Enhancing development and commercialization of Green technologies in the Republic of Korea

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Abstract

Technologies should be developed for commercialization. Companies developing technologies need to understand the needs in the market prior to commercialization and make efforts to faithfully meet them. Green technology should be commercialized according to green maturity of market which shall determine its successful commercialization. It is purposed to classify and investigate the green product market by green maturity of two parties, buyer and seller. Governmental policies should focus on low green maturity to promote green technology products. In addition, two Republic of Korean policies are introduced in this article. One is green certification to boost the green maturity of companies and the other is energy technology acceptance enhancement project to eliminate the obstacles of commercialization.

Introduction

The world has been going green. Every country has tried to reduce the greenhouse gas emission to keep pace with the climate change issue. Green technology is located in the center of this movement as it can make companies green throughout applying them to their manufacturing processes as well as products and offering opportunities to purchase green products, make people green throughout purchasing green products and make the society green in the long run. Green technology can function as mentioned above in the market through commercialization. Commercialization of green technology, important as much as its R&D, depends on the market condition (Slater and Mohr 2006). All green technologies, however, are not commercialized successfully.

It needs to understand why all green products are not commercialized successfully in the market. Companies should consider the market condition in the release of green products. It is not difficult to find products, even quality products, faded out of market just after releases. One reason of market failure is the market condition. That is to say, the market is not ready for the technology. As far as green technology concerns, the market readiness is characterized to be green maturity.

In this article, we shall classify and investigate the green maturity of market members, buyer and seller. Green maturity of consumers naturally creates the demand of green product and green market will flourish if companies try to meet the demand. On the contrary, if consumers have no interest on green product at all, even though companies release green products in the market, its market will not be successfully formed and green technology products will not be successfully commercialized. In addition, some cases shall be shown to boost the green technology development of suppliers and the green technology acceptance of consumers.

Classification of green product market

Market is typically composed of buyer and seller, in large. Buyer is the consumer and seller is the manufacturer in common. Two parties shall be classified by green maturity and four combinations are created as shown in Figure 1: green buyer and seller, green buyer and non-green seller, non-green buyer and green seller, and non-green buyer and seller.

Green buyer

It is the ideal and most developed stage of green product market that both are green. Each party is self-motivated and motivates the other so "the greener the better" statement is realized. Green companies can survive in the market as consumers preferentially purchase green products, so make efforts to develop green or eco-friendly technologies or products to meet the needs of consumers. As investment in firms based on environmental performance is well promoted, firms' green characteristics improve the corporate financial performance in the long run. Governmental intervention or support is not mandatory, can be minimized, as market mechanism goes well.

Green seller

Considering the gap between buyer and seller, the green seller and non-green buyer is investigated first. If seller is green but buyer is not green, it is difficult to commercialize green technologies as buyers have no willingness to buy them. Furthermore, if it is more expensive than non-green technologies the preference of buyers toward them will be very weak enough to make the commercialization of green technology difficult. That is to say, buyers are reluctant to purchase more expensive green products than non-green products. Consumers are thought to have little technology acceptance.

In this stage, the third hand, governmental support is necessary focusing on improving the understanding of the public on eco-friendliness. People should understand the need of eco-friendliness and what they should behave for environment. Financial support can be effective in raising the perception toward environment and making people's behaviors green in a short period, if possible.

