Ph. D. Dissertation in Engineering

Quantifying Public Acceptance of Innovation Policy

- A Demand-Oriented Analysis for Renewable Energy Policy -

혁신 정책에 대한 국민 수용성의 정량화
: 신재생에너지 정책의 수요 지향형 분석

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Abstract

Quantifying Public Acceptance of Innovation Policy

: A Demand-Oriented Analysis for Renewable Energy Policy

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Innovation policies are considered as key to encouraging innovative activity, which may serve as essential and valid means to survive and adapt to our current fast-changing society. To date, innovation policies have mostly focused on supply-side measures by creating and diffusing new technologies. However, since demand also plays a crucial role by being one of the primary sources of innovation, the importance of demand-oriented innovation policies has received much attention recently. Public acceptance is a very important consideration from the perspective of demand-oriented innovation policies, because innovation policies may face social resistance despite their obvious advantages and usefulness.

The purpose of this dissertation is twofold. The first is to quantitatively analyze

public preferences for an innovation policy and to forecast the level of public acceptance according to variations in policy attribute levels. To achieve this, stated preference data obtained from choice experiments are analyzed using a mixed logit model, one of the discrete choice models (DCMs). The second is to suggest an integrated approach to simultaneously analyze public preferences for multiple policies in a policy category. It is often necessary to understand public preference structure for a certain policy category in order to design overall policy direction. To achieve this, a data classification method is developed to classify various policy alternatives. The multivariate probit (MVP) model, which is also a DCM, is used to analyze these classified data.

Empirical analyses are conducted for three renewable energy policies: the Renewable Portfolio Standard (RPS), Renewable Fuel Standard (RFS), and two different types of Renewable Heat Obligations (RHOs), namely RHO schemes aimed at either heat suppliers or building owners. The selected policies represent a strong regulatory component and serve as quantitative policies in the electric power, transport, and heating sectors, respectively.

The results of the mixed logit model show that the public assigns great importance to the price attribute, which is critical to maintain relatively high public acceptance. In the case of the RPS, public acceptance will be maintained at above 89.5% if the increase in electricity bills is limited to under 6%. Public acceptance of the RFS varies from 91.2-48.8% when the price of transportation fuels is increased by 0-45%. In case of the RHO for heat suppliers, an increase of 0-30% in heating expenses decreases public acceptance

from 99.9-60.3%. Other important attributes having substantial influence on public acceptance of renewable energy policies are new job creation in the RPS, stability of the heat supply in the RHO for heat suppliers, and government subsidy in the RHO for building owners. In the case of the RFS, attributes other than increased fuel price have little effect on public acceptance.

The results of the MVP model show that the public is sensitive to increased energy prices in general, because they assign great importance to the price attribute. Moreover, the public's average preferences for renewable energy policies can change according to the type of RHO. While the public's level of knowledge about renewable energy policies has a positive effect on their choice of eco-friendly policies, their attitude toward environmental protection has no bearing on the same. Thus, in order to ease public resistance incurred by possible increases in energy prices, governments should map out efficient strategies to improve the public's knowledge of renewable energy policies.

In conclusion, the proposed methodology in this dissertation allows one to not only analyze public acceptance of an innovation policy more quantitatively but also to analyze public preferences for a superordinate policy category simultaneously. The framework of this research can be generally applied to any public innovation policy. Notably, the proposed integrated data classification method can be applied to any category of policies/products having common attributes.

Keywords: Innovation Policy, Public Acceptance, Stated Preference Technique,

Choice Experiment, Discrete Choice Model, Renewable Energy Policy

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Chapter 1. Introduction

1.1 Overview: Toward a Demand-Oriented Innovation Policy

The rapid acceleration in the pace of social change coupled with intensifying competition among individuals, firms, and nations has highlighted the importance of innovative activity. Innovation is an essential and valid means to survive and adapt to today's fast-changing modern society. Following Schumpeter's (1942) coining of the term "creative destruction," the theme of innovation has received academic and practical interest regardless of the field of study. Notably, for the past few decades, innovation has been regarded as an attractive topic by researchers, who have published many studies on defining innovation, classifying it, and investigating its influence on various fields of society. In terms of a comprehensive and general standpoint, the definitions by Rogers (2003) and Drucker (1985) are notable. Rogers (2003) defined innovation as an idea, practice, or object that is perceived as new by an individual or other unit of adoption, while Drucker (1985) defined it as the process of equipping in new and improved capabilities or increased utility. The former placed emphasis on the newness of innovation, and the latter, on the overall process of innovation. In addition to this broad perspective, if we limit the scope of the definition to the firm level, innovation can be defined as the application of new ideas to products, processes, or other aspects of the activities of a firm that lead to increased value (Greenhalgh and Rogers, 2010). Thus, innovation is nothing but a tangible or an intangible object that is perceived as possessing the properties of both newness and value.

Different methods have been proposed for classifying innovation into types. Schumpeter (1934) classified innovation into new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business. Innovation can also be classified into transformation innovation, radical innovation, and incremental innovation, according to the extent of its impact on market. Going beyond the scope of traditional technological innovation concepts, such as product and process innovation, the Organisation for Economic Co-operation and Development introduced marketing innovation and organizational innovation as types of innovation (OECD, 2005).

As indicated by the definitions and types of innovation coined by individual researchers, innovative activity has a great influence on almost every aspect of society, especially economic growth. Neoclassical economic growth theory became established after the early twentieth century. The second industrial revolution was already well underway by then. It regarded technological innovation—technological advance, to be exact—as an important factor for economic growth, and this proposition has been generally accepted (Solow, 1956; Mansfield, 1968). The endogenous growth theory inspired by Romer (1986, 1990) proposed that limits to growth could be overcome by use of knowledge, which was a novel idea at that time. The endogenous growth theory especially has contributed much to widening the horizons of government policy on economic growth, by verifying that innovative activity is a critical factor for promoting economic growth. Thereafter, numerous empirical and theoretical studies have proved the importance of innovative activity for economic growth. To sum up, innovation has always played a decisive role in the economic and social development of countries. Indeed, it is the main source of economic growth; it helps improve productivity, is the foundation of competitiveness, and improves welfare (World Bank, 2010). In a knowledge-based society where the success of the national economy depends on how effectively it can create and use essential knowledge when needed, innovation is one of the most important sources of national wealth.

For all the abovementioned reasons, the national government of each country utilizes various means to encourage innovative activity in its own country. Among them, innovation policy—a measure including tools to raise the efficiency of innovative activity—is key to achieving this objective. In the broader perspective, it is notable that among innovation policies, OECD (2005) includes not only policies for industrial innovation and economic growth but also policies aimed at improving the quality of life. The ultimate goal of innovation policy, which is determined by a political process, varies. Mostly, the ultimate goal primarily serves economic purposes, while environmental, social, health, defense, and/or security issues may also be served by it. Various policy instruments exist to realize the aforementioned objectives of innovation policy, but their classifications differ depending on research purposes and individual researchers. For example, Edler and Georghiou (2007) classified various innovation policies into supply- and demand-side measures, while Borrás and Edquist (2013) classified them into regulations, economic transfers, and soft instruments.

Looking back on the history of innovation policy, until now, most innovation policies—in particular, innovation policies in Korea—have focused on supply-side measures such as providing essential knowledge/capital as well as developing human resources to create and diffuse new technologies. In most cases, the general public (representing the demand side) has not been the target of traditional innovation policies, since there have been few specific measures to control the general public thoroughly. As a result, the policy making process of governments of most countries, including Korea, has not recognized the crucial role played in innovation by the demand side (Edler and Georghiou, 2007). However, given the increasing emphasis on the interaction between technology and society, the significance of responding to the needs of various social constituents, such as users and market customers, as well as improving their satisfaction levels, are emerging as important elements of innovation policy. In this context, demand-based innovation policy has been recently highlighted as a new area of innovation policy. Furthermore, when innovative activity enters a post catchup stage and there is no object to imitate, the main agents of innovation should be able to create new markets with new technologies. Therefore, innovative activity that can perceive public demand and meet its needs is important. In such circumstances, new approaches are needed for demand-side as well as supply-side policies. Further, various strategies to link supply-side and demand-side innovation policies are important. Most previous studies focusing on demand-side policies have emphasized the importance of public procurement in order to promote innovation (Edler and Georghiou, 2007; Myoken, 2010). However, a true demand-oriented innovation policy would consider public needs and preferences, thereby inducing a sustainable innovation. Therefore, public acceptance is a very important consideration from the perspective of demand-oriented innovation policy.

Another reason for considering public acceptance is that there are limited resources available for introducing and implementing an innovation policy. Thus, for rational decision making, possible policy alternatives should be evaluated and compared against one another before implementation. Such policy pre-evaluation can provide meaningful information necessary for policy decision making and implementation. This observation is also applicable to non-demand-oriented innovation policies. Various methods exist to evaluate an innovation policy before its introduction. Typical examples are data envelopment analysis (DEA), analytic hierarchy process (AHP), cost-benefit analysis, cost-effectiveness analysis, contingent valuation method (CVM), interindustry analysis, SERVQUAL scale method, meta-analysis, etc. (National Assembly Budget Office, 2007).

Each aforementioned policy evaluation method has its own advantages and disadvantages. However, they all suffer a common limitation in that they do not consider the demand side adequately; specifically, they do not consider the preferences of the relevant people who may be affected by the policy. It is especially difficult to examine detailed changes in public response according to variations in policy design with the existing methods. However, the target and ultimate beneficiary of innovation policy are often the general public. This underscores the need for a method to accurately forecast public response to innovation policy, since a national-level innovation policy can influence the public either directly or indirectly in most cases. This procedure is especially important for securing the success and sustainability of demand-oriented innovation policy, for which understanding public preferences and ascertaining acceptance are paramount. A quantitative analysis with an econometric model can allow such an *ex ante* evaluation of a policy and provide informed grounds for making changes to a detailed policy design.

Thus, this dissertation analyzes respondents' preference structure for an innovation policy in Korea's national energy sector, using a choice experiment (CE), a kind of stated preference technique, which has previously been applied to analyze preferences for new products and technologies. Then, based on the public preference, public acceptance of the policy is quantitatively forecasted before its implementation. Additionally, an integrated approach, which can simultaneously analyze public preferences for similar multiple policies in a category, is proposed. Overall, this dissertation contributes to the decision-making process for developing a demand-oriented innovation policy by applying the stated preference technique to the field of innovation policy.

1.2 Objectives of this Dissertation

The main objective of this dissertation is to analyze public acceptance of an innovation policy using the stated preference technique and to forecast the level of public acceptance for a particular policy design. This research is based on three perspectives.

First, public preference for an innovation policy is analyzed to forecast the level of public acceptance before its implementation using a CE (a kind of choice modeling (CM)). Previous studies have tended to use stated preference techniques to estimate the nonmarket value of an object (a product/service). The value of an object can be estimated most effectively with a well-designed survey that can eliminate hypothetical bias in stated preference techniques (Manski, 2000). With stated preference techniques, the researcher can present various hypothetical alternatives (alternatives that have not been introduced in the real market). Thus, he/she can estimate values that cannot be estimated with revealed preference data. Given such advantages, various researchers have used CM to analyze consumer preferences for new products and technologies. However, hardly any researchers have used CM to examine public acceptance or perceptions of a new policy, especially a new innovation policy. For efficient resource utilization, evaluation of an innovation policy and forecasting its public acceptance level should be done before its introduction/implementation. Thus, this dissertation applies CM not only for an *ex ante* evaluation of an innovation policy but also for simulating its acceptance level.

Second, this research suggests an integrated approach that can simultaneously analyze public preferences for several similar policies in a single category. Generally, the CE is very useful to analyze respondents' preferences for a single technology/policy. From a wider outlook, however, a manager/policy maker may sometimes need information about integrated (or overall) preferences for multiple products/policies in a specific category. It may be difficult to analyze public preferences for multiple but similar policies using a single CE. To treat this problem, this research proposes a new data classification method to classify numerous different policy alternatives according to type. By analyzing these reclassified data with an econometric model, this research provides an analytical tool that can integrate different choice data wherein the alternatives share a few common attributes.

Third, using the aforementioned methodological framework, this dissertation conducts empirical analyses of public preferences for three Korean renewable energy policies, which will either be introduced soon or have been recently introduced. Changes in public acceptance are also examined. Public acceptance is the single most important consideration for renewable energy policy introduction and its sustainable implementation. Considering that the production and utilization of renewable energy are costlier than in the case of conventional fossil fuels, renewable energy use will increase energy prices through increased electric power rates, transport expenses, and heating expenses, thereby burdening end users in the long term. Increased energy prices are likely to hinder public acceptance and act as a barrier to successful renewable energy policy deployment. In this context, this dissertation empirically analyzes Korean customers' public preferences for three renewable energy policies and quantifies their acceptance levels for the same.

