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Communication

In-depth analysis on R&D investment and strategy on PV in South Korea

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ABSTRACT

Photovoltaics (PV) is an eco-friendly and green technology, as a renewable energy source, with the aim of minimizing carbon dioxide emission into the atmosphere. The Korean government has financed various domestic installations as well as research and development (R&D) programs to enter and develop a lead in the worldwide PV market. In this study, R&D investments in the area of PV are analyzed in terms of the respective ministry, performer, research characteristics, PV materials and output levels in detail. The Korean government in the Fiscal year (FY) 2010 provided $178 million dollars from R&D funds for PV development. 74% of the R&D funds in the context of PV has been invested by the Ministry of Knowledge Economy (MKE). Expenditures for R&D programs in terms of PV are mainly funded by small-medium companies (40%), and the portion of the R&D investment in crystalline silicon solar cells is the highest in terms of materials. In spite of the high levels of R&D investment in PV, the output for commercialization was relatively lower compared to the R&D input in FY 2009–2010. With these results, we suggested to develop various solutions to improve the R&D investment efficiency for PV technology in Korea.

1. Introduction

Research and development (R&D) is generally defined as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2002). Potentially, it can have a highly momentous impact on economic growth and technology innovation. Because of this possibility, R&D in the field of science and technology is conducting and encouraging to secure higher levels of competitiveness in terms of cost and technology efficiency, compared to that of other institutions or countries.

Photovoltaics (PV) is an eco-friendly and green form of technology for power generation in certain 'materials' upon exposure to unlimited light. The materials of PV are largely categorized into crystalline silicon (c-Si) and thin films including silicon, copper indium gallium selenide (CIGS), cadmium telluride solar cells (CdTe), light-absorbing dyes (DSSC) and organic/polymer solar cells. The annual growth rate of cumulative installed PV power in International Energy Association Photovoltaic Power Systems Program (IEA PVPS) countries, from FY 2000 to FY 2010, was 48.3% (IEA, 2011). According to an IEA report, the countries in terms of R&D expenditure are ranked as follows; US, Germany, Korea, Japan, Australia and France. The major objective on R&D programs is to develop innovative and cost-competitive PV products. Thus, R&D investment strategies in the respective countries have been established, bearing in mind their environment and geographical features. For instance, materials development for long-term applications, attentiveness to PV and manufacturing process development have attracted most of the European funding in the 7th Framework Program (FP7) (IEA, 2010).

The effectiveness of R&D expenditure on energy policy has been studied in the previous works. (Tobias, 2012; Asami, 2004; Zhu, 2000). It was widely found that R&D expenditures support to develop innovative technologies as well as provide the necessary environment for policy-making. It is also known that the conversion efficiency on silicon solar cells exhibits a good correlation with R&D funds (Endo, 1998). In FY 2011, the DOE started the SunShot Initiative, a collaborative national initiative, to develop cost-competitive photovoltaic technologies by reducing the cost of solar energy systems by about 75% before FY 2020 (DOE, 2011). In Japan, the Ministry of Economy, Trade and Industry (METI) funded a public budget of 68.1 million USD in FY 2010. In FY 2010, the budget on photovoltaics mainly focuses on PV system-related R&D, demonstration programs and market incentives.

The main objectives of this study were to: (1) investigate the public R&D investment on PV in detail within Korea; (2) examine outputs in terms of research papers, patents and commercialization; and (3) improve R&D investment efficiency in the area of PV

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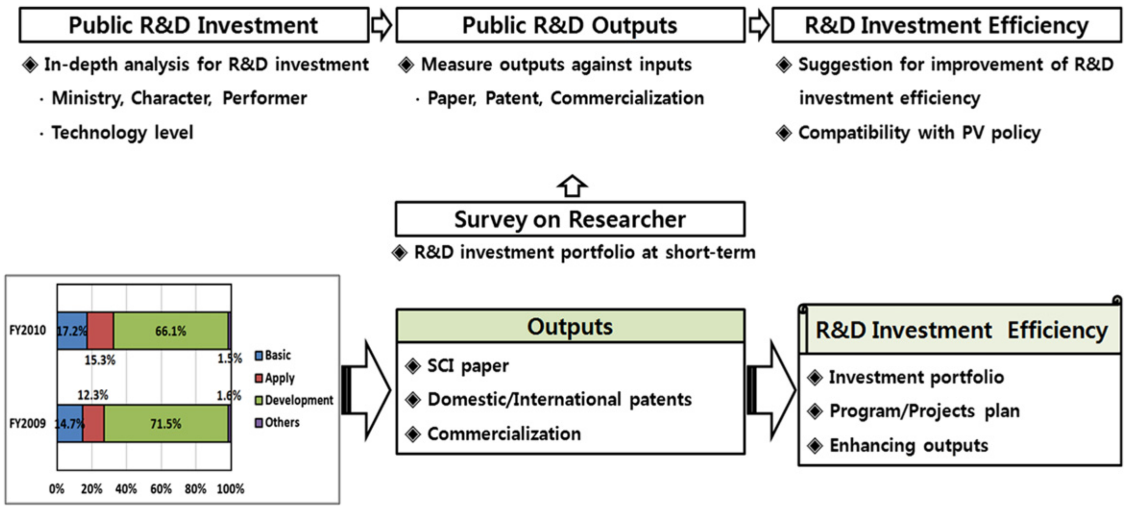

