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Korea's policies, R&D investment and competitiveness in the LED industry

韩国在光敏二极管行业的政策，研发投资和竞争力

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Abstract - **The Korean government released its plan to carry out intensive short-term investment in LED-related R&D projects to develop LED as a growth engine for Korea in the near future. It also announced ambitious goals regarding how to support LED technology and distribute it. In addition, it designated LED as a suitable business for small- and medium-sized enterprises (SMEs) to encourage the development of SMEs in the field. However, Korea's LED industry faces difficulties because of strong challenges from globalized multinational companies and the lack of fundamental technology. This research is to review Korea's LED policies and plans, its R&D investment in the field for years, and its competitiveness so as to assess the correlations of the three. The amount of R&D investment in the field can be a clear example of the government's support to nurture the industry and its competitiveness in the LED industry can be a good index to determine whether such investment is successful or not. Lastly, the research provides some suggestions for the vitalization of the LED industry in Korea.**

Keywords - **LED, Policy, R&D investment, Competitiveness, Korea**

I. INTRODUCTION

LED (Light-emitting diode) lighting is a lighting fixture consisting of a LED light source and module. It has advantages such as long-life and highly efficient lighting, which contribute to reducing energy consumption and CO2 emissions. Because of these advantages, the Korean government designated it as one of 27 Core Green Technologies [1] (NST, 2009). And the Korean government planned to promote the domestic LED industry as an export-led green industry through intensive short-term investment which can lead to improved price competitiveness and localized technology (PCGG, 2009).

However, the Korean LED industry experiences a lot of difficulties as, basically, it lacks fundamental technology and is aggressively challenged by foreign businesses equipped with vertical integration, high quality and low cost. Moreover, there was a serious conflict between SMEs and large businesses over the issue of designating the industry as an SME-suitable industry, which, some evaluated, might further lower Korea's LED competitiveness. In this regard, it is required to evaluate the current situations from diverse perspectives as they happened despite the government's policies to nuture the industry.

This research is to review the Korean government's policies and plans to develop, and distribute LED technology. It deals with the government's R&D investment in the field for years

[1] 27 core green technologies are as followings. (1) Monitoring and modeling for climate change (2) Climate change assessment and adaptation (3) Silicon-based solar cells (4) Non-silicon based solar cells (5) Bio energy (6) Light water reactors (7) Next-generation fast reactors (8) Nuclear fusion energy (9) Hydrogen energy (10) Fuel cell (11) Plant growth promotion (12) Integrated gasification combined cycle (13) Green cars (14) Infrastructure for intelligent transport and logistics (15) Green city and urban renaissance (16) Green buildings (17) Green Process technology (18) LED/green IT (19) IT-combined electric machines (20) Secondary batteries (21) CO_2 capture, storage, and sequestration (22) Non-CO_2 sequestration (23) Assessment and management of water quality (24) Alternative water resources (25) Waste reduction, recycling and energization (26) Monitoring and processing of hazardous substances (27) Virtual reality

and its competitiveness so as to assess the correlations of the policies, R&D investment and competitiveness. The amount of R&D investment of the government in the LED industry can be a clear example that shows the level of the government's nurturing policies. Its competitiveness in the LED industry, which is the result of such investment, can be an important index to determine whether the investment is successful or not. Through this, the research also provides some suggestions for the vitalization of the LED industry in Korea.

II. METHODS

For this study, three different aspects were examined: national LED promotion policies and plans, government expenditure on LED R&D, and the level of LED technology. First, the national master plan released by the government and its reports on LED were reviewed.[2] It also goes over the issue of designating the LED industry as an SME-suitable industry because the SME-suitable industry designation scheme has a lot of impact on Korea's LED industry. Second, the government's expenditure on LED R&D in Korea was analyzed. The national R&D database named 'National Science & Technology Information Service (NTIS)' was used. It is a portal service offered by the National Science & Technology Council and provides information on national R&D projects including R&D-related businesses, projects, human resources, lab equipment & devices, research outcomes, etc.[3] Third, the competitiveness of Korea's LED technology was assessed compared with those of major developed countries. Finally, based on the analysis, this study suggests some points for policies to promote the LED industry.

III. NATIONAL POLICY AND PLANS FOR THE LED INDUSTRY IN KOREA

3.1. NATIONAL STRATEGY TO PROMOTE THE LED INDUSTRY

The previous Korean government (Feb. 2008 ~ Feb. 2013) announced "Green Growth" as a national agenda and emphasized green technology which could facilitate not only economic development but also environmental conservation. It designated LED technology as green technology that should be quickly developed, demonstrated, distributed and timely commercialized through intensive short-term investment. By localizing LED components and enhancing their price competitiveness, the LED industry was expected to be developed as a leading export industry of Korea (PCGG, 2009).