1.3 Outline of this Dissertation

This dissertation is organized as follows. Chapter 2 reviews previous studies on the topic, summarizes several limitations of their approaches, and explains the contribution of this dissertation. Section 2.1 describes how previous studies have analyzed public acceptance of various new technologies and policies and the methodologies they used. In doing so, the limitations of previous studies are discussed, thus clarifying the advantages of the methodology employed in this dissertation. Section 2.2 reviews the previous studies that focused on renewable energy policy, the subject of the empirical analyses in this dissertation. Investigating the individual approaches of previous studies focusing on renewable energy policies highlights the novel approach employed in this dissertation and its expected implications. Chapter 3 details the methodology used in this dissertation. It begins by introducing the discrete CE, one of the most sophisticated stated preference techniques employed for collecting data. Then, it describes the two main analytical models, namely the mixed logit model and the multivariate probit (MVP) model. Chapter 4 presents the empirical analyses for the three representative renewable energy policies in the electric power, transport, and heating sectors in the Korean energy industry. Using the CE and discrete choice model (DCM), section 4.1 analyzes public preferences for the renewable portfolio standard (RPS), one of the most influential renewable energy policy dissemination tools in the electric power sector. Furthermore, changes in public acceptance according to variations in policy attribute levels are also forecasted. Sections 4.2 and 4.3 use similar methods as those in section 4.1 to analyze the renewable fuel standard (RFS) and renewable heat obligation (RHO), which are also expected to have substantial impact on the transport and heating sectors, respectively. Although each of three empirical analyses in chapter 4 analyze public acceptance of an individual policy, none of them can explain the integrated public preference for renewable energy policy as a whole. To tackle this limitation, chapter 5 proposes a methodology to analyze respondents' preferences for a policy category; in other words, similar individual policies having a few common attributes can be analyzed simultaneously. Then, this methodology is applied to analyze the three renewable energy policies simultaneously. Each policy alternative is separated and assigned to a different policy type. The MVP model, a kind of DCM, is used for this analysis. Chapter 6 summarizes the results of this dissertation, explains the policy implications, provides concluding remarks as well as the limitations of this research, and suggests guidelines for future research in this area. Figure 1 provides an outline of this research.

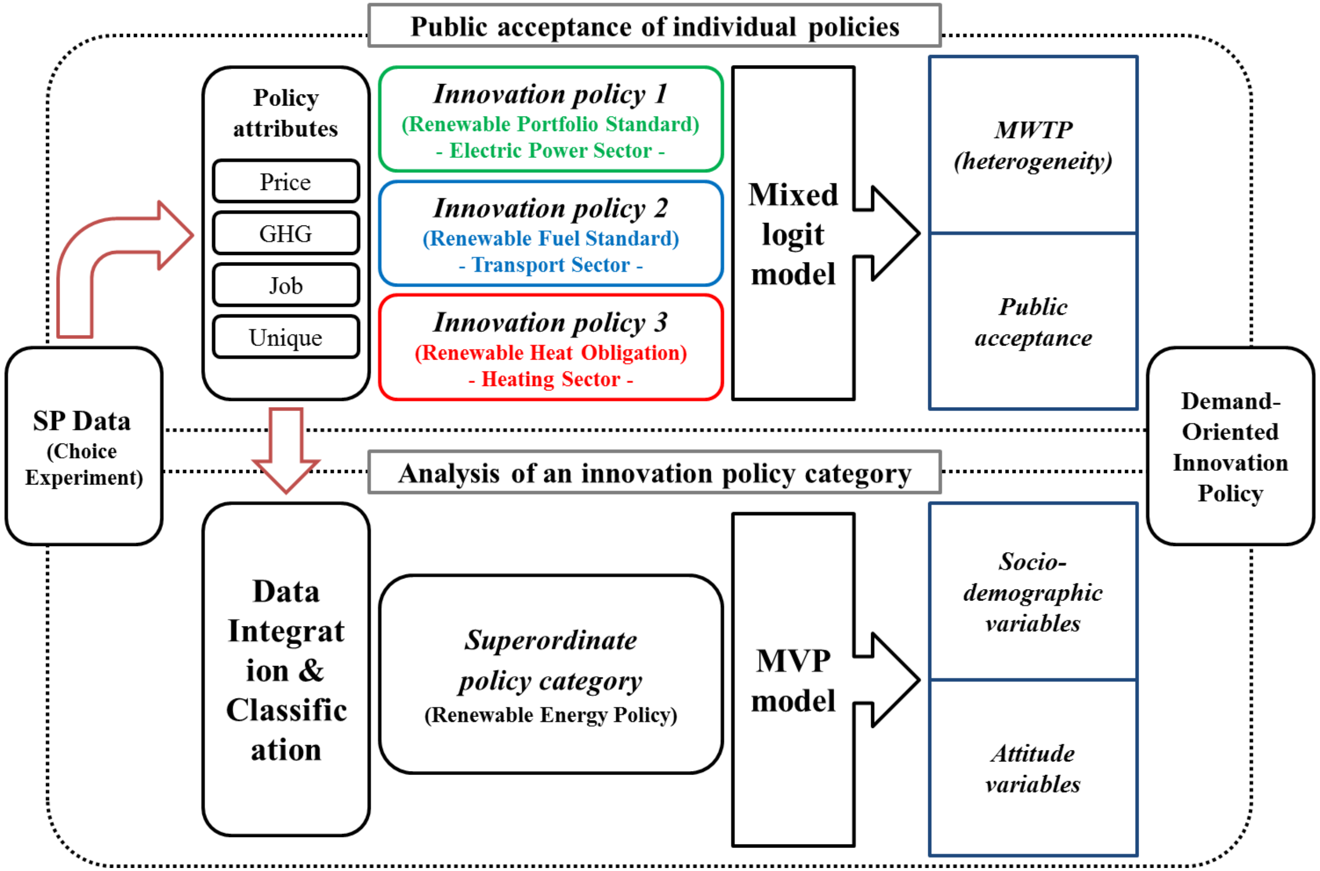

Figure 1. Summary and outline of dissertation

Chapter 2.　Literature Review

2.1 Public Acceptance of New Technology and Policy

Previous research dealing with public acceptance of new technologies and policies varies by purpose and focus. In this section, I broadly classify these studies based on specific categories such as the standpoint, methodology, main implications, limitations, and suggestions for improvement.

Despite its obvious convenience and usefulness, a new technology may be confronted with public resistance, which can result in a social cost caused by delayed adoption of the technology. In order to cope with such potential resistance, each country makes nationwide efforts to increase the social acceptance of new technologies. For example, the United States allocates a portion of government investment in nanotechnology to several social acceptance programs, while the Korean government has invested a portion of its R&D budget in exploring ethical, legal, and social issues (ELSI) pertaining to science and technology (Kim et al., 2010). Although a new technology has its obvious relative social advantages, it is uncertain whether public acceptance for it will be high. This is why it is vital to analyze new technology from the social science perspective. It should be acknowledged that uncertainty in public acceptance of a new technology embodies various determinants of individual acceptance, such as the adopter's experience, demographic characteristics, and surroundings.

A variety of technologies have aroused social controversy and were adopted or rejected depending on public choice. This proves that public acceptance is indeed one of the critical factors deciding the fate of a new technology. Thus, it is very important to examine the social acceptance of a new technology, and accordingly, academic interest in these issues has increased significantly. Issues pertaining to technology acceptance are special concerns in social and behavioral research (Sjöberg, 2002). Studies in the 1970s and the 1980s mainly focused on public acceptance of nuclear technology and pesticides, while several studies on public acceptance of genetic modification were published in the 1990s. Many studies focusing on the acceptance of radio frequency identification (RFID) and nanotechnology were published in the late 2000s (Gupta et al., 2012).

Based on a literature review, Gupta et al. (2012) identified various socio-psychological determinants of public acceptance of ten technologies that were considered as being socially controversial. They found that most of the existing studies had focused on six determinants: perceived risk, trust, perceived benefit, knowledge, individual differences, and attitude. Among them, perceived risk was the primary focus. The authors also used hierarchical cluster analysis to identify which determinants were more closely related to a particular technology; for example, the acceptance of pesticides mainly depended on health and environmental impacts, that of mobile phones on concern, and that of cloning and genomics on ethics.

Studies focusing on public acceptance of a specific technology in a particular field are also important. In this section, I classify such studies according to their technological field, such as information communication technology (ICT), biotechnology (BT), nanotechnology (NT), and environmental technology (ET). First, studies of ICT acceptance can be summarized as follows. Using regression analysis, Sjöberg and Fromm (2001) analyzed data from a mailing survey given to a random sample of the Swedish population. They intended to identify the perceived benefits and risks of ICT use. In general, respondents were quite positive toward ICT, and their attitude toward the use of ICT was strongly related to their general attitude toward computers. Studies explaining differences among national acceptance levels toward ICT as well as ICT usage behavior based on cultural differences also fall into this category (Calhoun et al., 2002; Kambayashi and Scarbrough, 2001). A great variety of studies on public acceptance of ICT has been published recently. Xanthidis and Nicholas (2004) identified why ecommerce was yet to reach measurable levels in Greece in terms of public acceptance of the internet. Thiesse (2007) investigated public acceptance of RFID and found that the public regards it as a risk to privacy. Wang et al. (2011) investigated Chinese adults' (aged 60-75 years) acceptance of ICT by analyzing their survey result with linear regression analysis. Aloudat et al. (2014) assessed the social acceptance of location-based services using a survey of Australian citizens.

Next, I review previous studies dealing with public acceptance of BT. Since the 2000s, various industries have converged around BT, a field that foresees favorable prospects for a bioeconomy era. Despite a high interest in BT and extensive R&D investment, however, poor performance in this field has deterred real industrial growth. It is often noted that one of the main reasons for this failure is the low level of social acceptance of new BT and its related products. In this context, a number of studies in the late 1990s and early 2000s focused on public acceptance of BT.

Within the field of BT itself, many researchers have focused on the acceptance of genetically modified (GM) foods. Oda and Soares (2000) conducted a survey of public acceptance of GM foods on 550 respondents in Brazil. They identified education level, household income, and residential district as the key determinants. Using the probit model, Hossain et al. (2002) also analyzed US citizens' acceptance of BT in food production. Their results suggested that there is general support for its use in plants but not in animals. Gender and racial characteristics were identified as key determinants of attitudes towards BT. Gaskell et al. (2004) also analyzed the determinants of laypeople's perceptions of GM foods and GM crops using qualitative interviews and surveys concerning BT in ten countries. Rothenberg and Macer (1995) and Frewer et al. (2003) also identified potential factors affecting public acceptance of food BT. Other than food BT, studies have also dealt with public acceptance of bioremediation technology (Westlake, 1999) and agricultural BT (Aerni, 2002).

Since the beginning of the twenty-first century—to be exact, after the U.S. National Nanotechnology Initiative was announced in 2000—NT became the center of social interest, leading to widespread studies examining its public acceptance. Cobb and Macoubrie (2004) investigated US citizens' perceptions about NT by conducting a telephone survey and analyzed the data using frequency analysis and logistic regression analysis. Their results showed that Americans' reactions to NT are generally positive.

Scheufele and Lewenstein (2005) examined American citizens' attitudes toward NT and their knowledge in this area through a national telephone survey of 706 people. Their results proved that empirical knowledge provided by the mass media is the most critical determinant of people's opinions about NT. Currall et al. (2006) also conducted internet and telephone surveys of Americans in order to investigate the perceived risks and benefits of NT compared with 43 other technologies. They concluded that public perceptions of NT had a very complicated decision-making calculus. Scheufele et al. (2008) used survey data of Americans and Europeans to examine the influence of religious beliefs on attitudes towards NT. They compared the results from the two regions and discovered a negative relationship between the levels of religiosity and moral acceptance of NT. Moreover, they found that Americans had lower public acceptance of NT than Europeans. Since NT offers wide applications, several researchers have also analyzed cases wherein it is applied to existing products/technologies, such as NT foods (Siegrist et al., 2007; Siegrist, 2008), and nanomedicine (Berube, 2009).

In relation to public acceptance of new technologies, the last technology category I review concerns ET and energy technologies. For the environmental sector, interest in climate change mitigation has grown exponentially since the late 2000s, leading to many publications on public acceptance of such technologies. Foremost examples include studies examining public acceptance of carbon capture and storage (CCS) technologies. Through experimental research, Terwel et al. (2011) investigated the effect of people's trust in other CCS stakeholders on their acceptance of CCS technologies. Wallquist et al.

(2012) used conjoint analysis to analyze public preferences for a CCS system in Switzerland. Kraeusel and Most (2012) and Krause et al. (2014) also examined public acceptance of CCS technologies.

Domènech and Saurí (2010) examined public acceptance of ET related to water. In order to identify the determinants of public acceptance of grey water reuse technologies, they conducted a survey and in-depth interviews of Spanish grey water users and analyzed the data with a linear regression model. Their empirical results showed that perceived health risk was the most influential factor in public acceptance. The authors also pointed out the necessity for establishing a strategy to raise the users' knowledge levels about grey water reuse systems.

As stated above, energy policy—especially renewable energy policy—is the subject of empirical analysis in this dissertation. Thus, it is necessary to examine existing studies on public acceptance of energy technologies in relatively more detail. There are numerous studies on public acceptance of energy technologies, because one of the most critical factors in realizing a successful energy project is public acceptance. In particular, many studies have focused on public acceptance of nuclear energy technologies/systems that have long been socially controversial.

Studies on public acceptance of nuclear power technologies/systems have been continually published from the late twentieth century. Most studies have focused on specific countries: Canada (Davies, 1974), Japan (Yamada et al., 1977), Spain (Lopezrodriguez, 1977), France (Lemrechal, 1984), United States (Cohen, 1996), China

(Liu et al., 2008), and Korea (Song et al., 2013). Recent studies have examined and compared public acceptance among several countries by combining data from different sources (OECD, 2010; Kim et al., 2014).

