Energy Policy 62 (2013) 573–581

Contents lists available at ScienceDirect

Energy Policy

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

Assessment of government support for the household adoption of micro-generation systems in Korea

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HIGHLIGHTS

- We investigate how government support affects household adoption of micro-generation.
- We analyze household preferences for the costs and benefits of micro-generation system installation.
- System with low install costs but high energy saving benefits and long warranty periods are preferred.
- Households prefer direct subsidies to low-interest loans.
- But the majority of households are unwilling to install systems despite government support.

ARTICLE INFO

Article history:
Received 4 March 2013
Accepted 6 July 2013
Available online 2 August 2013

Keywords:
Micro-generation
Renewable energy
Discrete choice experiment

ABSTRACT

This paper investigates how Korean government support affects household adoption of renewable energy-based micro-generation systems by analyzing household preferences in relation to the costs and benefits of system installation and different kinds of government support. The research adopts a discrete choice experiment approach and focuses on two micro-generation technologies: solar voltaic and solar thermal. Our empirical analysis revealed firstly that households prefer micro-generation systems that have low installation costs but high energy saving benefits and long warranty periods; and secondly that households prefer direct subsidies to low-interest loans. However, we also found that households are reluctant to install photovoltaic or solar thermal systems in reality because they see the cost of system installation as being higher than the benefits they would receive from such installation. In short, while existing government supports are somewhat effective in promoting household adoption of micro-generation systems, there also exists the obstacle that the majority of households are unwilling to install such systems despite government support. Thus several policy improvements, which focus on increasing the benefits and decreasing the installation costs of micro-generation systems, are suggested in this paper.

1. Introduction

Recently, governments worldwide have been painstakingly seeking ways to reduce greenhouse gases (GHG) and enhance energy efficiency in order to take action against the problems of global warming, climate change and natural resource depletion. As the use of fossil fuels is one of the main reasons for these problems, renewable energies are attracting attention as an alternative and most countries are applying policies (feed-in-tariffs, quota obligation, subsidy and tax incentives, etc.) to promote the use of renewable energies (Ayoub and Yuji, 2012; Hirschl, 2009; Kitzing et al., 2012; Moosavian et al., 2013).

In particular, energy used in the residential sectors of IEA countries took up around 20% of total final consumption of energy (TFC) in 2010, the third largest consumption sector following industry at 32% and the transport sector at 32% (IEA, 2012a). It is therefore necessary to encourage residential sectors to use more renewable energy. However, the residential sectors of IEA countries still rely on natural gas and electricity generated from fossil fuels for much of their energy. In fact, natural gas and electricity take up around 38% and 36%, respectively, of the overall energy consumption in residential sectors (IEA, 2012a).

Although Korea's figures differ somewhat from IEA averages, the residential sector in Korea also stands as the third largest sector in terms of energy consumed. The residential sector in Korea took up around 13% of TFC in 2010, following 52% for industry and 19% for the transport sector (IEA, 2012a, 2012b). Presently, natural gas and electricity take up around 45% and 27% of overall energy consumption in the residential sector, but the share of renewable energy is less than 1% (IEA, 2012a, 2012b). Moreover, energy consumption in the building sector (including residential and services) of OECD countries, which uses energy for

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http://dx.doi.org/10.1016/j.enpol.2013.07.015

heating, cooling, lighting, refrigeration and for powering electrical appliances, is expected to grow at an average annual rate of 1.0% from 2010 to 2035, an overall increase of 29% (IEA, 2012c).

Studies investigating the effects of renewable energy use on GHG emissions report that renewable energy use is effective in reducing GHGs. For example, El Fadel et al. (2013) estimate that the potential reduction in GHG emissions in the Middle East and North Africa, as a result of residential renewable energy consumption, ranges from 6% to 30% depending on renewable energy market penetration rates. Jun et al. (2010) estimate that by 2020 Korea's GHG emissions will have decreased by 4.8% using a renewable energy scenario as opposed to a business as usual scenario. Liu et al. (2011) estimate that, based on a scenario of renewable energy use in China, the amount of CO_2 emissions would be reduced by about 1800 Mt more than the amount reduced under a regular scenario.

Since the residential sector comprises a large proportion of TFC and its consumption is expected to increase steadily, world governments including the Korean government have been paying keen attention to residential micro-generation systems (Burns and Kang, 2012; Oh et al., 2013), which can provide electricity and heating energy from new and renewable energy, as a method for reducing residential energy usage and greenhouse gases.