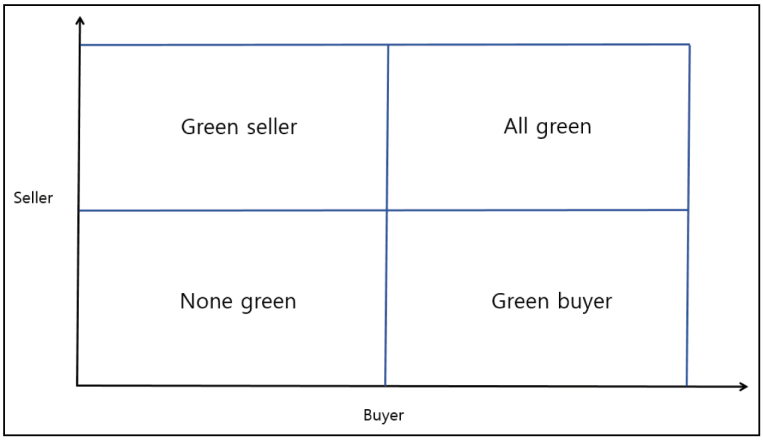


Figure 1: Four types of green market

Table 1: Ten fields of green technologies

1. Renewable energy	6. High-tech green house / city
2. Carbon reduction	7. Advanced materials
3. High-tech water resources	8. Clean production
4. Green IT	9. Eco-friendly agricultural and fishery food
5. Green vehicles and ships	10. Environmental protection and preservation

Source: www.greencertif.or.kr

Green buyer

The other case of gap between buyer and seller, green buyer and non-green seller shall be discussed. In this case, green consumer's role is very important in sustaining green products and coloring the market green. Consumers should purchase green or eco-friendly products to let companies develop and manufacture them. It can be regarded as the transition case to all green case. Consumers have the right to choose the proper manufacturer with the preference of green color in the competitive market so manufacturers should try to meet the green demand of consumers to survive in the market.

Governmental support should focus on promoting green technology development to keep pace with the demand. The role of government is to accelerate the green technology development for firms to timely provide the green technology products.

None green

If all players are not green, the government takes a crucial role in making both green. Governmental program should be launched for both to perceive the importance of green color. More specifically, the government should induce companies to develop and manufacture green technology products and promote the green movement of people, that is, consumers. As players have no willingness to become green, financial support can be very effective to boost the green characteristics in a short period. People can be enlightened through education and training.

This stage should move toward the ultimate "all green" phase and the route should be chosen. It depends on which player should be prioritized. If seller is preferred to become green, the strategic route will be "none green-green seller-all green". Otherwise, it will be "none-green buyer-all green". Government can make efforts to expand the environmental regulation which let firms and people green though it is an enforcement. Reinforced regulation constrains non-green behaviors of both.

The Republic of Korean government initiated the green growth policies in 2008. Two players were not green, so green finance was launched, prioritizing the seller, firms, and they have made efforts to develop and commercialized the green technologies in the market introducing the green certification policy in 2010.

Policies to boost green

1. Boosting green seller: Green certification in Korea (KIAT, 2017)

The Republic of Korean government initiated the green growth as a national motto by conceptualizing the green growth as a harmonized and balanced growth of the economy and environment in 2008. The Framework Act on Low Carbon Green Growth was provided in 2008 and enacted in 2010.

Under the green growth policy, it has made efforts to make core key industries green, foster low-carbon green industry, promote a green value chain, and maximize the synergy effects of both axes of the environment and the economy through the transformation of growth patterns and economic structure.

To promote the green technology development and green industry and overcome resource and environmental risks simultaneously as economic development has been accelerated such as the risk of resource depletion, intensified water shortage, increased greenhouse gas emission, and so on, the Republic of Korean government launched the national green certification certifying a green technology or a promising green project to clearly stipulate the object and scope of supporting green investment and concentrate on investment as part of the government´s low carbon green growth policy.

Green certification consists of green technology certification, green technology product certification, green project certification and specialized green enterprise certification. Ten fields of green technologies were pre-defined for certification shown in Table 1, which are mainly composed of technologies minimizing the emission of greenhouse gases and pollution. For certification, a technology is assessed mainly for technological excellence and green characteristics.

Green technology product is a commercialized product for sales that utilized green technologies and is certified by the Framework Act on Low Carbon, Green. It must utilize the green technology certified which evidently contributes to the

product function's manifestation.

Green project is defined as an economic activity related to green growth, such as installing green industry facilities and infrastructures, applying, propagating and spreading green technologies that have a significant economic and technical ripple effect. 105 businesses of nine fields were pre-chosen (Table 2). Feasibility of green technology, environmental expectancy effect and policy compatibility are assessed for certification.