The acceptance/rejection of new energy technologies, including different types of renewable energy technologies, has also aroused public interest. After the Kyoto Protocol came into force in 1997, numerous related studies have been published in this area. Using the Delphi technique, Iniyan et al. (2001) tried to foster a consensus among 300 experts regarding the social acceptance levels of solar, wind, and bioenergy technologies. Their survey result forecasted that the supplies of solar, wind, and biomass energy would account for 7-10% of the total energy supply in 2020. Wustenhagen et al. (2007) emphasized the need of social acceptance of renewable energy innovations and argued that three aspects of acceptance – sociopolitical, community, and market acceptance – should be examined. They also pointed out the lack of existing research on market acceptance and stressed the need for future research in this area. Stigka et al. (2014) reviewed existing studies by applying the CVM to investigate public attitudes toward renewable energy sources. They identified education, interest in environmental issues, and knowledge of renewable energy sources as major determinants of respondent willingness to pay (WTP) for these technologies. Zoellner et al. (2008), Carr-Cornish et al. (2011), Erbil (2011), Batel et al. (2013), Kasperson and Ram (2013), and Liu et al. (2013) also focused on multiple renewable energy technologies while addressing issues of public acceptance toward a general renewable energy system.

On the other hand, many studies have focused on public acceptance of a specific renewable energy technology/system. Examples include ocean and marine energy (Devine-Wright, 2011; Heras-Saizarbitoria et al., 2013; Lim and Lam, 2014), wind energy (Firestone et al., 2009; Evans et al., 2011; Firestone et al., 2012; Petrova, 2013), solar energy technologies (Yuan et al., 2011) including solar water heaters (Mallett, 2007) and photovoltaic systems (Müggenburg et al., 2012, Heras-Saizarbitoria et al., 2011), and geothermal energy technology (Dowd et al., 2011).

Thus far, I have extensively reviewed previous studies on public acceptance of a new technology by technology categories (ICT, BT, NT, and ET). Next, I summarize these studies by analyzing public acceptance of a new policy that is scheduled to be introduced or is perceived as being socially controversial. Considering that new technologies and new policies not only mutually influence each other but are also closely related in most cases, it is not easy to clearly distinguish these studies along these two categories. Therefore, I provide only a brief summary of the studies that do not largely concern new technologies, focusing instead on their analysis target policy and methodology framework. Studies on public acceptance of transport policies outnumber studies on other policies. Chen and Zhao (2013) examined public acceptance of China's vehicle control policy and found that although the respondents agreed to the potential effectiveness of the policy, they tended to be generally negative about its enforcement. Tornblad et al. (2014) also analyzed public acceptance of several restrictive measures for transportation improvements. Respondents were asked to express their preferences through individual measures on a scale of one to five. The authors compared the mean value of each measure and analyzed the determinants of its acceptance. Furthermore, Cools et al. (2012) and Rentziou et al. (2011) also studied public acceptance of transport policies. Cohen et al. (2014) calculated the mean score of survey results from 47 European countries to analyze the public acceptance of euthanasia in Europe. Other notable studies have focused on public acceptance of a new electricity price hierarchy (Wang et al., 2012) and an environmental taxes policy (Thalmann, 2004; Kallbekken and Sælen, 2011).

From the perspectives of methodological framework and the main findings, existing studies on public acceptance of a new technology and/or policy can be summarized as follows. First, with regard to the methodological framework, the majority of the reviewed studies were empirical analyses of survey data. The majority of studies performed quantitative analyses based on simple analyses of variance, which have become mainstream. Second, with regard to the contents and main findings, most studies focused on investigating factors affecting public acceptance, such as demographics and respondents' experiences. Most of the empirical analyses revealed risk and benefit perceptions, trust, knowledge, ideology, and religion to be key variables determining the level of public acceptance. To sum up, most of previous literature merely tried to identify the determinants of public acceptance levels of a technology/policy; they could not quantitatively forecast the changes in public acceptance and consumer responses depending on variations in the attribute levels of the studied technology/policy.

2.2 Research on Renewable Energy Policies

As stated in chapter 1, the subjects of empirical analysis in this dissertation are three Korean renewable energy policies, namely the RPS in the electric power sector, the RFS in the transport sector, and the RHO in the heating sector, which were either introduced recently or are scheduled to be introduced in the coming years. More precisely, I analyze public preferences for individual renewable energy policies, elicit marginal WTP (MWTP) for each attribute of the policy, and forecast the level of public acceptance according to the variations in specific attribute levels. In this section, therefore, it is worth reviewing existing studies on renewable energy policies. Because three renewable energy policies in each energy sector will be analyzed separately, existing studies related to each policy are summarized as follows.

First, with regard to the RPS, I summarize the existing studies on renewable energy policies in the electric power sector. Previous studies that have focused on the public acceptance of renewable energy, especially in terms of MWTP, can be divided into two major categories. The first analyzes preferences for renewable energy sources (i.e., green power), and the second analyzes preferences pertaining to renewable energy policies (i.e., promoting renewable energy programs). Compared to other (conventional) energy sources, studies pertaining to renewable energy sources and technologies are still in the nascent stage. The same situation exists for renewable energy policies. Thus, previous studies in this field are mostly based on stated preference data. In particular, the CVM and conjoint analysis have been widely employed to analyze consumer preferences on unreleased commodities/services and to derive MWTP.

Research on consumer preferences and WTP for renewable energy sources are summarized as follows. Batley et al. (2001) estimated British citizens' WTP for wind power using the CVM. Their results revealed that poor WTP coupled with the high cost of producing wind power would make rapid expansion of wind power capacity difficult. Nomura and Akai (2004) also used the CVM to estimate WTP for renewable energy in terms of monthly additional costs for Japanese families. The median WTP was approximately JPY 2,000/month (about USD 17/month). Yoo and Kwak (2009) analyzed Korean consumers' WTP for green power using the CVM. The results of the parametric and nonparametric methods indicated that the estimated average WTP was KRW 1,681/month (about USD 1.5/month) and KRW 2,072/month (about USD 1.85/month), respectively. Kim et al. (2012) employed the CVM to estimate Korean families' additional WTP for wind, solar, and hydro energy. They concluded that while WTP for wind power was the highest and that for hydropower the lowest, the difference was statistically insignificant. Therefore, domestic consumers appear to prefer portfolios that minimize power supply costs. In addition, Abdullah and Jeanty (2011), Bollino (2009), Savvanidou et al. (2010), and Zografakis et al. (2010) used the CVM to analyze public preferences for renewable energy technologies and marginal WTP in Italy, Greece, Crete, and Kenya, respectively.

Roe et al. (2001) analyzed American consumers' WTP for green electricity through conjoint and hedonic analyses. They found increased WTP when emissions reductions result from increased reliance upon renewable sources of energy. Ku and Yoo (2010) used conjoint analysis to estimate Korean families' preferences and WTP for renewable energy power plants. The results indicated that while the subjects valued the protection of wild animals, decreased pollution, and increased employment opportunities, they did not place much emphasis on natural landscapes. Á lvarez-Farizo and Hanley (2002) and Scarpa and Willis (2010) also analyzed preferences for renewable energy sources through a conjoint analysis in the United Kingdom and Spain, respectively.

Next, I review studies on consumer preferences and WTP pertaining to renewable energy policies in the electric power sector. Wiser (2007) conducted a CVM survey to investigate WTP for renewable energy under collective and voluntary payment vehicles in the US. The subjects were asked whether they preferred the government or the private sector to collect the additional cost incurred for renewable energy generation. The analysis showed a relatively higher WTP with the collective payment method and when the collection of the additional cost would be done by the private sector. Mozumder et al. (2011) also used a CVM survey of families in New Mexico to estimate WTP for a renewable energy program. It queried respondents about their WTP an additional monthly cost for various scenarios (such as if renewable energy were to constitute 10% and 20% of the total energy supply).

Through CEs, Longo et al. (2008) examined WTP of local residents in the UK for a hypothetical policy promoting renewable energy production. They analyzed the respondents' preferences by setting up four attributes for the hypothetical policy: annual reduction in greenhouse gases (GHGs), number/length of annual power shortages, changes in the number of employees in the electricity supply sector, and increase in annual electricity charges due to the increase in the share of renewable energy in the total energy portfolio. The results indicated that the respondents were in favor of a renewable energy policy on account of the benefits in GHG reductions and improved energy security. Moreover, it was perceived that such a policy would provide public as well as private benefits.

Next, I examine studies related to the RFS, particularly, on renewable fuel policies in the transport sector. Past literature on renewable energy technologies and policies contains limited references to renewable fuels, both quantitatively and qualitatively. As public interest in renewable fuels is increasing, however, the number of studies focusing on the RFS has increased recently.

A renewable fuel policy is normally introduced with expectations of various environmental and economic benefits. However, implementation of such a policy can also bring about unexpected consequences. Accordingly, several studies have analyzed and forecasted the possible impacts of RFS implementation. Gallagher et al. (2003) estimated the changes in additives markets and the ethanol industry according to demand expansion and policy scenarios related to the RFS. Anderson and Coble (2010) investigated the potential impact of RFS ethanol mandates on the corn market and found that a mandate could have a substantial impact on corn prices and quantities. Chen et al. (2014) compared the welfare effects and climate benefits of three renewable fuel policies, including the RFS, and they concluded that the RFS elicits the highest social welfare among them. Huang et al. (2013) examined whether a higher net economic benefit as well as greater GHG emissions reductions could be achieved when the RFS was combined with another policy. Sarica and Tyner (2013a) estimated the impacts of different policy and technology choice scenarios related to the RFS on biofuel production. Soratana et al. (2012) accessed the potential of specific types of biofuels to meet RFS requirements. Studies in this category provide some criteria to help judge whether the RFS can actually provide the expected benefits.

Public response to the effects of policy implementation is very important for its sustainability. Therefore, it is worth referring to studies that have examined the preference and acceptance of end customers for renewable fuels and/or related policies. These can be subdivided into two categories: investigations of public opinion on (a) renewable fuels (such as bioethanol/biodiesel) and on (b) renewable fuels promotion policies.

First, several researchers have examined public responses to renewable fuels (mostly biofuels). Savvanidou et al. (2010) examined social acceptance toward biofuels in Greece using face-to-face interviews and summarized the various opinions of respondents on biofuels. Cacciatore et al. (2012) examined how respondents' sociodemographics and biofuel labeling could affect public acceptance of biofuels. Khachatryan et al. (2013) analyzed consumer preferences for biofuels from a psychological viewpoint. Van de Velde et al. (2011a) analyzed the determinants of consumer information insufficiency in relation to biofuels and found that women, the elderly, and the less educated had a higher a priori interest in receiving more information about biofuels. Other studies also investigated public attitudes and opinions about, and their acceptance of renewable fuels using surveys (Lahmann, 2005; Kubik, 2006; Wegener and Kelly, 2008; University of Wisconsin-Madison, 2009).

Second, studies have also investigated public opinion on renewable fuel policies and/or analyzed factors affecting this opinion. Delshad et al. (2010) explored detailed public attitudes toward biofuel technologies and policy options and found that respondents were most supportive of an alternative fuels standard and least supportive of a fixed subsidy and a cap and trade policy. Zhang et al. (2011) analyzed Chinese drivers' views on promotion policies for biofuel use and showed that respondents thought that increasing subsidies for using biofuels was likely to be most effective. Focusing on the information channels with regard to biofuels, Van de Velde et al. (2011b) showed that the majority of consumers preferred to obtain information via newspapers and brochures and were interested particularly in the tax (dis)advantages associated with biofuels. Delshad and Raymond (2013) analyzed the influence of media framing on public attitudes toward biofuels and emphasized the importance of framing effects on public attitudes toward energy policies.

Most previous studies examining public acceptance of renewable fuels utilized a simple survey method and focused on public preferences for the renewable fuel itself. That is, few studies have identified detailed public preference structures for a policy like the RFS using an advanced econometric model. Further, as indicated by Cacciatore et al.

(2012), it is difficult to discern a clear pattern of public opinion among past studies. This unclear pattern may be attributed to the fact that most previous studies merely analyzed public opinion on renewable fuel policies; they did not quantitatively estimate the change in the public's acceptance level depending on variations in policy design.

With regard to the RHO, compared to the other two sectors, renewable deployment in the heating sector has attracted public attention fairly recently. Thus, studies on renewable heat energy policies are fairly limited. Burger et al. (2008) reviewed various innovative instruments supporting renewable energy in the heat market. By comparing them qualitatively and quantitatively, the authors evaluated several renewable heat policies in Germany and found that the Bonus Model is a more favorable measure than government grants and obligations. Steinbach et al. (2013a) also evaluated three different policy instruments for expanding renewable energy sources for heating. Although both the quota policy and the remuneration-based policy held promise in enhancing renewable energy deployment in the heating sector, there was greater acceptance among stakeholders for the remuneration-based policy. Using a bottom-up energy system model, Steinbach et al. (2013b) quantitatively assessed different levels of renewable heat policy harmonization in six European countries. They concluded that a harmonized use obligation could facilitate the targeted achievements. Kranzl et al. (2013) forecasted the demands of three European countries for renewable heat through a bottom-up energy system model. They considered the potential effects of subsidies and obligation policies on the growth in future demand for renewable heat in their forecasting procedure. They concluded that use obligations for renewable heating would be more effective in helping the renewable heat market to grow. Other studies have also analyzed renewable heat policies from a broader perspective. Connor et al. (2013) reviewed various renewable heat policies and discussed their respective advantages and disadvantages. Abu-Bakar et al. (2013) evaluated UK's renewable heat incentive (RHI) scheme in terms of economic perspectives such as total profit, payback period, and average annual return on investment.