Currently, the Korean government is making active efforts to enforce policies and carry out programs that can stimulate household adoption of renewable energy-based micro-generation systems. Such systems include photovoltaic systems (electricity), solar thermal systems (hot water), geothermal heat pumps (heating and cooling), fuel cells (electricity), and small wind turbine systems (electricity). Government policies include providing direct financial support (subsidy or loan with low-interest) or indirect support to household.

As the Korean government pushes ahead with such programs, it has become necessary to evaluate their effectiveness to determine whether certain policies should be strengthened, maintained, modified, or even eliminated. Since the government is promoting the residential adoption of renewable energy-based micro-generation systems, it is important to understand household preferences in relation to government support, along with the costs and benefits of installing renewable energy-based micro-generation systems.

The purpose of this study is to first, analyze the household preference for lower costs and higher benefits and government support in relation to renewable energy-based micro-generation system installation; second, investigate the effects of government support on the adoption of micro-generation systems; and third, seek improvements of existing government supports. To achieve the purpose, this research adopts a discrete choice experiment approach and focuses on two micro-generation technologies, such as solar voltaic and solar thermal.

The remainder of this paper is organized as follows. Section 2 summarizes the policy framework and current situation regarding renewable energy-based residential micro-generation systems in Korea. Section 3 briefly reviews the previous literature on household preferences in relation to micro-generation systems and outlines the methodology adopted in this paper. Section 4 presents our estimation results and the policy implications of our findings, and in Section 5, we offer our concluding remarks.

2. Renewable energy-based residential micro-generation systems in Korea

2.1. Supporting policies

As an implementation strategy of the Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy, the Korean government has launched various programs supporting the household adoption of renewable energy-based residential micro-generation systems. The purpose of the Act is to contribute to the preservation of the environment and the sustainable development of the national economy by diversifying energy resources through the promotion of technological development, use, and diffusion of new and renewable energy.

In 2004, the Korean government launched its first program called the *100,000 Solar Roof Program*. The *100,000 Solar Roof Program* was a subsidy program to facilitate the installation of photovoltaic systems in residential sites (IEA, 2012b; Korea Energy Management Corporation, 2012) and entailed the government subsidizing a portion of the total installation costs.

In 2009, Korean government revised the *100,000 Solar Roof Program* and launched a new program called the *One Million Green Homes Project*. The main differences of the *One Million Green Homes Project* over the earlier program were that the scope of target technologies and the coverage of subsidies were expanded. While the previous *100,000 Solar Roof Program* supported the installing of photovoltaic systems in homes, the *One Million Green Homes Project* supports the installation of a wide range of technologies including photovoltaic systems, solar thermals, fuel cells, geothermals, and small wind turbines. Detached houses or villages with at least 10 families that want to adopt micro-generation systems can apply for this subsidy program. The coverage of subsidies varies from a minimum 40% to a maximum 75% of the standard installation costs (which are set by the government), and also depends on the type of renewable energy system. For example, the government provides installation-cost subsidies of up to 40% for solar photovoltaic systems, up to 50% for solar thermals, geothermals and small wind turbine systems, and up to 75% for fuel cells.

In addition, the *One Million Green Homes Project* offers new indirect support in the form of a 3-year warranty and free repairs for all new and renewable energy systems (photovoltaic, solar thermal, geothermal, fuel cells, or small wind turbine).

In 2011, the Korean government launched an additional *Solar Home Project* specifically for the installation of solar voltaic technology and for households that consume more than 600 kW h of electricity per month. The main differences between the *One Million Green Homes Project* and the *Solar Home Project* are that the latter is a loan program, not a subsidy program, and it includes expanded indirect support. The low-interest loan program involves financial institutions providing low-interest loans to households for the installation of solar voltaic technology. The households pay back the loans after their system installations with the savings from reduced electricity or heating costs. The merits of the low-interest loan program are that a household can install the system without much financial stress and the government can lessen its financial burden compared to the direct subsidy approach. In addition, the *Solar Home Project* also offers a 5-year warranty and free repairs on photovoltaic systems.

2.2. Market data

The Korean government programs have been successful, given that more than 160,000 micro-generations systems were installed from 2004 to 2012 after the launch of the *100,000 Solar Roof Program* in 2004, the *One Million Green Homes Project* in 2009, and the *Solar Home Project* in 2011. Solar photovoltaic systems were installed under the *100,000 Solar Roof Program,* the *One Million Green Homes Project,* and the *Solar Home Project*, and other renewable energy systems were installed under the *One Million Green Homes Project*.

Over 160,000 micro-generation systems were installed from 2004 to 2012, as shown in Table 1, the overall number of installations increased sharply between 2009 and 2012 by nearly