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Determining the scale of R&D investment for renewable energy in Korea using a comparative analogy approach

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ABSTRACT

The rising price of fossil energy due to increasing global energy consumption has stimulated investment in renewable energy. Despite Korea's high dependence on foreign energy sources, it is well behind other developed countries with regard to renewable energy production. This study attempts to develop a reasonable R&D investment plan based on the forecasted diffusion of renewable energy in the Korean market by analyzing the experiences of other developed countries. The German market is selected as the reference case on the basis of its similarity to the Korean market. The realized data indicate that the growth of technology is proportional to cumulative R&D investment. A final investment schedule is established based on the goal of meeting the target penetration level. The suggested investment plan, which differs substantially from the plan recently announced, indicates the necessity of more active investment in early stage and supportive policies for R&D into renewable energy.

Contents

1. Introduction

Rapid industrialization of developing countries like China and continuous global economic growth has led to a drastic increase in global energy consumption. According to the “World Energy Outlook 2012” [1], global primary energy consumption is predicted to increase by more than 33% through 2035, and daily global oil

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consumption is expected to increase from 87.4 million barrels in 2011 to 99.7 million barrels in 2035, which would result in a price increase to $125 per barrel (in 2011 dollars). The global petroleum market has experienced a trend of rising prices; from $25 per barrel in 2001 to $98 in 2007, and recent spot prices have exceeded $100 [2]. This price increase could potentially affect Korea more severely than other countries, because Korea is not only one of the world's largest energy consumers (8th in total primary energy and 7th in oil), but is also a resource-poor country that imports more than 97% of total energy resources.

The rising price of fossil energy caused by the sharp increase in global energy consumption has focused attention on renewable energy as an alternative energy source. This increased focus has led to various supranational efforts such as ‘Sustainable Energy for All’ [3] and the ‘Earth Summit in Rio de Janerio’ [4], and many countries have started to develop relevant policies and invest in necessary facilities and R&D. Decades of efforts have achieved results to some degree. In 2011, the global investment in renewable energy reached $257 billion, which is 17% higher than that in 2010. Above all, renewable energy accounted for 44% of the newly added global generation capacity in 2011.

However, unlike advanced countries that have made dedicated efforts to develop renewable energy for more than 30 years, Korea still shows disappointing indicators regarding renewable energy. As of 2011, the contribution of renewable energy to total primary energy consumption in Korea was only 2.75% [5], which is far lower than the global average of 6%, including both developed and developing countries [6]. Beyond OECD countries, several developing countries such as China and India are far ahead of Korea in renewable energy. China is in a race with the United States to be the leading investor in renewable energy, and India has achieved the world's steepest growth in renewable energy with an investment of $12 billion in 2011, 62% higher than the previous year [6]. To reform the situation, the Korean government announced a $37.1 billion budget ($30 billion for technical supplies and $7.1 billion for development) as part of a master plan to escalate investment in renewable energy with the goal of a renewable energy penetration rate of 11% (3.03 TOE) [7].

However, experts and opinion leaders in the energy industry have raized concerns about the viability of the plan. Specifically, one of the most controversial questions is whether the amount of investment planned is sufficient to ensure that the target renewable energy penetration rate is achieved. It has been argued that the scale of investment seems insufficient compared to that of other countries, and that it is necessary to reexamine what the investment budget should be to achieve the goal of an 11% penetration rate of renewable energy by 2030. The present paper is motivated by this argument, which is critical to the success of the development of renewable energy in Korea.

To estimate the appropriate scale of investment to meet the target penetration level of renewable energy in a systematic manner, several factors should be considered, such as the cost drivers of technology development, diffusion processes, technological uncertainty, and market success. This is a complicated task requiring forecasting of the technology diffusion process and a good understanding of the relation between investment and the renewable energy penetration rate. As a first step, we examine the technology diffusion process. Generally, the diffusion process of a technology exhibits an S-shaped pattern [8,9], and is thus suitable for diffusion curves based on logistic [10], Gompertz [11], and Bass models [12]. Studies on the diffusion of renewable energy have been conducted with a variety of methods since the late 1990s. Jacobsson and Johnson [13] proposed an analytical framework to describe the transformation process of renewable energy technologies from the perspective of innovation. Painuly [14] investigated barriers to the diffusion of renewable energy penetration, and suggested country-by-country measures to overcome the identified barriers. There have also been attempts to utilize the diffusion process to forecast the future of renewable energy, such as the study of Purohit and Kandpal [15], who forecast irrigation water pumping in India based on four diffusion processes of other renewable energy technologies.

Diffusion of energy technologies also possesses a unique quality that often resembles that of precedents. Precedents include two different categories: primitive or previous technologies that exist in the same market, and the same technology that previously prevailed in more developed markets or countries. One of the most remarkable studies on this topic is by Grübler et al. [16], who conducted a comparative analysis of various energy technologies across countries. They argued that diffusion patterns of a technology in different markets were similar, and thus it was reasonable to consider a connection between these patterns. This emphasizes the importance of investigating cases of developed or advanced countries and making predictions based on the experiences of these countries when forecasting the diffusion process of energy technologies.

A critical recent advance is an understanding of the relation between diffusion and investment. Tsoutsos and Stamboulis [17] argued that a successful policy for renewable energy should be based on identifying its innovation process. Popp et al. [18] analyzed diffusion patterns and the impact of technological change on investment in renewable energy in many countries by counting patents. Pettersson and Soderholm [19] investigated the effectiveness of climate policy and future investments in Sweden. Similarly, Aslani et al. [20] studied policies and achievements in renewable energy based on data from Nordic countries. More broadly, Rao and Kishore [21] conducted an in-depth review of the various diffusion models applied to renewable energy to assess the impacts of these policies. Above all, Grübler et al. [16] argued that diffusion patterns of new technologies resemble those of existing technologies by observing various energy technologies, which provides the basis for an analogous approach to estimate a renewable energy diffusion process. In support of Grübler and colleagues’ findings, Pettersson and Soderholm [19] argued that technological learning in the Swedish power sector was strongly related to R&D spillover.

Nevertheless, to the best of our knowledge, the analogy approach has not been used in combination with renewable energy diffusion. This is surprising, because numerous other studies have used this methodology, e.g. Thomas [22] and Mahajan et al. [23]. Considering the prevalence and effectiveness of the guess-by-analogy method in the absence of enough data [24], it is worthwhile to apply the analogy approach to the renewable energy diffusion process to determine a reasonable investment policy in renewable energy for Korea.

The breadth of related work is relatively narrow in Korea. Hwang et al. [25] found that inconsistent or untimely policies had a negative impact on penetration rates of renewable energies, and forecast future penetration levels through diffusion models. Park et al. [26] predicted the grid parity of solar photovoltaic energy based on two factors from a learning curve model that considered supporting policies and R&D investment plans in Korea. Kim [27] analyzed the diffusion process of renewable energy penetration and R&D investment in Korea utilizing the German case as an analogy. Ku and Yoo [28] provided a basis for renewable energy policymakers by assessing benefits with a choice experiment at an individual level. However, Korean studies have mostly focused on analysis of historical data, whereas many foreign studies have undertaken to understand and forecast diffusion patterns of renewable energy. Thus, there is a paucity of studies on forecasting the diffusion process and estimating the required scale of investment in renewable energy in Korea.