Chapter 3. Methodology

3.1 Stated Preference Technique: Discrete Choice Experiment

People reveal their preferences for decision alternatives through choice among them. When aggregated, these individual choices ultimately constitute demand for the products/services or public acceptance of new technology/policy. Therefore, observing and analyzing people's choices are important for both the government and the firm that desires quick diffusion of its innovation, such as a new product/service or a new technology/policy.

For these reasons, in order to analyze the aggregated preferences of people—consumers or the general public, depending on the situation—the researcher needs relevant data to enable him/her to observe their choices. Traditionally, two different approaches have been used to collect such data. The first utilizes real market information about goods and services that need to be evaluated, while the second requires relevant preference/choice data, which are collected by asking people their opinions on the relevant product/service through a method like a survey. In general, the former is known as the revealed preference (RP) technique, and the latter, the stated preference (SP) technique. Considering these techniques from the viewpoint of economic evaluation, the RP technique is considered an *ex post* evaluation method, because it is based on observations on people's actual purchases and trading activity in the real market. On the other hand, the SP technique is considered an *ex ante* evaluation method, because it assumes a hypothetical market for nonexistent/recently launched goods and services.

Each technique has its own advantages and disadvantages.[1] The RP technique can develop a model more similar to people's actual behavior, because it collects objective data that are based on the actual (observed) behavior of each individual. However, RP field studies are generally expensive, because it takes substantial time and money to collect data on individual characteristics affecting a person's purchase behavior. Furthermore, one of the critical limitations of the RP technique is that it cannot observe the individual's choice pattern for existing alternatives such as prelaunch products/services. For these reasons, RP techniques usually do not provide useful information to guide the development of a new product/service, and they often are ill-suited for answering "what if" type questions about products that exist (Raghavarao et al., 2011).

To observe an individual's behavioral change and response to a hypothetical situation (a product/service), SP techniques are based on the individual's statement on hypothetically assumed choice situations. SP techniques offer several advantages over RP techniques. Given that experimental manipulation of choice situations in the SP technique is relatively easy, SP studies are generally more rapidly completed and inexpensive. Thus, forecasting the behavior and intention of an individual in a hypothetical situation is accomplished using SP techniques, especially when observation of and investigation into

[1] For this reason, various methods of combining RP and SP data have been presented recently. However, there have been relatively few publications due to its own disadvantages such as being harder to implement, statistically complex model.

the actual behaviors of individual actors are difficult. Moreover, in terms of a firm's marketing perspective, SP studies can be conducted in controlled settings, and thus, they are not susceptible to competitive sabotage (Raghavarao et al., 2011). Because the three Korean renewable energy policies explored in this dissertation have either not yet been implemented or have recently been introduced, it is more appropriate to use the SP technique for the empirical analysis. A typical work plan for an SP study is presented in Figure 2.

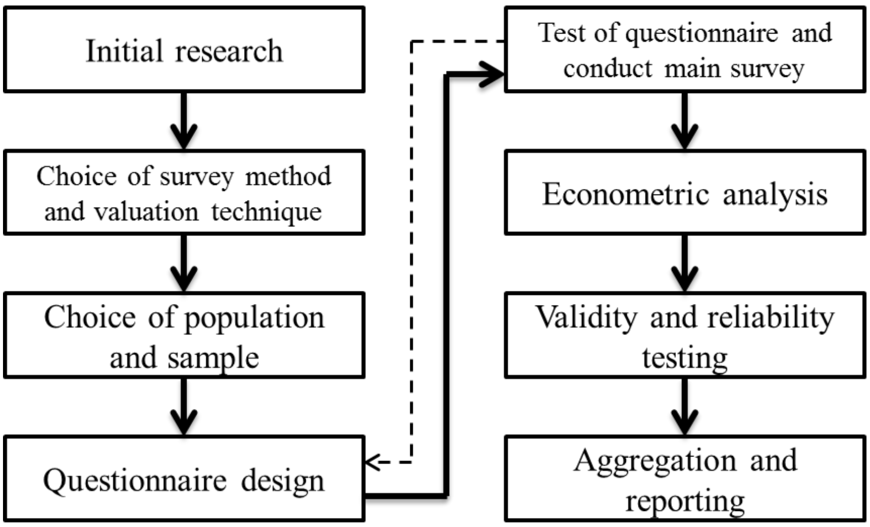

Figure 2. A typical workplan for a stated preference study

Source: Adapted from Bateman et al. (2004)

The SP techniques of concern include CM and contingent valuation (CV). The choice of technique depends on the research purpose and characteristics of the analysis target. Generally, CV is used when one needs to assess the overall WTP for a nonmarket good/service, that is, its total value as assessed by the public. CM is useful if one needs to assess WTP for an individual attribute and gather information on relative values for different attributes of a good/service. The CM approach has several advantages over the CV approach. While CV presents some cognitive problems, CM does not explicitly ask about monetary values, and therefore, CM is arguably easier for people to understand. CM also offers a more efficient means of sampling, since more responses can be obtained from each individual with CM than with CV. Besides, CM designs can reduce the extreme multicollinearity problems associated with variations in actual attribute values (Bateman et al., 2004). As one of the objectives of this dissertation is to forecast changes in the level of public acceptance according to variations in individual attributes, it is more appropriate to use the CM approach to estimate the part-worth of individual attributes.

CM is based on the idea that any good/service can be described in terms of its attributes or characteristics and the levels they assume. CM includes various techniques such as CEs, contingent ranking, contingent rating, and paired comparisons. These methods differ in their ability to produce WTP estimates that are consistent with the usual measures of welfare change. These techniques are also sometimes known as “conjoint analysis,” which is a somewhat confusing term, because CM originated from market research and has started being applied only relatively recently. Among the several techniques of CM, CE is a method that presents respondents with a series of alternatives and asks them to choose their most preferred one. A baseline alternative, corresponding to the status quo, is usually included in each choice set and must be used for welfare-consistent estimates to be produced. In a contingent ranking, respondents are required to rank a set of alternative options according to their order of preferences. In a contingent rating, respondents are presented with a number of scenarios one at a time and are asked to rate each one individually on a semantic or numeric scale. Lastly, in a paired comparison, respondents are asked to choose their preferred alternative from a set of two choices and to indicate the strength of their preference in a numeric or semantic scale. Table 1 presents these four types of CM alternatives.

Table 1. Main choice modelling alternatives

Approach	Tasks	Welfare consistent estimates?
Choice experiments	Choose between (usually) two alternatives versus the status quo	Yes
Contingent ranking	Rank a series of alternatives	Depends
Contingent rating	Score alternative scenarios on a scale of 1-10	Doubtful
Paired comparisons	Score pairs of scenarios on similar scale	Doubtful

Source: Bateman et al. (2004)

As presented in Table 1, only CEs give welfare-consistent estimates among the various CM methods.[2] Thus, in this dissertation, I use the CE as the survey technique for data collection.

[2] There are four reasons why choice experiments give welfare-consistent estimates. For a more detail discussion on this issue, refer to the Bateman et al. (2004).

In short, the CE is a technique in which a choice approach is applied to the conjoint analysis. The DCM is one of the most suitable econometric models to analyze CEs, because it describes a decision maker's choice from among the available alternatives. Among the fundamental DCMs, the multinomial logit model is most frequently used to analyze 0/1 choice data arising from such CEs (Haaijer and Wedel, 2003). Following the popular use of the random utility model approach, which was applied to conjoint surveys by several researchers such as Madanski (1980) and Louviere and Woodworth (1983), conjoint and discrete choice approaches were integrated and developed further. Thus, in the next section, I describe the mixed logit model, one of the most sophisticated models among DCMs, which reflects heterogeneity among respondents. I also examine its potential applicability to this dissertation's empirical analyses.

3.2 Mixed Logit Model

Derived from random utility models, a DCM is used to analyze public acceptance of innovation policy (specifically renewable energy policies in this case). CE survey data essentially have discrete properties, because respondents choose an alternative that gives them the highest utility in a choice set. Thus, DCM is a suitable analytical tool for the present research objective.

DCMs are derived under the assumption of utility-maximizing behavior by a decision maker (Train, 2009). Therefore, the probability P_{nj} that consumer n chooses alternative j is represented as equation (1) (Train, 2009).

$$
\begin{aligned}
P_{nj} &= \Pr\left(U_{nj} > U_{ni}, \forall i \neq j\right) \\
&= \Pr\left(V_{nj} + \varepsilon_{nj} > V_{ni} + \varepsilon_{ni}, \forall i \neq j\right) \\
&= \int_{\varepsilon} I\left(\varepsilon_{ni} - \varepsilon_{nj} < V_{nj} - V_{ni}, \forall i \neq j\right) f\left(\varepsilon_n\right) d\varepsilon_n
\end{aligned}
\tag{1}
$$

where U_{nj} is the utility that the consumer obtains from the alternative, V_{nj} is the representative utility that relates the observed factors to the consumer's utility, ε_{nj} is a disturbance that is the unobserved portion of the utility, and $I(\cdot)$ is the indicator function. Different DCMs, such as the logit, probit, and mixed logit models, are obtained from different assumptions about the distribution of the unobserved portion of the utility.

Of the several types of DCMs, the mixed logit model is very flexible and can approximate any random utility model (McFadden and Train, 2000). It can reflect the heterogeneity of consumer preferences by assuming that coefficient vector β_n follows a certain probability distribution, the density function of which is $f\left(\beta\right)$. Moreover, the mixed logit model is not restricted to a specific distribution (Train, 2009); thus, different distributions can be assumed according to the attributes' effects on consumer preferences (Train and Sonnier, 2005).

In the mixed logit model, the utility U_{njt} that consumer n obtains from an alternative j in a choice set t is represented as equation (2) (McFadden, 1974; Train, 2009).

$$U_{njt} = V_{njt} + \varepsilon_{njt} = \beta_n ' X_{njt} + \varepsilon_{njt}, \qquad \beta_n \sim N(b, W) \tag{2}$$

where vector X_{njt} denotes the attributes and their level of an alternative j in a choice set t, and β_n is a coefficient vector that follows a normal distribution with mean b and variance W. Assuming random disturbance ε_{njt} follows an independent and identically distributed (i.i.d.) extreme value distribution, the choice probability P_{nj} is expressed as equation (3) (Train, 2009).

$$P_{nj} = \int \left(\frac{e^{\beta_n' x_{nj}}}{\sum_i e^{\beta_n' x_{ni}}} \right) f(\beta) \, d\beta \tag{3}$$

The likelihood function takes the form of equation (4), after assuming a specific distribution for each coefficient.

$$L(y_n \mid \beta_n) = \prod_{t=1}^{T} \frac{\exp(\beta_n ' x_{jt})}{\sum_{k=1}^{J} \exp(\beta_n ' x_{kt})} \tag{4}$$

where y_n denotes the collected vector that each consumer n chooses as the alternative in the choice set.

Each coefficient estimate in the mixed logit model merely represents the marginal contribution of each attribute to the marginal utility in arbitrary units. Thus, it is better to calculate a consumer's MWTP from estimates in order to compare the consumer's relative preference for attributes. MWTP is the amount of money that consumers are willing to pay to maintain their current level of utility when the level of an attribute changes by one unit. Assuming that V_{nj} consists of a price attribute $x_{j,price}$ and other attributes x_{jk}, the MWTP for each attribute can be calculated by equation (5).

$$MWTP_{x_{jk}} = -\frac{\partial U_{nj} / \partial x_{jk}}{\partial U_{nj} / \partial x_{j,price}} = -\frac{\beta_k}{\beta_{price}} \qquad (5)$$

The relative importance (RI) represents the degree to which each attribute affects consumer choice and can be calculated by the part-worth of each attribute as shown by equation (6).

$$RI_K = \frac{part-worth_K}{\sum_k part-worth_k} \times 100 \qquad (6)$$

The part-worth of attribute k can be obtained by multiplying β_k, the coefficient of attribute k, by the difference between the maximum and minimum levels of each attribute.

3.3 Multivariate Probit Model

In this dissertation, I suggest an integrated approach to analyze public preferences for several similar policies in the same category. That is, all the policy alternatives of the three renewable energy policies presented in the survey are classified into a few categories regardless of the policy.[3] In this case, respondents face a situation where they can make multiple choices from alternatives, which in turn points to the need for a multivariate DCM. The multivariate logit model and the multivariate probit model (MVP) have been most frequently used to analyze multiple response data (Boztuğ & Hildebrandt, 2006). The multivariate logit model exhibits independence from irrelevant alternatives (IIA), which is common for a logit model. The MVP relaxes the IIA property and can thus analyze simultaneous multiple choice patterns among several alternatives with a covariance matrix. Specifically, a multivariate logit model that extends the multinomial logit model assumes its disturbance to have the Gumbel type I extreme value distribution. An MVP is an extension of a multinomial probit model and assumes its disturbance to have a normal distribution. Unlike the multinomial models that allow only a single choice from mutually exclusive alternatives, however, multivariate models allow multiple choices among them. Given these advantages, I prefer to employ the MVP model over the

[3] The methods of classifying policy alternatives and arranging respondents' choice data are described in chapter 5 in detail.

multivariate logit model to analyze the public's simultaneous choice patterns in a multiple choice situation.

