation of R&D results by key green technology area and the diffusion of the results, it is desirable to develop a common standardization plan for testing, analysis, and measurement. This common standardization plan should also gradually integrate and systemize individual components of green technology-related testing, certification and standards. For this purpose, it is necessary to develop a roadmap to secure testing, certification and standards by key green technology area in consideration of capabilities of R&D players like industry, academia, and research institutes and changes in the global environment. Once this roadmap is developed, then standard system of green technology can be established, and, based on this system, standards can be developed. This process should also cover the development of standards in response to climate change convention, promoting resource cycling and improving energy efficiency, and the redefining and development of standards for laying the foundation for green technology industries. At the same time, facilities and equipment for testing, certification and standards should be updated to international standards by key green technology area, and the scope of application should be further expanded. For this purpose, the level of facilities and equipments should be upgraded in accordance with the degree of public interests and future market growth potential. Along with this effort, the utilization of facilities and equipments of players of green technology R&D and commercialization can be improved. One of the possible approaches to drive the implementation of these measures is to make it mandatory for government ministries and agencies to develop plans for testing, certification and standardization when they pursue green technology-related government R&D projects.

Establish G-NTIS (Green-National Total Information System) and Database

It is necessary to build the G-NTIS and designate an overall coordinating institution responsible for analyzing green technology-related innovation activities and managing overall projects at the national level. Through this effort, the government will be able to configure green technology-related online portal system and develop and utilize various green growth-related indices by key area. In this process, a user-friendly database containing green technology-related information on technology, market, and industry can be established and efficiently utilized. Once this database is solidly built, business incubation using R&D information service will be activated and the database will be actively used in planning and implementation of the government R&D projects. In addition, it is desirable

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[10] The World Class University (WCU) is a program of KOSEF and supported by the Korean Ministry of Education, Science and Technology (MEST). The aim of this program is to transform Korean universities into world-class universities with a total budget of $1,155 trillion.

[11] ITER (the International Thermonuclear Experimental Reactor) is an international tokamak (magnetic confinement fusion) research/engineering project that could help to make the transition from today's studies of plasma physics to future electricity-producing fusion power plants.

to include greenhouse gas emission statistics and information system that is near to the advanced countries' level as part of the G-NTIS. Through this approach, cumulative statistics on greenhouse gas emission by technology, product, company and industry can be calculated and forecasting scenario models can be developed. These achievements will be offered to both public and private sectors, which will greatly enhance R&D and industrialization.

4. CONCLUDING REMARKS

Green growth, which is being actively pursued by the Korean government, has not been presented simply for fulfilling its obligation as a member of the international society. It was presented as a higher level, new growth paradigm of the Korean economy, so the strategic development of green industry through green technology development has now become a core component of the country's development. To more actively develop green technologies and industries, the following policy considerations should be made[12].

First, the first priority in developing green industry is to create a green market. This implies, both, the entrance of green products into the existing markets and creating markets for green products separately from the existing markets. The reason why this market creation is now possible is because increased income has elevated consumers' preference of green environment and the landscape of consumption is now being restructured toward green products. One of the direct approaches to create markets for green products is through environmental regulations. However, as was mentioned before, this might shrink existing economic activities, so it is desirable to adjust the degree and the speed of regulations.

Second, when developing "5-Year Green Growth Plan", the most important focus of the government was to expand investment in technology development. The Green Technology Development Investment Plan, developed on the technology roadmap, presents key technology areas as potential candidates for green growth. Therefore, to further elaborate a big picture, more detailed sub-plans should be developed for each area. For this purpose, value chain analysis is a must and investment in a certain technology should be made only when the decision is based on an in-depth analysis of economic opportunities, for example, how a certain green technology can be commercialized and in what economic situation it can be effectively utilized.

Third, the government should, not only create a green market, but also provide various supportive measures to allow private companies to freely enter the green market. One of the most important supportive measures is utilizing technology development. The Green New Deal Project of "supplying green cars and clean energy" and green technology industries as new growth engines share the same list of technology development items requiring investment. In all of the six areas of green technology industries, they cannot be evolved into industries without relevant technology development. So, if domestic technology development is not feasible, it is inevitable to rely on foreign technologies, which, however, is not desirable for the nation.

Fourth, recently, there have been active discussions over green technology certification system. The original purpose of this system was to secure differentiation of green technologies from other

[12] Jang, J. et al. (2010).

technologies by providing accurate information on green technologies. In the case of Korea, the grading system for energy saving has been implemented, but it needs to be further expanded. In addition, the carbon emission label system needs to be introduced. Since this is a system that officially recognizes the efficiency and social contribution of green technologies, it will play the role of a catalyst, promoting the market entry of new green technologies. Of course, it is not easy to predict whether this differentiation directly affects the consumers' choice. However, as consumers' recognition of environment diffuses, their preference of green technologies will increase, so it is necessary to provide minimum technical information required in the process.

Lastly, a systematic and comprehensive coordination of green technology R&D is needed. The need for comprehensive coordination has been raised in two aspects; one is to secure equality between different research disciplines and between different research methods and the other is to achieve balance between green market creation and green technology development. By establishing a comprehensive coordination system, the government can not only perform coordination at the macro level between green market creation and green technology development, but also adjust R&D targets and approaches, which will ultimately help maximize the efficiency of government investment. In order for this comprehensive coordination to be effectively implemented, an effective supervision and monitoring system over the relevant areas is needed.

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