Specialized green enterprise certification is a green company certification and specialized green enterprise is defined as a one-year-old or older company whose certified green technology has over 30% of the total sales turnover in the year prior to the application, where there are many certified green technologies. If the sum of individual turnover amounts is over 30%, the appropriate company may become a green company. Certification status as of August 2019 is presented in Table 3.

The benefits of green certification to companies are supporting the green industry loan, supporting the market reclamation and marketing, constructing the commercialization promotion system, and consulting the green certification. For small and medium enterprises (SMEs), green certification lets the participation in public procurement market easier than ever as a SME with a green certified product will get additional points by the recognition of green certification holding in the qualification assessment of Korean Public Procurement Service. Public procurement market participation is a good business opportunity to SME because it can stably create sales.

2. Boost green buyer: enhancing energy technology acceptance (KETEP 2019)

Technology acceptance model originated from the theory of planned behavior of Ajzen (1991) explains that the perception influences the attitude which impacts the intention and the intention affects the acceptances, so it is very important to improve the perception toward the technology if people have reluctance to use the technology (Figure 2).

R&D with no consideration on technology acceptance will confront the difficulty in commercialization in spite of its successful technology development. Technologies should meet the requirements from customers to be commercialized successfully (Zahra and Nielson 2002). Commercialization is very crucial in technology development for growth, so should be considered since developing the technology (Table 4).

Energy R&D recorded low commercialization rate[1] and showed the limitation of R&D focusing on technology development with no interest on commercialization. For recent decades, the budget of energy R&D has rapidly increased and the more interest of companies has improved the

Table 2: Nine fields of green projects

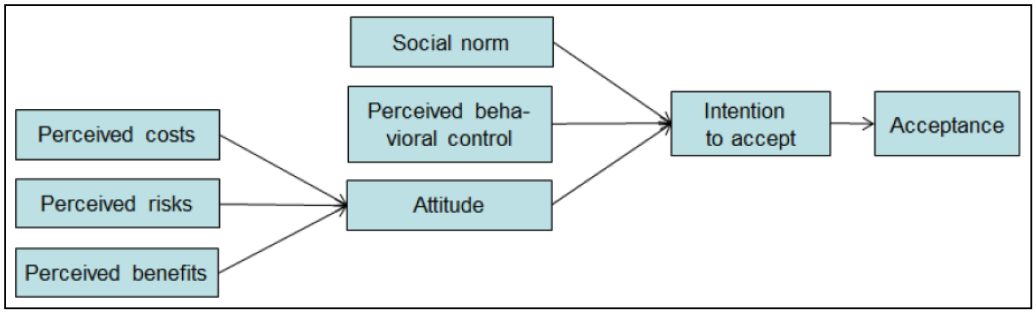
1. Propagating and spreading renewable energy
2. Building carbon reduction plants, systems
3. Developing, handling and managing high-tech water resources
4. Using and propagating green IT
5. Propagating and spreading green cars, green vehicles and systems
6. Propagating and spreading high-tech green houses, cities and infrastructure
7. Establishing the infrastructure for clean production
8. Supporting and supplying eco-friendly agricultural foods
9. Environmental protection and preservation

Source: www.greencertif.or.kr

Table 3: Status of green certification (as of August 2019)

Content	Green technology	Green technology product	Green project	Specialized green enterprise
Number of effective certifications	812	986	2	55

Source: www.greencertif.or.kr



Source: Hujiits, Molin and Steg (2012)

Figure 2: Technology acceptance model

[1] Average commercialization rate of energy technology is 26.6% for the period of 2009 to 2015 while the 46.5% in total (Chungangilbo, 2016).

Table 4: Differences from traditional R&D concept

	Traditional R&D	Enhancing the acceptance and R&D for commercialization
Goal	Assuring the technology competitiveness	Problem solving in the field and commercialization
Who	supplier	User & supplier
Characteristic	Indirect examination of market demand	Direct diagnosis and analysis of problems in the field
Support	Technology development	Development of technology as well as business

Source: KETEP (2019)

technology development performance of national energy R&D projects. However, commercialization outcome such as large market creation was so poor. It needed to converse the direction of R&D from competitive technology development to problem solving for commercialization. Total solution technical, political and economic is necessary to improve the commercialization rate, reflecting the field demand to R&D rather than recognizing the problem just in the laboratory.