According to the random utility model derived from the utility maximization theory, the utility U_{ij} consumer i obtains from purchasing product/service j can be represented as equation (7).

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \alpha_j + \sum_k \beta'_{jk} X_{jk} + \varepsilon_{ij} \qquad (7)$$

$$Y_{ij} = \begin{cases} 1 \text{ if } U_{ij} > 0 \\ 0 \text{ if } U_{ij} \leq 0 \end{cases} \qquad (8)$$

In equation (7), total utility U_{ij} is decomposed as V_{ij} and ε_{ij}. The deterministic utility - or representative utility - V_{ij} can also be decomposed as an alternative specific constant (ASC) α of each product/service j and the multiplied term $X\beta$. X denotes the independent variables that affect the utility, and β denotes their parameter vector. Different assumptions about the distribution of random disturbance ε_{ij}, which captures the factors affecting the utility but are not included in V_{ij}, can be assumed to obtain a different DCM. Consumer i will choose alternative j if and only if the utility obtained by choosing j is greater than that by not choosing it, meaning Y_{ij} equals 1.

That is, Y_{ij} is a binary indicator that equals 1 if decision maker j chooses alternative i or 0 otherwise.

As explained above, the MVP model relaxes the IIA restriction and assumes that disturbance ε_i ($\varepsilon_i = \{\varepsilon_{i1}, \varepsilon_{i2}, \ldots, \varepsilon_{iJ}\}$) follows a multivariate normal distribution with 0 mean and variance-covariance matrix Σ, which is represented by equation (9). Then, the probability density function of ε_i can be represented as equation (10).

$$\varepsilon_i \sim MVN[0, \Sigma],\ \Sigma : J \times J \text{ variance-covariance matrix} \tag{9}$$

$$\phi(\varepsilon_i) = \frac{1}{(2\pi)^{J/2} |\Sigma|^{1/2}} e^{-\frac{1}{2}\varepsilon_i' \Sigma^{-1} \varepsilon_i} \tag{10}$$

The MVP model is advantageous in that it can simultaneously analyze independent choice patterns by allowing a correlated error structure of purchase utilities (Manchanda et al., 1999). In this case, the sign of the correlation provides useful information about the simultaneous choice pattern. That is, if $\text{cov}(\varepsilon_{ij}, \varepsilon_{ik}) > 0$, then an increase in the purchase utility of category j will lead to an increase in the purchase utility of category k. In other words, the error correlations capture the linkages between the uncontrollable factors that drive joint purchases (Manchanda et al., 1999). Additionally, the sign and magnitude of the error correlations can suggest various implications, because the magnitudes provide a measure of the strength of the impact of unobserved factors in inducing joint purchasing activity. In the strict use of the word, however, the sign of the error correlation represents a joint purchase probability rather than the substitution/complementary relationship among alternatives.

The choice probability that a consumer chooses multiple alternatives can be represented as the following form of multiple integration.

$$\Pr\left(y_i \mid \beta, \Sigma\right) = \int_{S_1} \cdots \int_{S_J} \phi_J\left(\varepsilon_1, \ldots, \varepsilon_J \mid 0, \Sigma\right) d\varepsilon_1, \ldots, d\varepsilon_J \tag{11}$$

$$y_i = \left(y_{i1}, \ldots, y_{iJ}\right) \tag{12}$$

$$S_j = \begin{cases} (-\infty, 0), \text{ if } \; y_{ij} = 0 \\ (0, \infty), \quad \text{if } \; y_{ij} = 1 \end{cases} \tag{13}$$

where $\phi_J\left(\varepsilon_1, \ldots, \varepsilon_J \mid 0, \Sigma\right)$ in equation (11) represents the probability density function of disturbance. However, the MVP model is empirically intractable. Models with more than three dimensions are extremely difficult to estimate, because it is computationally difficult to evaluate the high order multivariate normal integrals required to specify the likelihood. Therefore, I use a Bayesian estimation technique with Gibbs sampling, which is necessary for modeling observed and unobserved sources of consumer heterogeneity. The Bayesian approach is widely used to estimate the MVP model (Manchanda et al., 1999; Edwards and Allenby, 2003; Seetharaman et al., 2005). In Gibbs sampling, one of the most representative Markov chain Monte Carlo (MCMC) methods, a joint posterior density can be easily obtained by repeated draws from the conditional distribution. The Bayesian procedure also has several advantages over a classical procedure such as the maximum likelihood estimation (Train, 2009). It avoids the complicated integration of the multivariate density function and overcomes the initial point problem, as it does not require maximization of the nay function. Furthermore, the result from the Bayesian estimation can also be converted into a classical estimation result.[4]

[4] Detailed description of Bayesian procedure for probit models can be found in Albert and Chib (1993), McCulloch and Rossi (1994), Allenby and Rossi (1999), and McCulloch et al. (2000).

Chapter 4. Quantifying Public Acceptance of Renewable Energy Policies

4.1 Renewable Portfolio Standard: Analysis in the Electric Power Sector

4.1.1 Research Background

Korea relies on imports for 97% of its energy needs. Globally, it was the eighth largest energy consumer and the seventh largest carbon dioxide (CO_2) emitter in 2012 (Enerdata, 2013). Korea has been making a number of efforts to respond to climate change. In 2008, Korea pledged to reduce its GHG emissions by 30% below the business as usual (BAU) baseline by 2020. Moreover, the Korean government declared low-carbon green growth as its top priority. Therefore, the government is adopting various policies and systems designed especially for climate change mitigation in various fields, such as electricity, transportation, waste management, agriculture, and weather forecasting. Notably, the Korean government actively promotes renewable energy dissemination because such policies not only reduce Korea's carbon emissions and its dependence on overseas energy sources but also create new markets for renewable energy. Of the various such policies being implemented in Korea presently, this section focuses on the RPS.

The RPS obligates electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. In Korea, the feed-in tariff (FIT)[5] was

[5] This government program was designed to compensate for the difference between the electricity costs of

replaced by the RPS in January 2012, wherein 13 electricity supply companies were mandated to generate 2% of their gross power generation from renewable sources, such as solar, wind, hydro, tidal power, fuel cells, hydrogen, biomass, and waste, from 2012. This percentage is set to rise to 10% in 2022. Compared to electricity generation from fossil fuels, this entails higher initial investment and increased electricity generation costs. Thus, the generation costs of the electricity supply companies are likely increase considerably. The companies want to cover these increasing costs due to RPS implementation by passing them on to the consumers in their electricity bills. However, the government will make efforts to suppress such increases because of public resistance, the present structure of Korea's electricity industry, and political reasons. Therefore, currently, electricity supply companies are burdened with the increasing electricity generation cost caused by the RPS (see Figure 3). The modalities of the increase in electricity prices needed to cover the companies' additional expenses due to RPS implementation are still under discussion; that is, the degree, method, and timing of increase in electricity prices have not yet been decided.

renewable energy and those of fossil fuel power generation, in order to promote the production and use of the former.

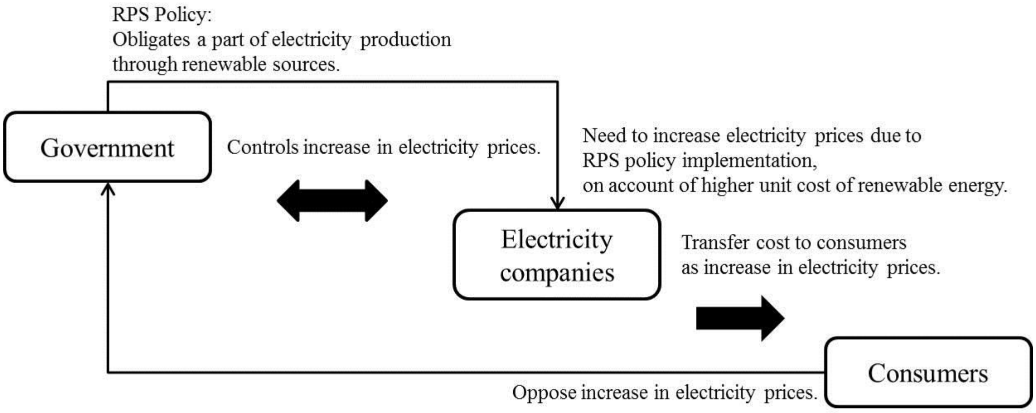

Figure 3. Overview of RPS

Clearly, this state of affairs cannot continue and requires sustained consultation with various stakeholders, which include the electricity supply companies, the government, and the consumers. In order to ensure effective implementation of the RPS, it is crucial to understand public acceptance and their MWTP in relation to the RPS and to derive the most effective strategy to hasten its successful implementation. However, public acceptance of RPS is difficult to ascertain, unlike the acceptance of the government and electricity supply companies. This makes it difficult to take reasonable decisions with regard to the RPS as well as to quantify the inevitable increase in electricity prices. Therefore, understanding public acceptance and their MWTP is a critical first step toward reaching a consensus on issues related to the RPS that would satisfy the government, electricity supply companies, and consumers.

Therefore, in this section, public (especially household) preference for the RPS policy and their MWTP for its implementation are quantitatively analyzed. The results help us to propose solutions, such as electricity prices that may be more acceptable to the public, as well as effective strategies to enhance the acceptance of the RPS in the public realm.

4.1.2 Data: Design of Choice Experiment

As this empirical research intends to investigate public preferences and predict changes in public acceptance level (which is actually the choice probability of policy adoption based on hypothetical attributes), it is necessary to undertake a segmentation of the existing RPS. Accordingly, I employ CEs to record the stated preferences of the respondents. The CE is one of the most appropriate analytical methods to collect stated preferences, since it allows us to propose hypothetical policy situations or alternative outcomes by asking respondents to repeatedly choose one alternative from different sets of policy scenarios constructed from core attributes defined at certain levels (Haaijer and Wedel, 2003). Furthermore, a CE aggregates the part-worth of each analyzed object's attributes, thus helping us to predict public preferences from among numerous alternatives. I define attributes that may affect public acceptance of the RPS (Table 2) and conduct the CE to record the public's stated preferences for the RPS.

While constructing the survey, I try to calculate the costs incurred and expected benefits earned by each respondent due to RPS implementation. First, RPS implementation would create development liabilities for the electricity supply companies, causing their development costs to rise. This increase would be passed on to consumers as a rise in electricity prices, or in other words, increased electricity bills. Reduced GHG emissions and new job creation are the positive effects of this cost, while its negative effects include increased probabilities of power outages and forest damage (Table 2).

Table 2. RPS attributes for the choice experiment

Attributes	Attribute Levels
Increased electricity bills[1]	2% increase (Based on a monthly electricity cost of KRW 50,000, the additional cost is KRW 1,000/month or KRW 12,000/year.)
	6% increase (Based on a monthly electricity cost of KRW 50,000, the additional cost is KRW 3,000/month or KRW 36,000/year.)
	10% increase (Based on a monthly electricity cost of KRW 50,000, the additional cost is KRW 5,000/month or KRW 60,000/year.)
Reduced GHG (CO_2) emissions	3% per year (18 million ton CO_2-eq)
	5% per year (30 million ton CO_2-eq)
	7% per year (42 million ton CO_2-eq)
New job creation	10 thousands per year (0.04% decrease in the unemployment rate)
	20 thousands per year (0.08% decrease in the unemployment rate)
	30 thousands per year (0.12% decrease in the unemployment rate)
Power outage time	10 minutes per year
	30 minutes per year
	50 minutes per year
Forest damage	530 km^2 per year

	660 km^2 per year
	790 km^2 per year

The Korea Electrotechnology Research Institute (2009) estimates that electricity bills will rise by about 3% due to RPS introduction in Korea. Accordingly, I introduce three distinct choices/attribute levels, 2%, 6%, and 10%, for the increase in electricity bills in the CE survey.

Kydes (2007) predicted that GHG emissions rates will decrease by about 4%/year when the obligated ratio of renewable energy in US energy markets – which is twice the level proposed by the RPS in Korea – is imposed. Using EIA (US Energy Information Administration) data, Palmer and Burtraw (2005) predicted that GHG emissions rates will decrease by about 5.8%/year when the imposed obligated ratio of renewable energy equals the RPS mandate. Using their research as a base, I set the attribute levels for GHG emissions reduction as 3%, 5%, and 7%/year.

According to the Renewable Energy Center of the Korea Energy Management Corporation (KEMCO),[6] the enforcement of the RPS in the US has led to the creation of 35,000 new jobs annually. Accordingly, the Center estimates that implementing the Korean RPS policy will create employment for over 10,000 people/year. Based on this, I provide attribute levels for employment creation as 10,000, 20,000, and 30,000 people/year.

Generating one unit of renewable energy entails a higher unit cost than that for

[6] http://www.knrec.or.kr/knrec/index.asp

conventional fossil fuel power generation. The probability of power outages also increases due to the higher uncertainty of electricity supply, as the same may be affected by the climate. As a result, I add annual outage as an attribute and establish attribute levels (30, 60, and 120 minutes) based on the large-scale blackout that lasted 30-60 minutes across different regions of Korea on September 15, 2011 and the findings of Longo et al. (2008).