The Korean government set the goals for the world market share of Korean LED products at 20% and their luminous efficiency (210 lm/W) by 2020 (joint assessment by related departments, 2012). The LED Lighting 2060 Plan was announced where the national goals for the LED distribution rate would be 100% in public offices and 60% in the whole country by 2020. It was also planned to improve LED efficiency and decrease its price through increased R&D investment, to enhance consumer awareness about domestic LED lighting through follow-up services, and to establish a collaboration system between large companies and SMEs (MKE, 2011). Under the National Energy Master Plan 2.0, all lamps installed in subway, tunnels, public offices and passenger terminals should be replaced with LED ones by 2020.

3.2. DESIGNATION OF LED AS AN SME-SUITABLE INDUSTRY

Designating LED as an SME-suitable industry was an important issue in the Korean LED market in that it substantially affects Korea's competitiveness in the industry. The Korean government introduced the SME-suitable industry designation scheme in 2011. It is aimed to foster the competitiveness and growth of Korea's SMEs by restricting the entry and expansion of large companies into the field. And LED production was included in the scheme in November 2011. After the decision, large companies' sales and production of LED and its components in the consumer market were prohibited in Korea except for multi-faceted reflector (MR), parabolic anodized reflector (PAR), and bulb type LED. It was expected to ease economic polarization between large companies and SMEs in the LED industry. However, there was a serious conflict between them over the policy. While SMEs supported the scheme, large domestic companies opposed it. Large companies insisted that domestic SMEs would play just a simple role of assembling parts in LED production while foreign companies would make inroads into the domestic market. Looking at the result after the designation, they insisted it was doubtful whether the scheme really contributed to improving domestic competitiveness and supporting the economic growth of SMEs in the domestic market. Actually, the competition among domestic SMEs in the LED market has become intensified and has made domestic SMEs concentrate on producing low price LED products. This caused an invasion of foreign LED companies with low-priced, high-quality LED products and the deterioration of the technological competitiveness of SMEs. It was reported that foreign LED companies occupied up to 60~70% of the consumer LED market in Korea (KCCP, 2013).

In January 2015, the Korean government finally cancelled the designation of LED as a suitable market for SMEs. In line with it, large domestic companies and SMEs made a 'cooperation agreement for the development of LED lighting

[2] The statistics related to the distribution of LED in Korea hasn't been properly accumulated by the government yet so this research doesn't deal with the evaluation on it.

[3] NTIS homepage (http://www.ntis.go.kr)

products' without government enforcement to strengthen global competitiveness of the Korean LED industry and promote mutual cooperation. (KCCP, 2015). According to the agreement, large domestic companies would not enter the domestic LED procurement market until 2018, making an effort to promote the domestic LED industry through signing an Original Equipment Manufacturing (OEM) and/or an Original Design Manufacturing (ODM) with SMEs.

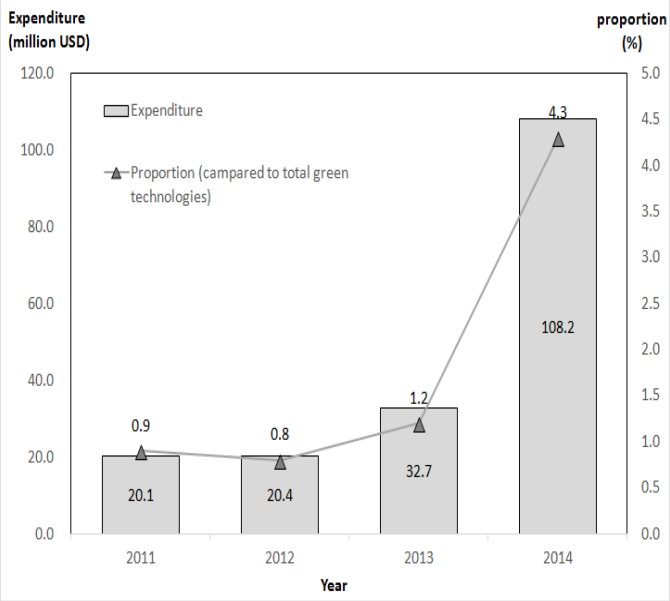
This agreement could be reached because of the understanding that it is necessary for the two players to cooperate for the vitalization of Korea's LED industry and mutual growth and prosperity. In fact, the global LED lighting market is dominated by three major lightning companies - namely Osram, Philips and GE - which strengthen their competitiveness through vertical integration (Sanderson et al, 2008). Against this backdrop, it is essential to establish such collaboration system in Korea. In fact, there used to be some attempts led by large companies to achieve vertical integration in the Korean LED industry; however, such plans were given up in the middle or substantially changed soon. It was because the vertical integration by large domestic businesses didn't create much comparative advantage while foreign businesses entering the Korean market could expand their production capacity and lower production costs through it. In this regard, it is necessary to strengthen collaboration between SMEs and large companies so that such close cooperation can produce advantages like the ones vertical integration can create.