Energy technology is a combined system with various devices, so there was a problem combination such as conflicts with local communities and economic problem during introducing and operating the system. Companies confronted the valley of death after R&D due to the failure of acceptance assurance, lack of fund, excessive marketing cost and so on (Barr, *et al* 2009). Therefore, the acceptance problem is very crucial in commercializing the energy technology.

Supplier-centered national R&D planning needed conversion to market-oriented. For the industrial technology whose market was well activated, the feedback of early adapters was utilized to product planning and improvement but energy technology market was not activated well so there were no early adapters enough to feedback.

Two types of problem solving approaches were applied for energy technology. The first one is to improve the problem of energy product or equipment on initial dissipation in the field and the other is to develop the energy product with diagnosing, analyzing and solving the acceptance problem of user or local area. For the first type of problem solving, target local area and target people such as users and related people were set and problems they thought were collected and analyzed. Solutions finally provided based on analysis results were implemented, which includes the improvement in equipment as well as business model. In the second type of problem solving, acceptance problems including safety, site, cost burden, conflict of interests, governmental approval and so on were diagnosed and solved through operating the open platform where users participate in.

The Republic of Korean government launched the project to enhance the acceptance of energy technology besides the energy technology development project in 2016. It focused on technology development meeting the requirements of customers while the previous R&D project pursues only to ensure the technological competitiveness.

The project to enhance the energy technology acceptance showed the high ex post satisfaction score, 84.1 on average, much higher than the ex ante score, 35.1 on average. The score rose through solving mainly lack of basic information and difficulty in access to field problems that were pointed out by offering explanation and guideline documents and letting experts directly access to field problems (Table 5).

Enhancing the renewable energy acceptance

Living lab was organized and operated and developed the user-friendly DIY product design and micro credit business model in 2017. It was provided to enhance the acceptance of mini photovoltaic equipment of below 1kW capacity for home use by finding the proper technology, education, and financing tool through citizen leading living lab. Distributed energy is still very important to enhance the renewable energy usage in the Republic of Korea as it costs less than the large scaled renewable energy generation facility in construction, installation and operation. To encourage the distributed renewable energy generation, the local government has provided the financial aid program in installing the equipment at home. Several households, however, were not willing to install the small photovoltaic power generation equipment, so it needed to eliminate the obstacles to improve the willingness and enhance the renewable energy use.

Small scale photovoltaic power generation system is normally weak in maintenance. The decline of trust towards the system due to the close of installation company, the use of poor-quality product, inappropriate execution and so on, and the rise of user complaint due to lack of information and systematic guideline to install and maintain the system were considered as the potential industrial threats. To resolve them, the complaints and opinions from users were collected first and both experts and users examined and analyzed together. Then, user manuals to install and maintain the system and malfunction case book to prevent the similar malfunction were developed and dissipated for enhancing the acceptance.

This project was progressed to develop the mini photovoltaic DIY system and the financial product with a local financial institution through citizen participation. Resident workshop was held seven times for four months and collected the village researcher who participated in three focus groups: 1) development of mini photovoltaic DIY system, 2) development of related financial product, and 3) development of education method in the kindergarten and advertisement method. Village backup center was established composed of seven village researchers who participated in the technical focus group and were thought to be highly skilled.