According to the Korea Nuclear Energy Promotion Agency,[7] 33 km^2 and 165 km^2 of land is needed to generate 1 million KRW each of solar energy and wind power, respectively. Using these numbers, I calculate that 3,074 km^2 of land is needed to comply with the 2012 target set by the RPS. Therefore, a sizeable portion of forests will be damaged. Accordingly, I also add forest damage to the attributes in Table 2.

The combination of attributes and levels presented in Table 2 gives rise to 243 possible alternatives. Since it would be very difficult to complete a consumer preference survey for all the 243 alternatives, I employ fractional factorial design to choose a total of 18 alternatives, thus ensuring the orthogonality of each attribute. Thereafter, these 18 alternatives are divided into 6 choice sets, and the alternative “no choice” is included in each choice set. Fundamentally, I combine 3 alternatives randomly from 18 alternatives to make 6 choice sets and rearrange some specific choice sets to avoid having a superior or an inferior alternative exist in the choice set. The respondents were asked to choose the best alternative from among these four alternatives (see Figure 4). To reduce consumer

[7] http://www.konepa.or.kr/eng/index.html

response time, I divide the respondents into two groups and provide three choice sets to each respondent.

Q . Assuming that you can accrue possible benefits and disbenefits from CO2 emissions reductions (benefit), new employment (benefit), electricity shortages (disbenefit), and forest damage (disbenefit) by paying increased electricity bills for a year, please choose the most preferred type of Renewable Portfolio Standard (RPS) from among the four hypothetical options provided below (including "no choice," i.e., retaining the status quo).

Please circle your most preferred policy from the four options given here.

▣ Questionnaire 1: Renewable Portfolio Standard (RPS)

Attributes of Policy	Policy A	Policy B	Policy C	No choice
1. Increase in Electricity Bills	2% increase (Based on a monthly electricity bill of KRW 50,000, you would additionally pay KRW 1,000.)	6% increase (Based on a monthly electricity bill of KRW 50,000, you would additionally pay KRW 3,000.)	6% increase (Based on a monthly electricity bill of KRW 50,000, you would additionally pay KRW 3,000.)	No choice (Do not need the RPS policy)
2. Reduction in CO_2 Emissions	7% decrease/year (42 million ton of CO_2-eq decrease/year)	5% decrease/year (30 million ton of CO_2-eq decrease/year)	7% decrease/year (42 million ton of CO_2-eq decrease/year)	
3. New Employment	30,000 new jobs created/year (0.12% decrease in the unemployment rate)	20,000 new jobs created/year (0.08% decrease in the unemployment rate)	30,000 new jobs created/year (0.12% decrease in the unemployment rate)	
4. Length of Electricity Shortage	50 minutes/year	10 minutes/year	30 minutes/year	
5. Damaged Forest Area	660 km^2 forests damaged/year (an area 230 times bigger than Youi Island)	660 km^2 forests damaged/year (an area 230 times bigger than Youi Island)	530 km^2 forest damaged/year (an area 180 times bigger than Youi Island)	
Circle your most preferred policy from the four options	Policy A	Policy B	Policy C	No choice

Note: Assume that all the other attributes, besides the five proposed here, remain the same.

Figure 4. CE example in the survey questionnaire: RPS (originally in Korean)

A consumer survey conducted from August 30 through September 19, 2012 provided the data for this research. The survey used purposive quota sampling based on respondent gender and age to compose a sample most similar to the real component ratio of the population (see Table 3). A total of 500 adults representing their households participated in one-to-one face-to-face interviews located in Seoul and other major metropolitan cities of South Korea. The survey was conducted by Gallup Korea, a professional survey company. The key characteristics of the respondents are summarized in Table 3.

Table 3. Characteristics of survey respondents and the population

		Number of Samples (Ratio %)	General Population (Ratio %)
	Total	500 (100%)	29,158,471 (100%)
Gender	Male	249 (49.8%)	
	Female	251 (50.2%)	
Age (Years)[1]	20–24	54 (10.8%)	3,055,420 (10.5%)
	25–29	66 (13.2%)	3,538,949 (12.1%)
	30–34	49 (9.8%)	3,695,348 (12.7%)
	35–39	89 (17.8%)	4,099,147 (14.1%)
	40–44	56 (11.2%)	4,131,423 (14.2%)
	45–49	72 (14.4%)	4,073,358 (14.0%)
	50–54	72 (14.4%)	3,798,131 (13.0%)
	55–59	42 (8.4%)	2,766,695 (9.5%)
Education Level (Graduation)	Less than middle school	13 (2.6%)	
	High school	223 (44.6%)	
	University/College	249 (49.8%)	
	Above graduate school	15 (3%)	
Monthly Household Income	Under KRW 1 million	1 (0.2%)	
	KRW 1–3 million	109 (22.2%)	
	KRW 3–6 million	327 (66.7%)	
	KRW 6–9 million	53 (10.3%)	

4.1.3 Results and Discussion

First, in order to examine current general perceptions and attitudes toward renewable energy in Korea, preliminary questions were presented to the respondents. When queried whether it is necessary for renewable energy to be widely adopted in Korea, most people (93.6%) answered in the affirmative ("very necessary" or "necessary"). The respondents felt that a wider diffusion of renewable energy is required to ensure a cleaner environment and to cope with resource depletion. Only 2% of the respondents, however, were fully cognizant of the Korean government's target for renewable energy supply in 2030,[8] while as many as 75% had never heard about it.

Next, the awareness level and the necessity of seven domestic policies enforced by Korean government for promoting renewables[9] were examined by posing a series of questions with 5-point likert scales. Most policies scored less than two points on average in terms of the level of awareness; thus, most Koreans are unaware of renewables promotion policies. Notably, the RPS scored 1.86, the second-lowest awareness score. However, despite these results, respondents firmly believe that renewables promotion policies are indispensable; each respondent rated this question as 3.5 points or more. Thus, it is fair to say that while the respondents shared a general consensus on the necessity of renewables promotion policies aimed at mitigating environmental pollution and resource depletion, they had poor understanding of the RPS and related policies.

Estimation results of public preference for the RPS are as follows. In this empirical

[8] The Ministry of Knowledge Economy has mandated that by 2030, 11% of primary energy consumption should be supplied by renewable energy resources.
[9] The Korean government currently enforces several promotion policies for renewables. I included seven policies related to climate change in our survey.

analysis, I use the mixed logit model described in section 3.2, which is one of the DCMs based on the random utility model. The logit and probit models share an unrealistic assumption, namely that consumers have the same preference for goods. On the contrary, the mixed logit model reflects heterogeneity since it includes the stochastic term in the attribute coefficients, thus indicating the preference of each consumer. In addition, the mixed logit model has the advantage of being able to set several forms of attribute coefficient distribution, depending on the effect that attributes have on the consumers (Train, 2009; Train and Sonnier, 2005). As explained in section 3.2, based on the random utility theory, the utility U_{ni} that consumer n receives by choosing choice alternative i can be shown as equation (14) (McFadden, 1974; Train, 2009).

$$\begin{aligned} U_{ni} &= V_{ni} + \varepsilon_{ni} = \beta_n{}' X_{ni} + \varepsilon_{ni} \\ &= \beta_1 X_{elect\_cost} + \beta_2 X_{reduc\_CO_2} + \beta_3 X_{employ} + \beta_4 X_{time\_black} \\ &\quad + \beta_5 X_{damage\_forest} + \beta_6 D_{No-choice} + \varepsilon_{ni},\ \ \beta_n \sim N(b, W) \end{aligned} \tag{14}$$

Here, X_{ni} is defined as a vector with related attributes, as choice alternative j within a choice set. β_n is a vector representing the coefficient of attributes and follows the normal or lognormal distribution with average b and variance W. ε_{ni} is defined as a random disturbance with an i.i.d. extreme value distribution. Equation (14) is derived from the general utility function and includes the attributes in the choice experiment as variables. In an empirical analysis, the variables X_{elect_cost}, $X_{reduc\_CO_2}$, X_{employ},

X_{time_black}, and X_{damage_forest} entail an increase in the electricity bills, reduced GHG (CO_2) emissions, new job creation, length of annual power outage (blackout) time, and annual damaged forest area respectively, due to the introduction of the RPS. $D_{no-choice}$ is inserted as a dummy variable, which indicates the rejection of the RPS by a consumer, where 1 implies rejection, and 0, adoption.

As stated in section 3.2, a mixed logit model with Bayesian inference is used to estimate public preference, which is represented by the utility function seen in equation (14).

Generally, the parameter in the mixed logit model is assumed to have a normal distribution. However, for some parameters whose attributes are certain to show one-sided directions, the estimates can be assumed to have lognormal distributions, so that they constantly have specific positive or negative signs (Train and Sonnier, 2005). Thus, I assume a lognormal distribution for the parameters of variables such as reduced GHG (CO_2) emissions (+), increased electricity bills (−), and power outage time (−), while the other parameters are assumed to have a normal distribution.

Estimation results using the mixed logit model for the entire data are presented in Table 4. It includes the MWTP and the RI of each attribute, as well as mean b and variance W of the estimates. The mean and variance of all coefficients are significant at the 99% level of confidence.

Table 4. Estimation results: public preferences for RPS

Attribute	Assumed Distribution	Mean	Standard Deviation	MWTP	RI (%)
Increased electricity bills (KRW 100/month)	Log-normal	-0.1010***	0.1646***	-	11.78
Reduced GHG emissions (million ton CO_2-eq/year)	Log-normal	0.0400***	0.0837***	KRW 3.1764 /10,000 tons of CO_2	3.89
New job creation (1,000 persons/year)	Normal	0.0454***	0.1958***	KRW 0.5124 /person	13.50
Power outage time (Minutes/year)	Log-normal	-0.0219***	0.1030***	KRW -66.6672 /minute	1.99
Forest damage (33 km^2/year)	Normal	-0.1208***	0.3044***	KRW -1.5895 /0.033 km^2	9.01
Reject RPS/year	Normal	-17.1697***	10.2448***	KRW -320,721 /Reject RPS	59.83

*** implies significance at the 1% level.

The results show that consumer utility increases with the increase in GHG (CO_2) emissions reductions and the number of jobs created each year, and it decreases with more costly electricity bills, power shortages, and damaged forests. All the coefficients are statistically significant. A relatively large negative value is obtained for "reject RPS," thus indicating that consumer utility would decrease by a considerable degree if the RPS policy is not adopted. According to Louviere and Woodworth (1983) and Oppewal and Timmermans (1993), the probability for the dummy variable ("no choice") might then be interpreted as an indicator for the overall preference for products/services. Thus, the estimation result "reject RPS" represents overall preference for RPS policy in this research.

The MWTP for each RPS attribute is calculated using the estimation results. As shown in Table 4, a household is willing to pay KRW 3.1764 (USD 0.0029) for reductions in CO_2 emissions by 10,000 tons of CO_2, KRW 0.5124 (USD 0.00046) for creating employment for one person, KRW 66.6672 (USD 0.06) for decreasing electricity outages by 1 minute, and KRW 1.5895 (USD 0.0014) for decreasing damaged forest areas by 0.033 km^2. Significantly, the Korean household is willing to pay KRW 320,721 (USD 288.57) for implementing the RPS. That is, KRW 320,721 (USD 288.57) is the overall median MWTP for implementation of the RPS.

The RI of each attribute is also calculated based on the estimation results and is summarized in the last column of Table 4. RI can affect the inherent adoption process of the RPS. People consider new job creation on account of RPS implementation as most important, followed by the increased electricity bills and damage to natural forests. The remaining two attributes, GHG (CO_2) emissions reductions and the length of power outages, are assigned less priority. Therefore, the fact that many new jobs can be created due to RPS implementation should be emphasized in government consultations with consumers, and this would serve as an effective way to promote household adoption of the policy.

Next, I quantify and forecast public acceptance for variations in the RPS. I calculate public acceptance of the RPS, which is actually the rate of RPS adoption, using the estimation results. A standard policy scenario is devised to serve as the baseline scenario; this would entail a 6% rise in the electricity bills, 30 million tons of equivalent GHG (CO_2) annual emissions reductions, the creation of 20,000 new jobs, 30 minutes of blackout/year, and 660 km^2 of annual damaged forest area. According to this standard scenario, 91.67% of Korean households will adopt the RPS, which is quite a high rate. This result coincides with the fact that 95.27% of survey respondents chose to implement the RPS from the conjoint alternatives provided to them. This high adoption rate of the RPS is partly explained by the analytical results of the survey, namely the fact that most respondents perceived policy diffusion to be highly important and also that they had an affirmative attitude toward the policy.

In the acceptance simulation, the levels of several variables in the standard scenario are changed in order to examine the impact of variations in attribute levels on the choice probability. First, rising electricity bills have been a topic of social debate in Korea in recent times. The Korean government hopes to increase electricity bills to defray production costs for electric power producers, at least partially, in the future. However, it has repeatedly put off this decision due to public resistance. In this context, a scenario analysis of the attribute "increase in electricity bills" can be utilized as a guideline for government policy. Other attributes inducing negative effects, such as increased power outages and increased damaged forest area, can also be partly controlled through appropriate policy design and/or technological development. A scenario analysis of such attributes, therefore, can provide meaningful guidance to policy makers for revising the design of the current RPS and may suggest new directions for renewable energy technology development.