Fig. 1. Analytical framework.

by considering national renewable energy policies and research initiatives.

2. Method

The analytical framework of this study is illustrated in Fig. 1. The in-depth analysis for R&D investment on PV within Korea is firstly performed by collecting raw data, which is effectively funded by the government from FY 2009 to FY 2010. The Korean government has exclusively provided projects totaling 39,179 in FY 2010. Projects for PV including research, development, policy and training of human resources were extracted to analyze R&D investment via peer reviews. Secondly, R&D investment in PV has been quantitatively investigated with respect to the ministry, character of R&D, performer and materials. Here, the characteristic of R&D are categorized into basic research, applied research, development research and others based on the OECD Frascati manual (OECD, 2002)

The materials in the field of PV, described in the above section, are categorized into crystalline silicon and thin films including silicon, CIGS, CdTe, DSSC, III–V/concentration PV (CPV), organic/polymer solar cells and next-generation PV in this study. Lastly, output on PV within Korea, produced yearly, has been investigated in terms of research papers, patents and commercialization. The Science Citation Index (SCI) for papers, which is published by Thomson Reuters, is quantitatively calculated by dividing the number of authors in the papers. The numbers of domestic and international patents are calculated at technology levels. The amount of commercialization for technology transfer is also measured.

3. Public R&D investment on PV in Korea

3.1. Trends in public R&D

Table 1 shows the trends of public R&D on PV in Korea from FY 2008 to FY 2010. The R&D expenditures for PV technology, as one of the future energy sources, have continuously increased with an annual average rate of 44.8%. The R&D investment of $178 million, a 27.4% increase, has been funded for PV research. It is 2.7 times higher than that of the national R&D expenditures between FY 2009 and FY 2010. The solar PV funds per number of projects have gradually decreased from 0.34 to 0.33. It means that the funding for a particular project is being reduced as well as being diversified.

Table 1
Trend of R&D investment on PV (FY 2008–2010).

	FY 2008	FY 2009 (A)	FY 2010 (B)	B/A (%)
Fund (million $) (C)	85	139	178	27.4
# of projects (D)	222	405	535	32.1
C/D	0.38	0.34	0.33	

3.2. Public R&D by ministry

The R&D investment on PV is investigated by various Ministries in Korea, as is illustrated in Fig. 2. The six Ministries, including the Ministry of Knowledge Economy (MKE), Ministry of Education, Science and Technology (MEST), Small and Medium Business Administration (SMBA), Ministry of Land, Transportation and Maritime Affairs (MLTM), Ministry of Food, Agriculture, Forestry and Fisheries (MiFAFF) and Defense Acquisition Program Administration (DAPA), have supplied funds for PV projects in FY 2010. 75.1% of the total allocated R&D funding in the area of PV, a 0.2% increase, was provided by MKE in FY 2010. The MEST and SMBA are in pursuit, yielding 18.1% and 6.5% of R&D investment ratios, respectively. Other Ministries including MLTM, MiFAFF and DAPA provide less than 1% of R&D expenditures in FY 2010. Each Ministry is by and large providing funding in an effort to achieve its own set policy through R&D programs. However, there are no specific and large R&D programs designed in terms of PV within Korea. Sixty six of the R&D programs to do with PV in FY 2010 have been entirely supported by the six Ministries. An R&D program with the ratio (PV expenditure/total program funds) for each program has been calculated. The ratio of 39.4%, which is funded by the new and renewable energy program at MKE, is higher than that which is allocated for any other R&D program. As can be seen in Table 2, the number of R&D programs over $9 million is merely two. These R&D programs, including new and renewable energy in addition to regional industry supporting programs, are funded entirely by MKE in Korea.

3.3. Public R&D by character and performer of R&D

As described in Section 2, the R&D investment by character is analyzed in Fig. 3. Most of the R&D investment is in the form of development funding with 68.6% of the total funds allocated for PV, due to the large expenditure at MKE in FY 2010. Meanwhile,