Renewable Energy 66 (2014) 523–531

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

An integrated adoption model of solar energy technologies in South Korea

Heetae Kim, Eunil Park*, Sang Jib Kwon, Jay Y. Ohm, Hyun Joon Chang

Graduate School of Innovation and Technology Management, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea

A R T I C L E I N F O

Article history:
Received 28 October 2013
Accepted 23 December 2013
Available online 25 January 2014

Keywords:
Solar energy
Renewable energy
South Korea

A B S T R A C T

With recent developments of many significant social problems in South Korea, such as the national blackout events of the nuclear plants components in the South Korean energy industry due to use of low-quality parts, citizens have begun asking tough questions about the country's energy industry in connection to economic, security, and environment. In regards to this same issue, there is rapidly growing interest in renewable energy technologies to reduce the potential problems with traditional energy plants. Among many kinds of renewable energy technologies, solar energy technologies have been considered as one of the most promising energy technologies in South Korea by many energy experts. However, the amount of electricity and energy provided by solar energy technologies constitutes only a small percentage of the total energy production in South Korea. Therefore, in this study, we explored the factors that have a significant effect on the intentions of the public to use solar energy technologies. The results from applying a structural equation modeling method to the integrated research model indicated that three positive factors comprising of system quality, perceived benefits, and trust, significantly contributed to determining the public's attitude toward solar energy technologies. The intention to use the technologies was also determined by two positive variables (public attitude and satisfaction) and one negative variable (perceived cost). Based on the empirical findings of the current study, both implications and suggestions are presented and discussed in this paper.

1. Introduction

The emergence of renewable energy technologies in recent years spurred great amount of interests among researchers, policy makers, and industry leaders in understanding the economic viability of this new source of energy. In particular, many experts considered solar energy as one of the most promising technologies, but there are some barriers to the technology that may pose significant challenges to the technology adoption. Many researchers and policy makers have strongly supported solar energy technology for the reason that it will bring many positive benefits to society, such as environment-friendly energy source. With this heightened interest, many studies have been conducted to better understand the current state of the technology adoption and the key drivers impacting the future technology trends.

So far, only few studies have been conducted in South Korea on the use of solar energy technologies in the Korean energy industry [1,2]. In order for Korea to succeed in renewable energy development, it is critical that a systematic approach to solar energy needs to be established prior to actual use of technologies in the industry. Solar energy is a very important component of any national renewable policy. Globally, all nations are exploring the development of diverse energy supply methods that are important to the protection of the environment and to the application of new and renewable energy methods [3].

On the contrary, the current status of renewable energy in South Korea is considered to be in extremely weak position compared to other Organization for Economic Cooperation and Development (OECD) nations. For example, OECD indicated that South Korea ranked the lowest in the energy and electricity production of renewable energy technologies out of all of the OECD nations [4,5]. The reason for this indifference to solar energy technologies in South Korea may be attributable to the distinct characteristics of the area. In the early stages of the development of renewable energy technologies, including solar energy, there was little effort and concern devoted to production of safe, environment-friendly energy, because Korean government and industry wanted to conduct further investigation on the economic viability of technology and the level of market penetration necessary to achieve economies of scale in the industry [6].

* Corresponding author. #2101, KAIST College of Building 2 (N5), I&TM, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea. Tel.: +82 42 350 4342; fax: +82 42 350 4340.
E-mail addresses: pa1324@kaist.ac.kr, pa1324@gmail.com (E. Park).

0960-1481/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.renene.2013.12.022

The solution to most of the problems described above is to develop a differentiated solar energy application. Growing global energy demand is producing intense competitive pressure to develop advanced renewable technologies and customer-oriented strategies [7]. Today the primary concern is to secure personalized solar energy technology methods. South Korea has been challenged to develop user-oriented energy facilities, while satisfying diversified customer base and building trust in solar energy technologies at the same time. Nowadays, while many people are still not familiar with solar energy production and application in South Korea [8], extensive technology limitations are holding back the development of renewable energy in South Korea. Therefore, South Korean people are demanding more individualized solar energy equipment and facilities.

The remainder of this paper consists of the following sections. First, a literature review including a general overview of solar energy technologies in South Korea is presented. Second, the hypotheses and the proposed research model are provided. Third, the statistical results are presented. Fourth, the discussion and conclusion including the implications of our results are explained. Finally, limitations of our results are discussed as well as guidelines and recommendations for future studies.