Figure 5 shows the results of varying the attribute "increase in electricity bills." If the electricity bills increase by 0-30%[10] due to the RPS, the adoption rate will drop from 92.2-64.4%.[11] Notably, if the increase in the electricity bills exceeds 46%, more than half the households will not adopt the RPS. According to the simulation results, public acceptance will be maintained at above 89.5% if the increase in the electricity bills is limited to under 6% (see Figure 5). Second, if the damaged forest area increases by 0-

[10] Many studies using the choice experiment, including Choi et al. (2008), Choi et al. (2012), and Lee et al. (2011), have analyzed consumer utility after defining a range of hypothetical attributes and assuming that utility between the levels of attributes is linear. Moreover, based on the estimation result, they conducted the simulation analysis by expanding the levels of hypothetical attributes. Following the simulation analysis process used by previous studies, this research also analyzes changes in choice probability by changing the attribute levels in hypothetical scenarios.

[11] Economically, as the price of a good rises, the purchase intention of rational consumers for the same good will decrease. In the same perspective, if the electricity bills rise without additional benefit(s), consumer resistance against this increase will be higher. However, in this research, if consumers recognize the benefits they could accrue from RPS policy implementation, they are willing to accept the increase in their electricity bills as a compromise for the better good (i.e., benefits of the RPS implementation).

4,620 ㎢ annually, public acceptance of the RPS will vary from 93.9-48.1%; if the damaged area exceeds 3,966 ㎢/year, more than half the households will not adopt the policy (see Figure 6). Third, if the length of power outages, which displays the lowest RI among all the attributes (1.99%), increases by 0-140 minutes/year, the public acceptance of RPS will drop slightly from 89.8-86.2% (see Figure 7). The abovementioned simulation results indicate that among all the policy attributes, increased electricity bills and damaged forest area have significant effects on the public acceptance of the RPS, while the length of power outage does not.

The RPS should be redesigned to maximize the utility of electricity consumers while simultaneously minimizing the costs of implementation. In this context, several policy implications can be drawn from the simulation results. Because rising electricity bills will result in a huge decline in RPS adoption, a sudden increase in electricity bills accompanied by the rapid expansion of power generation from renewables is not recommended. Instead, the implementation of the RPS policy should be accompanied by government efforts to lower power demand by power load control and improved energy efficiency.[12] A combination of the RPS implementation and restraining demand will not only hasten the pace of RPS adoption and reduce GHG (CO_2) emissions but also help balance out the rise in electricity bills on account of energy conservation. Because Koreans value the country's natural forests highly (as demonstrated by the effect of

[12] According to the special report on the electricity demand control project for the Ministry of Knowledge Economy (Korea Electrotechnology Research Institute, 2011), in 2010, Korea conserved domestic energy worth 355 GWh by demand control, which accounted for 0.08% of total electricity sales (434,160 GWh) for that year. This demand restraint achieved CO_2 emissions reductions of 166.5 thousand tons.

damaged forest areas on RPS acceptability), weighted renewable energy certificates (RECs) would serve as a strong incentive to minimize damage to forests.[13] Additionally, in order to increase consumer acceptability of the RPS, a major proportion of government R&D investments should be devoted to energy conversion efficiency programs.

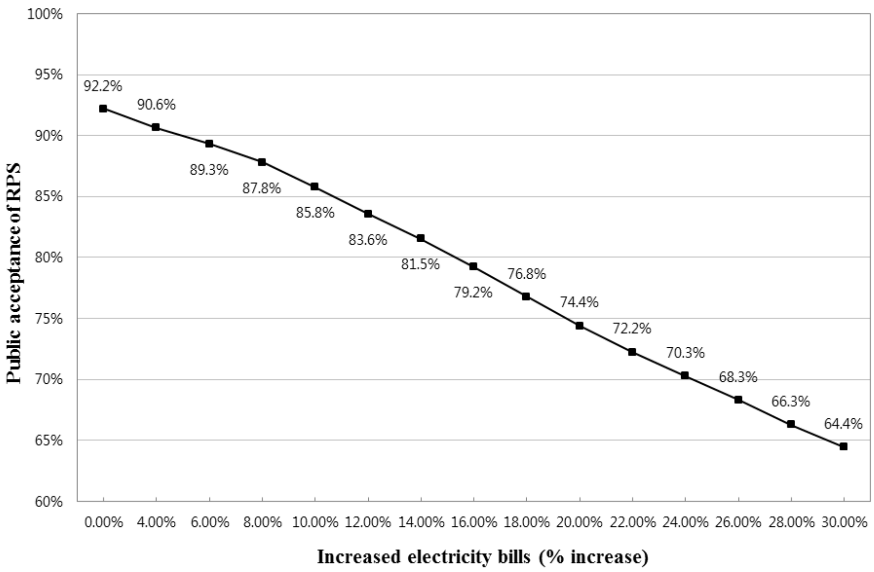

Figure 5. Public acceptance of RPS according to the increased electricity bills

[13] A solar photovoltaic system mounted on the roof of a building can be considered as a typical example of an RPS technology benign to forests.

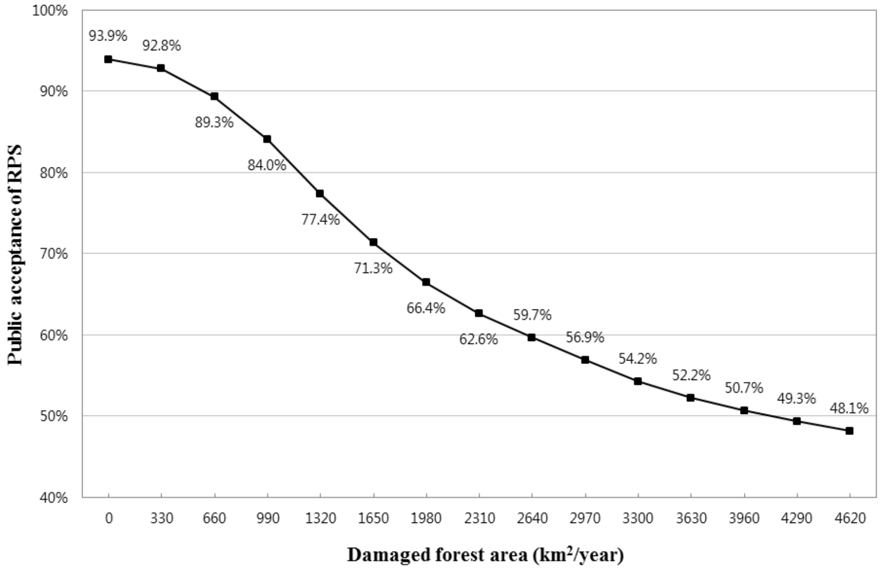

Figure 6. Public acceptance of RPS according to the damaged forest area

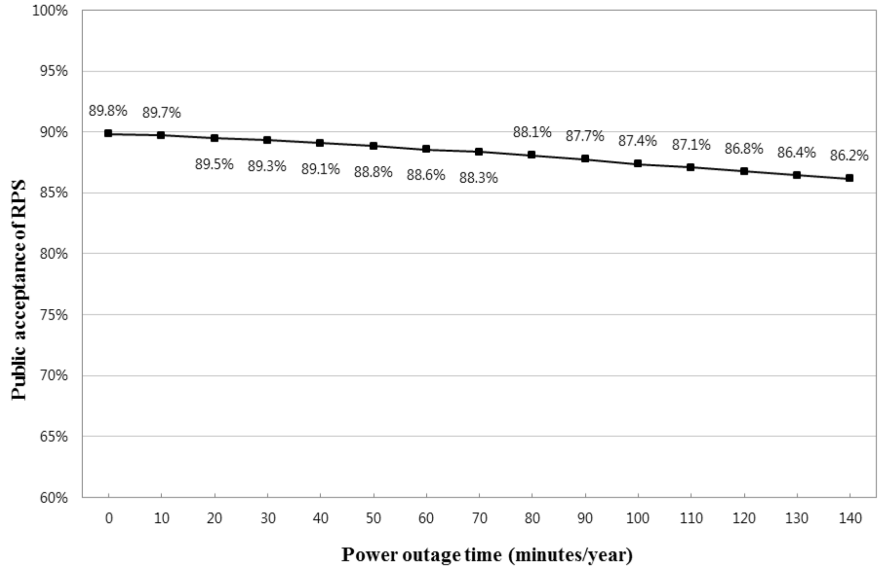

Figure 7. Public acceptance of RPS according to the power outage time

4.1.4 Section Summary

In this section, I conducted quantitative analyses of the possible outcomes of the implementation of the Korean RPS policy. Data from a choice experiment coupled with a DCM were used to estimate households' marginal utility and MWTP for each attribute. Then, using the estimation results, I simulated changes in the public acceptance of the RPS by assigning levels to the attributes.

Answers to my preliminary survey questions revealed that most Koreans seem to agree about the importance of promoting the RPS and the fact that it is indispensable toward environmental protection. However, they have poor knowledge about it and other related policies.

The MWTP for each attribute of the RPS was estimated using the CE and the Bayesian mixed logit model. The estimated MWTP is KRW 3.1764 (USD 0.0029)/household for 10,000 tons of CO_2 emissions reductions, KRW 0.5124 (USD 0.00046) for each newly created job, KRW 66.6672 (USD 0.06) for decreasing power outages by 1 minute, and KRW 1.5895 (USD 0.0014) for decreasing damaged forest areas by 0.033 km^2. Moreover, a Korean household is willing to pay about KRW 320,721 (USD 288.57) for implementing the RPS. As the creation of new jobs recorded the highest RI and was thus found to be the most important attribute, it would be prudent for government agencies to highlight this aspect of the RPS while publicizing it.

Finally, I used the estimation results to simulate policy adoption rates according to the attribute level. An increase in the electricity bills and damaged forest area will decrease the adoption rate of the RPS significantly, while the possibility of increased blackouts would have a comparatively weaker effect. Therefore, it is important for policy makers to revise the RPS such that the possibilities of damage to forest areas and increased electricity bills are lessened to the extent possible.

4.2 Renewable Fuel Standard: Analysis in the Transport Sector

4.2.1 Research Background

Most existing renewable energy policies have focused on expanding renewable electricity supplies because it is easier to achieve tangible goals in the electric power sector, where scale and market impact are greater than in other sectors. In recent years, however, most governments have acknowledged that policies for promoting renewable electricity alone would be insufficient to achieve their entire renewable energy supply target, thus generating public interest in renewable energy supply in other sectors. In particular, the production and use of renewable fuels in the transport sector are rapidly increasing; global production levels of bioethanol and biodiesel were 83.1 and 22.5 billion liters, respectively, approximately 3% of global road transport fuels (REN 21, 2013). Furthermore, policies supporting the use of renewable fuels in the transport sector have been identified at the national level in 49 countries as of early 2013 (REN 21, 2013).

Among various renewable energy policies in the transport sector, the RFS is expected to have a greater market impact than others. The RFS sets a mandatory minimum volume of biofuels to be used in the national transportation fuel supply

(Schnepf and Yacobucci, 2013) and is a representative strong regulatory component and quantitative policy in the transport sector. Although official names differ between countries, blending mandates have been identified at the national level by 27 countries (REN 21, 2013).

The US, UK, and Germany appear to be the leading countries in RFS implementation. The US enforced the RFS1 from 2007-2010 following the Energy Policy Act of 2005, and from 2010 to the present, it has been implementing the RFS2, which requires the use of 36 billion gallons of biofuels annually by 2022. The UK's Renewable Transport Fuel Obligation (RTFO) has been enforced since 2008, and the German Biofuel Quota Act, since 2007, with 2013 percentage standards of 5.26% and 6.25%, respectively (Kpetro, 2013). The RFS is expected to become more common worldwide.

The Korean government christened 2004 as "the first year of RE (renewable energy)" and has steadily implemented various projects to diffuse renewable energy. The goal of Korean government, which was declared in "The Third Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy (2009-2030)," is to supply 11% of the country's primary energy with eligible renewable sources by 2030 (MKE, 2008). Though renewable energy supply in the transport sector, one of the main focus points in this dissertation, accounted for only 2.5% (165,000 TOE) of total renewable energy supply in 2008, it is expected to increase to 13.2% (2.31 million TOE) by 2020 (MKE, 2012).

Although there have been continuous debates about the need for the RFS to increase renewable energy supply in the transport sector, its formal enforcement has never been achieved owing to stakeholder opposition. Nevertheless, after considerable research and debate, RFS implementation was finally agreed upon in July 2013 and will be enforced from July 2015 after a two-year preparatory period.

According to the Bill, oil refinery operators and petroleum export/import businesses in Korea would be obligated mix their transportation fuels with a certain percentage of renewable fuels. The current 2% ratio of bioethanol and biodiesel will increase by 0.5% every year, reaching 5% in 2020 (see Table 5). Further, a dedicated government agency is authorized to enforce effective RFS implementation. Despite the official declaration of RFS implementation, however, resistance is still prevalent among stakeholders, such as fuel suppliers, in the transport sector. They argue that the oil industry will bear the entire cost rise, because renewable fuels in the Korean market are mostly imported from foreign countries.

Table 5. Annual percentage targets of Korea's RFS

Year	2013	2014	2015	2016	2017	2018	2019	2020
Bioethanol(%)	demonstration project / test for vehicle use				3	3	4	5
Biodiesel (%)	2	2.5	2.5	3	3.5	4	4.5	5

Source: KPetro (2013)

However, public acceptance is a more important consideration for RFS introduction and its sustainable implementation than any other factor, including supplier resistance.