In the initial dissipation stage of mini photovoltaic system, several problems were

Table 5: Solutions of major projects to enhance the acceptance

Project	Problem	Solution
Improvement of the acceptance of welfare service through energy usage monitoring system	Lack of information	Providing the integrated guideline of operation and management of house energy
Enhancement of the acceptance of local citizens through high quality biogas	Difficulty in understanding the capability of product or service, in particular, facility operation	Providing the biogas guideline reflecting the requirement from users
Technology adaptation to Improve the energy efficiency and safety problem in the traditional marketplace	Lack of technological advance and explanation documents	Adapting the high efficiency technology and developing the product reflecting the opinions of people
Optimized model development to enhance the efficiency in energy usage in the facility horticulture	Lack of assurance of sustainability of maintenance and service delivery	Developing the optimized model to resolve the problems of users
Enhancement of acceptance of the dissipation of power generation system through providing the maintenance guideline of photovoltaic generation facility of small and medium scale	Lack of information	Providing the maintenance guideline
Development of guideline for installation and maintenance through diagnosis of performance of mini photovoltaic power generation system and field problems	Lack of information	Providing the guideline for problem diagnosis
Development of standard heat storage model to enhance the acceptance of photovoltaic facility	Access to field problems	Providing the standard manual for design, construction, maintenance of solar heat integrated heat storage system
Enhancement of acceptance for Building Integrated Photovoltaic System (BIPV) installation and dissipation	Lack of information, user convenience and explanation document	Providing the guideline of BIPV design and construction improvement, BIPV performance test standard and method, suggesting the policy to support the BIPV and BIPV economic feasibility evaluation standard
Dissipation of energy saving method in the small store	Difficult access to field problems	Introducing the diagnosis and monitoring system of refrigeration system
Enhancement of acceptance through small and medium scale ESS installation, operation, and maintenance	Lack of information	Developing the program to calculate the ESS capacity and expected profit. Providing the ESS guide and information system

Source: KETEP (2019)

found difficulty in citizens' information access, economic burden, lack of function and convenience in the system, which showed it was a supplier-centered business. For the purpose of diagnosing, analyzing and resolving the obstacles in dissipating the mini photovoltaic system, this project overcame the limitation of existing top-down approach through bottom-up approach where local residents directly developed mini photovoltaic system and financial product through living lab. The most distinguished one is that people participated in developing the financial product, My Home Solar Loan, together with local credit union to minimize the economic burden. It had no interest rate on loan, so people reduced the installation cost burden. It is one of the best collaboration models with financial institution. Throughout this project, people resolved the misunderstanding toward photovoltaic system. Some worried about the electronic wave so empirically measured it altogether with experts and resolved their concern.

This project recorded the lowest ex ante satisfaction score, 13.3, before launching the project, but its ex post score skyrocketed to 98.8 after finishing the project. Thus, it is very important to resolve the inconvenience and problems of users in enhancing the acceptance.

Technology adaptation to improve the energy efficiency and safety

It was proposed to enhance the acceptance through pursuing the energy efficiency and improving the safety in the traditional marketplace and current status, problems, and requirements were examined and analyzed. Then the solution was provided: development of gas detector with Internet on Thing (IOT) based Volatile Organic Chemicals (VOCs) gas sensor to prevent the electricity fire and fire prevention system for traditional marketplace.

Merchants in the traditional marketplace used the low efficiency LED lightings due to economic burden and the marketplace is very weak to electricity fire because of old electricity facilities and disordered wire work, and non-systematic safety management. To resolve problems, high quality and low-price LED lightings and VOCs sensor module for fire detection were newly developed and installed. Developed products shall be applicable to other traditional marketplaces as they have similar circumstances, which will let the commercialization easier.

Conclusions

As we have shown above, it needs to examine the green maturity in the market prior to commercialization if you are going to commercialize green technologies. No or little needs toward green technology occurs market failure even though green technology is already developed and launched in the market. To minimize the market failure, the examination of target market is a pre-requisite before launching the products.

It also needs to develop green technology considering commercialization. Technology development due to intellectual curiosity might offer developer the satisfaction in the mind but not offer the fund for further development. Therefore, commercialization should be considered to sustain the technology development as well as survive in the market.

Governmental effort is required to boost the green technology commercialization. Successful commercialization provides the internal fund to develop additional green technologies and reduces the government's budgetary burden for R&D project in the long run, so government should make efforts for companies to commercialize green products successfully.

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