IV. Government Expenditure on LED R&D in Korea

4.1. Annual Government Expenditure on LED R&D in Korea

Annual government expenditure on LED R&D[4] in Korea and its relative proportion to total government R&D expenditure on green technology between 2011 and 2014 are presented in Fig. 1. The Korean government spent 20.1 million USD in 2011, 20.4 million USD in 2012, 32.7 million USD in 2013 and 108.7 million USD in 2014, accounting for 0.9%, 0.8%, 1.2% and 4.3% of annual total government R&D expenditure on green technology respectively. During the period from 2011 to 2014, the rate of government expenditure on LED R&D had increased by 5.4 times. It is quite a big figure considering the fact that Korea's total R&D investment in green technology increased by 1.1 times during the period. (MSIP&GTC, 2014). Such huge increase in the government's R&D investment in LED fit its policy to nurture the industry.

[4] Ministry of Science, ICT and Future Planning (MSIP) and Green Technology Center (GTC) provide a report including annual government expenditure on green technology.



Source: MSIP & GTC (2015)

Fig.1, Annual government expenditure on LED R&D in Korea between 2011 and 2014

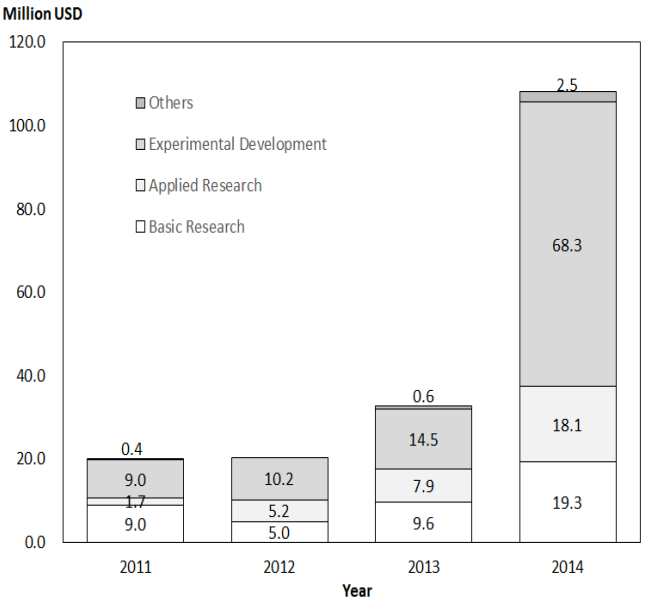
4.2. Annual Government Expenditure on Different Stages of LED R&D

Depending on R&D stages, the national R&D could be classified into 'basic research', 'applied research' and 'experimental development' (OECD, 2002). Investment in basic research is the investment to support theoretical or experimental researches to be conducted to acquire new knowledge of natural phenomena or observable facts without any particular use or application. Private enterprises invest in basic research to prepare technologies required for the next generation. Applied research is the creative study to obtain the new scientific knowledges for specific practical aim or objective and typically utilizes results obtained from basic researches. The business enterprise sector creates new project to explore promising results of basic research program. The results of applied research are typically valid for limited number of products, methods, operations or systems. Experimental development is systematic work to improve those already produced or installed or to produce new materials, products and devices through knowledge gained from basic research, applied research and practical experience.

The annual government expenditure on different stages of LED R&D in Korea between 2011 and 2014 is shown in Fig. 2. A large amount of LED R&D budget was used for the stage of 'experimental development' research in Korea, ranging from 44.3% ~ 63.1% of total government expenditure on LED R&D annually. The share of experimental development increased greatly at 63.1% in 2014. Such increase can be interpreted as the result of the Korean government's LED promotion policies, one of which considered LED lighting as the technology needed to be developed, demonstrated, and distributed within a short period of time. (PCGG, 2009). In order to obtain a tangible outcome, the Korean government

intensively invested in LED R&D, especially in the stage of 'experimental development' research.

However, in order for LED technology to be a real growth engine, Korea should have fundamental technology. It can be possible by expanding investment in basic research among the four LED R&D stages. As Korea's LED R&D is concentrated on experimental development and Korea's LED companies fail to obtain fundamental LED technology, the investment hasn't made noticeable results like the industry's growing rapidly and becoming a growth engine as the government expected. In this regard, it is very important to increase LED R&D budgets for 'basic research not only for the development of the LED industry, but also for the development of next-generation LED products in Korea.