2. Literature review

2.1. Trends and overview of solar energy technologies

Global energy consumption has consistently increased, trigged by the consistent increase in global population and the improved overall quality of life. As a result, the costs for energy and related environmental issues are at the forefront of national debate in many countries. Awareness of renewable energy has been elevated, because many governments have explored solutions to address the lack of energy supply and other related issues [3].

With this increased interest in renewable energy, it is essential to define renewable energy and articulate its technological improvements. The International Energy Agency defined three generations of renewable energy [9]. The first generation is referred to as the renewable energy technologies are mature. Technologies for hydropower, biomass combustion, and geothermal energy are included in this first generation. The second generation is defined as the renewable energy technologies that are going through fast growth and it includes solar, wind, and new-fashioned bio-energy. The third generation embraces a wide range of renewable energies in the various stages of development, such as concentrating solar power, ocean energy, modern geothermal energy, and integrated bio-energy.

As fossil fuels are depleted, harnessing of renewable energies, especially solar energy, is very important to people who are concerned about environment and ecological hazards [10,11]. The reason is that solar energy is a “renewable energy” or “alternative energy” that can replace conventional energies such as coal and oil. Thus, it is one of the most eco-friendly energy resources that does not cause climate change [12]. Due to greenhouse gases and other noxious gases not being emitted, solar energy is considered to be one of the most environmentally friendly energy sources in comparison to other energy sources. In addition, solar energy also allows countries to set up green islands that are independently maintained from the national power systems, thus helping to diversify the energy supply chain [12–14].

Previous studies defined solar energy technologies as “the technologies which directly use energy from the sun to produce electricity, and to replace fossil fuel generation at the point of end-use employing active means” [15]. Solar energy is primarily categorized into three groups: solar thermal electric, heating/cooling, and photovoltaic. Solar thermal electric energy is usually defined as “the result of a process by which directly concentrated solar energy is converted to electricity through the use of a kind of heat to power conversion instrument” [16]. Although solar thermal electric energy is one of the greatest potential power sources, its development has been delayed in the energy market, because of the need for large inefficient plant sizes for making electricity [17]. Solar thermal heating or cooling is considered to be the easiest and most direct method to produce solar energy. It provides the hot water generated by solar thermal heating for industry, apartment, and commercial buildings. Solar photovoltaic (PV), which is generated by panels and has some similarity to semiconductor, converts photons into electricity [18]. When sunlight beats down and hits the panels, photons that have a specific wavelength trigger electrons to flow through the semiconducting materials in order to generate direct current electricity [19].

Solar thermal is the most efficient way to generate solar energy for heating. However, the solar photovoltaic method is the most efficient way to get energy from solar energy, because solar thermal can convert solar heat to electricity through mechanical energy.

Given the portion of solar energy in global energy demands (approximately 0.05% of the total energy consumption), solar energy has just been considered to have the potential to be the greatest energy source. Solar energy still only generates approximately 1% of the total energy supply, because of its high installation charges (Tables 1and 2) [4,5]. Compared to other renewable energy sources, solar energy’s portion of the energy supply is quite low (Tables 1and 2).

Nowadays, customers can choose among a range of differentiated energy sources and they can assess energy supply services and prices [21]. Therefore, a large number of energy suppliers are attempting to improve customers’ perceptions towards the services and systems of energy suppliers [22–24]. Although solar energy technologies have taken great strides over several years, solar energy suppliers should consider what customers’ real needs are in order to satisfy them and to be sustainable in the market.

2.2. The current state of solar energy technologies in South Korea

A number of leading European countries in solar energy technologies – Germany, Denmark, and Spain – have used a FIT (Feed-In Tariff), which is a political mechanism to induce investment in renewable energy technologies [25]. On the other hand, U.S, U.K, Japan, and Sweden have used a RPS (Renewable Portfolio Standard), to stimulate more investment.

As a result of the German government’s failure in forecasting economic and social effects of the FIT implemented in Germany, nowadays many nations have fully re-examined their national energy plans [26]. In the meantime, South Korea changed its plans for renewable energy technologies from a FIT to RPS to minimize financial burden on the government [27].

South Korean domestic market for renewable energy technology is too small to actuate an industrial ecosystem. The simulation of the domestic market is critical to realize economies of scale, establish a track record, and become competitive in this field. Therefore, increasing the market penetration is mportant for renewable energy technology. In South Korea, sales of renewable energy technologies have increased steadily from 1461 hundred million KRW in 2004 to 8128 hundred million KRW in 2010, while the number of manufacturing firms and employees have also increased 4.7 and 16.2 times, respectively. The South Korean domestic renewable energy market has steeply increased due to the continuous growth of the world renewable energy industry and technology [28]. With this growth, South Korea has established several generating systems for domestic services and export,