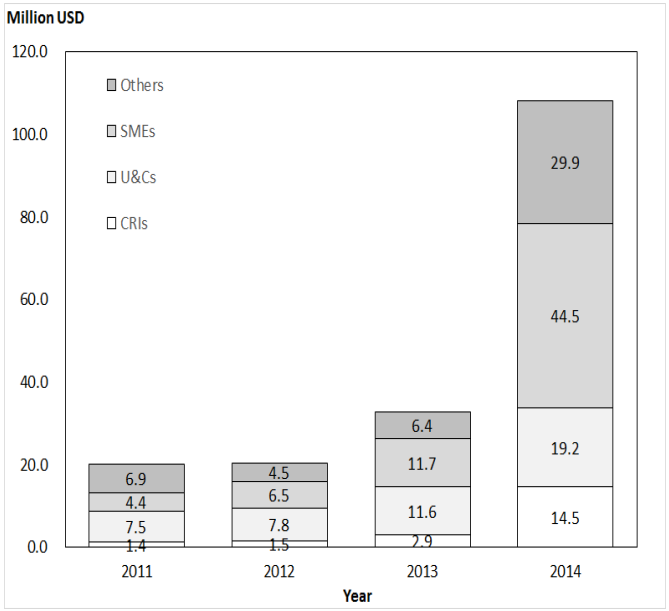


Source: MSIP & GTC (2015)

Fig.2, Annual government expenditure on different stages of LED R&D in Korea between 2011 and 2014

4.3. Annual Government Expenditure on LED R&D Led by Different Institutions and Companies

In Korea, most national projects for LED R&D are carried out by Combined Research Institutions (CRIs), University and Colleges (U&Cs), and SMEs. Others include Public Research Institutions (PRIs), Large Enterprises (LEs) and High Potential Enterprises (HPEs). As presented in Fig. 3, 37.1% and 38.4% of annual total government expenditure on LED R&D in 2011 and 2012 were allocated to U&Cs respectively, contributing to its highest proportion of R&D activities in Korea. Then from 2013, SMEs started to take the largest share and it reached at 41.2% in 2014. This seems to be affected by the decision of the Korean government to designate LED production as a suitable business for SMEs.



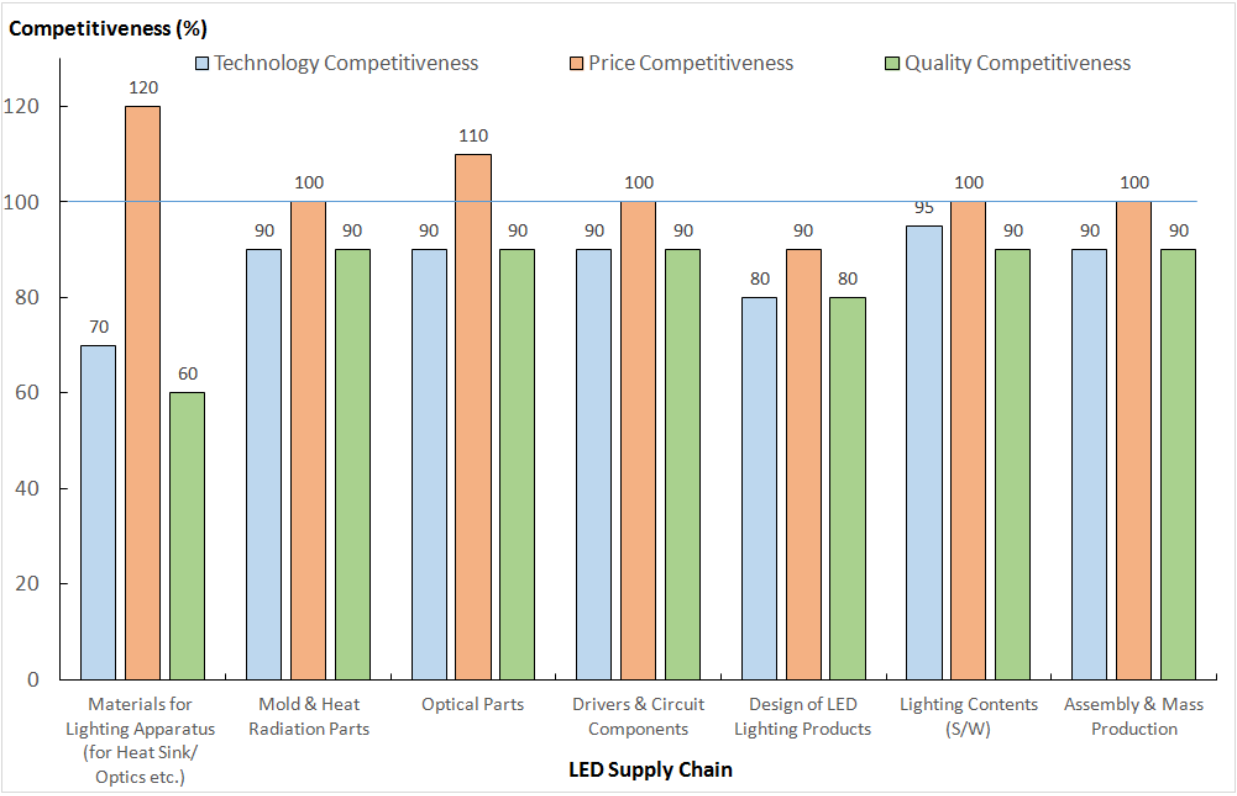
Source: MSIP & GTC (2015)

Fig.3, Annual government expenditure on LED R&D carried out by different institutions and companies between 2011 and 2014

V. Competitiveness of Korea's LED Technology

It is a global trend to make a high-efficient, low-priced LED lighting. Competition among LED companies is more intensified than ever before, especially in the field of lighting modules and lighting engines. At present, Korean companies have LED technologies with 190lm/W of luminous efficiency and over 50,000 hours of lifetime and have made efforts to improve energy efficiency and price competitiveness of LED products.

This study evaluated the competitiveness of Korean LED lighting products by comparing it with those of major developed countries. Fig. 4 shows Korea's technology competitiveness, price competitiveness, and quality competitiveness on different stages of the LED supply chain against major competitors, namely, the US, Japan and European countries (Germany, Italy, the Netherlands, etc.) As shown in Fig. 4, Korean LED price levels are quite competitive in comparison to those of major developed countries. However, the competitiveness of Korean LED product's quality and technology is relatively inferior to those of major developed countries. In addition, the localization ratio of LED materials is only 40% in Korea, while those of chips, modules, optical parts and heat sinks used for LED production are 60 to 80% (KAPID, 2014). The reason why the competitiveness of Korean LED materials is low is that Korean companies do not have enough fundamental technology. The Korean LED industry lacks fundamental technology such as a LED packaging technology and has a



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※ Values in each column denote the relative competitiveness of the Korean LED technology compared with the level of the best technology (100) in each supply chain
Source: KAPID (2014)
Fig.4, Levels of competitiveness of Korean LED technologies

vulnerable infrastructure for the promotion of the LED market. In order to develop related technology and the quality competitiveness of Korean LED products, it is necessary for Korean LED businesses to develop fundamental LED technology. It is a fundamental way to promote the Korean LED industry and win over fierce global LED competition.

VI. Discussion & Conclusions

This study analyzed Korea's national policies and plans for LED R&D, annual government expenditure on LED R&D and the competitiveness of LED technology in Korea for the past years. In terms of policies and plans, the Korean government designated LED technology as the one that should be quickly developed, demonstrated, distributed and timely commercialized, set up goals to achieve regarding the level of LED technology and distribution and established plans like requiring the installation of LED lighting in public places. In addition, it designated the LED industry as an SME-suitable industry and tried to encourage the development of LED by SMEs. Such plans were reflected on its intensive short-term investment which led to the substantial increase in LED R&D investment by the government and increased share of SMEs in LED R&D investment.

However, in spite of the government's efforts along with intensive short-term investment, the LED industry in Korea is in trouble due to lack of fundamental LED technology. In addition, a large portion of Korea's LED market is occupied by aggressive global companies with low-priced, high-quality products and the competitiveness of Korean companies has been much weakened. It seems to be the result of Korea's R&D investment which was concentrated not on basic research but on experimental development research, which led to the difficulties in developing fundamental LED technology.

Based on this, two suggestions can be made for the vitalization of the LED industry in Korea. First, the government should expand its R&D investment in basic research so that Korea could obtain fundamental technology. Moreover, regarding LED chips, it can stimulate the development of next generation optical semi-conductor while utilizing Korea's highly advanced technology in memory semi-conductor and IT fields. Second, the government should help strengthen the collaboration between SMEs and large businesses in the LED industry, which started to collaborate with the recently reached cooperation agreement for development of LED lighting products. Through vertical integration, global players have acquired price competitiveness of LED lighting. The agreement could play a key role to cope with the market penetration of global companies with low-priced, high-quality LED products.

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