Considering that the production and distribution of renewable fuels are more costly than those of gasoline/diesel, the RFS will increase transport fuel prices, burdening end users in the long run. Increased fuel prices will cause low public acceptance, which will act as a barrier to successful RFS implementation.

In this context, this section analyzes public preferences for the RFS and quantifies public acceptance level for this policy. CE data are analyzed with a mixed logit model to reflect the heterogeneity of respondents' preferences. Several policy implications to help successful implementation of the RFS are suggested.

4.2.2 Data: Design of Choice Experiment

To analyze public preferences for the RFS, I conduct a CE survey in which the respondent is asked to choose the most preferred alternative among several hypothetical product/service alternatives. The CE makes inferences about the part-worth of attribute levels from respondents' stated preferences (Raghavarao et al., 2011). It can measure buyers' tradeoffs among multi-attributed products/services (Green and Srinivasan, 1990).

In order to make up a choice set with appropriate attributes of the RFS and their levels, the potential market/environmental impact of RFS implementation should be examined.

First, there is a high possibility that transportation fuel prices would increase due to RFS implementation in Korea. However, the levels of estimated price increase differ from study to study. Bae (2009) estimated that biodiesel would more expensive than after-tax diesel by KRW 25/liter and KRW 257/liter in 2008 and 2009, respectively. Assuming that the RFS will be implemented in Korea, the Korea Petroleum Association estimated that the price of gasoline will increase by KRW 31/liter with the BE5 scenario, while that of diesel will increase by KRW 35/liter with the BD4 scenario (NEWSis, 2013). Hence, KRW 20, 60, and 100/liter are selected as the three levels of the price attribute for increased transportation fuel price.

Reduced GHG (CO_2) emissions are the main environmental benefit of RFS implementation. In the case of biodiesel, BD100, BD20, and BD5 implementation is expected to reduce GHG emissions by 75, 15, and 3%, respectively (Won, 2008). The levels of this attribute are selected considering the total potential changes in CO_2 emissions within the transport sector on account of RFS implementation. According to the calculation based on the national database system (NETIS, 2013), Korea's electric power and transport sectors emit almost similar amounts of CO_2. Therefore, following Shin et al. (2014), 3, 5, and 7% are selected as the three levels of reduced GHG (CO_2) emissions attributes.

RFS implementation is expected to create new jobs in the production, distribution, and storage of biofuel. The RFS will also provide substantial rural employment opportunities (Schnepf and Yacobucci, 2013). For example, the ethanol industry supported more than 380,000 jobs in all sectors of the US economy in 2012 (Urbanchuk, 2013). Al Seadi et al. (2008) also suggested that the development of the biofuel sector contributes to the establishment of new enterprises and creates new jobs. To the best of my knowledge, however, no study has directly estimated the number of new jobs likely to be created by RFS implementation in Korea. Thus, I refer to the effect of new job creation by other policy tools such as the RPS and the RHO in Korea. KEMCO (2013) estimated that implementing the Korean RPS will create over 10,000 jobs/year, and 6,000 new jobs/year will be created if the number of houses with geothermal heating facilities increases to 50,000. Accordingly, 5,000, 10,000, and 15,000 new jobs/year are selected as the three levels of the new job creation attribute.

Increased demand for agricultural products resulting from RFS implementation is expected to increase the cost of food. The Environmental Protection Agency (EPA) estimated an annual increase of about USD 10 in the cost of food per capita by 2022 under the RFS2 standards (EPA, 2010). OECD (2006) estimated that crop prices could increase by between 2 and 60% in 10 years due to the production of biofuels. Thus, I selected 2, 6, and 10% as the three levels of increased cost of food attribute.

At the current technology level, biofuels are generally known for having lower fuel efficiency compared with pure gasoline/diesel. A liter of ethanol has only 70% of the energy content of a liter of gasoline (Pessoa et al., 2011). Biodiesel also has a lower energy content, which is about 93% of that of diesel fuel (Hofman et al., 2006). Consumers can thus experience decreased fuel efficiency resulting from blending mandates. Accordingly, I select 2, 5, and 8% as the three levels of this attribute.

Table 6 summarizes the levels of the five attributes that may affect public acceptance of RFS implementation. The respondents were explained that other potential attributes of the RFS not included in this survey are assumed to be identical across alternatives.

Table 6. RFS attributes for the choice experiment

Attributes	**Levels**
Increased price of transportation fuels	KRW 20 per liter
	KRW 60 per liter
	KRW 100 per liter
Reduced GHG (CO_2) emissions	3% per year (18 million ton CO_2-eq)
	5% per year (30 million ton CO_2-eq)
	7% per year (42 million ton CO_2-eq)
New job creation	5 thousands per year (0.02% decrease in the unemployment rate)
	10 thousands per year (0.04% decrease in the unemployment rate)
	15 thousands per year (0.06% decrease in the unemployment rate)
Increased cost of food	2% (Additional KRW 2 thousands/month based on a monthly food cost of KRW 100 thousands)
	6% (Additional KRW 6 thousands/month based on a monthly food cost of KRW 100 thousands)
	10% (Additional KRW 10 thousands/month based on a monthly food cost of KRW 100 thousands)
Decreased fuel efficiency	2%

	5%
	8%

There were 243 possible alternatives for the hypothetical RFS based on the combination of attributes and levels in Table 6. It would be difficult, however, for a respondent to articulate his/her preferences for all 243 alternatives. Thus, I employ the fractional factorial design to ensure the orthogonality of each attribute and select 18 alternatives. These are divided into six choice sets, and the alternative “no choice” is included in each choice set. Finally, respondents were asked to choose their most preferred alternative among these four alternatives (see Figure 8).

Q Assuming that you can accrue possible benefits and disbenefits such as reduced GHG (CO_2) emissions (benefit), new job creation (benefit), increased cost of food (disbenefit), and decreased fuel efficiency (disbenefit) from paying increased price of transportation fuels, please choose the most preferred type of Renewable Fuel Standard (RFS) among the four hypothetical options provided below (including "no choice," i.e., retaining the status quo).

Please circle your most preferred one from the four alternatives given here.

▣ Questionnaire 1: Renewable Fuel Standard (RFS)

Attributes of Policy	Policy A	Policy B	Policy C	No choice
1. Increased price of transportation fuels	KRW 60 per liter	KRW 100 per liter	KRW 100 per liter	No choice (Do not accept RFS policy)
2. Reduced GHG (CO_2) emissions	3% per year (18 million ton CO_2-eq)	5% per year (30 million ton CO_2-eq)	5% per year (30 million ton CO_2-eq)	
3. New job creation	10 thousands per year (0.04% decrease in the unemployment rate)	10 thousands per year (0.04% decrease in the unemployment rate)	15 thousands per year (0.06% decrease in the unemployment rate)	
4. Increased cost of food	10% (Additional KRW 10 thousands/month based on a monthly food cost of KRW 100 thousands)	6% (Additional KRW 6 thousands/month based on a monthly food cost of KRW 100 thousands)	10% (Additional KRW 10 thousands/month based on a monthly food cost of KRW 100 thousands)	
5. Decreased fuel efficiency	2%	5%	2%	
Circle your most preferred one from the four options	Policy A	Policy B	Policy C	No choice

Note: Assume that all the other attributes, besides the five proposed here, remain the same.

Figure 8. CE example in the survey questionnaire: RFS (originally in Korean)

As in the case of the RPS analysis in section 4.1, the CE data were collected from a public survey, and its sampling and fieldwork were conducted by a professional polling firm (Gallup Korea). The well-trained interviewers carried out one-on-one face-to-face interviews from August 30-September 19, 2012. For accuracy, the respondents were restricted to 279 owner-drivers, because only they can fully perceive and understand the potential effects of the attributes listed in Table 6.

The characteristics of the 279 sample respondents are shown in Table 7. The average age of the respondents was 41.14 years, and the number of male and female respondents were 189 (67.7%) and 90 (32.3%), respectively. According to the Korean Statistical Information Service (KOSIS, 2013), the actual proportion of Korean male and female drivers was 16.47 million (60.5%) and 10.78 million (39.5%), respectively in 2011. Considering that Korean men are somewhat more socially active than Korean women, the gender ratio of my sample can be seen as being representative of the actual gender ratio of Korean drivers. The largest residential district was Seoul followed by Busan. The average monthly household income was about KRW 4.26 million, with most of the respondents earning between KRW 2 and 6 million/month. Meanwhile, 93.2% of respondents felt that it is necessary to increase the renewable energy supply, thus confirming the positive image of renewable energy in the public mind.

Table 7. Characteristics of survey respondents sample

Total		**279 (100%)**
Gender	Male	189 (67.7%)
	Female	90 (32.3%)
Age (Years)	20-29	41 (14.7%)
	30-39	87 (31.2%)
	40-49	83 (29.7%)
	50-59	68 (24.4%)
Education level (Graduation)	Primary scholl or less	2 (0.7)
	Middle school	2 (0.7)
	High school	124 (44.4)
	University/College	145 (52.0)
	Above graduate school	6 (2.2)

Monthly household income	Under KRW 2 million	9 (3.2%)
	KRW 2-4 million	126 (45.2%)
	KRW 4-6 million	104 (37.3%)
	KRW 6-8 million	28 (10.0%)
	KRW 8-10 million	7 (2.5%)
	Above KRW 10 million	5 (1.8%)

4.2.3 Results and Discussion

Public preferences for the RFS are analyzed using CE data and the mixed logit model. For the analysis, the utility U_{nj} that respondent n obtains from alternative j is defined as follows:

$$U_{nj} = \beta_1 X_{price} + \beta_2 X_{CO2} + \beta_3 X_{job} + \beta_4 X_{food} + \beta_5 X_{eff} + \beta_6 X_{no-choice} + \varepsilon_{nj} \quad (15)$$

where X_{price}, X_{CO2}, X_{job}, X_{food}, X_{eff} are the variables for increased price of transportation fuels, reduced GHG (CO_2) emissions, new job creation, increased cost of food, and decreased fuel efficiency, respectively. $X_{no-choice}$ indicates “reject RFS,” a dummy variable that equals 0 if the decision maker chooses the RFS alternative and 1 otherwise.

Equation (15) is estimated using the Bayesian estimation method with a mixed logit model. As stated previously, the mixed logit model generally assumes that parameters have normal distributions, but some parameters that are expected to have a one-sided directional nature only can be assumed to have lognormal distributions. Therefore, the parameters for increased price of transportation fuels, reduced GHG (CO_2) emissions, and decreased fuel efficiency are assumed to have lognormal distributions, and the other parameters, normal distributions.

The estimation result is presented in Table 8. The means and variances of β are estimated, and the median MWTPs and RI are calculated using 2,000 draws from the distributions of the estimated parameters. The estimation result shows that all parameters, except the mean of "new job creation" parameter, are significant at the 95% confidence level.

Table 8. Estimation results: public preferences for RFS

Attribute	Assumed distribution	Mean	Standard deviation	MWTP	RI (%)
Increased price of transportation fuels (10 KRW/liter)	Log-normal	-1.8797***	4.0507***	-	11.37
Reduced GHG (CO2) emissions (%)	Log-normal	3.5218***	59.4875***	KRW 0.2072 / liter·%	4.74
New job creation (1,000 people)	Normal	-0.0523	0.3925***	KRW -0.4580 / liter·1000 people	6.68
Increased cost of food (%)	Normal	-0.0939**	5.8700***	-	7.11
Decreased fuel efficiency (%)	Log-normal	-5.3301***	133.5574***	KRW -0.0906 / liter·%	2.20
Reject RFS	Normal	-46.9211***	36.4860***	KRW -758.47 / liter	67.90

*** 1% significance level, ** 5% significance level, * 10% significance level

As expected, the estimation result confirms that the increased price of transportation fuels and decreased fuel efficiency cause consumer utility to decrease, and reduced GHG (CO_2) emissions cause consumer utility to increase. These parameters also have statistical significance. In addition, the mean value for the “increased cost of food” parameter has the negative sign, indicating that consumer utility decreases when grocery prices rise. The mean value for the “new job creation” parameter also has the negative sign, which is contrary to my expectation; however, this parameter has no statistical significance. The mean value for “reject RFS” parameter is the highest and is statistically significant, which indicates that consumer utility will increase drastically with RFS implementation.

The standard deviations of the “increased cost of food,” “decreased fuel efficiency,” and “reduced GHG (CO_2) emissions” parameters are much greater than their corresponding mean values; thus, the distribution of respondents’ preferences for these attributes is regarded as widespread. On the other hand, the ratios of the standard deviation to the mean for the “increased price of transportation fuels” parameter and the “reject RFS” parameter are smaller than those of the above three attributes. Accordingly, it is considered that the ranges of preferences for these attributes are restricted, because they are concerned with cost increases that the drivers can perceive more directly.

MWTP for a reduction of 1% in CO_2 emissions is estimated as KRW 0.2072/liter, while the corresponding values for the creation of 1,000 new jobs and a 1% decrease in fuel efficiency are KRW -0.4580/liter and KRW -0.0906/liter, respectively. In other words, Korean drivers are willing to pay KRW 0.035/liter on average when CO_2 emissions decrease by 100 million tons (considering that a 1% reduction equals to about 6 million tCO_2eq reduction in South Korea). For “new job creation,” the sign of MWTP is contrary to expectation. However, it is important to note that the real MWTP for this attribute cannot be identified in this study, because the value is derived from a nonsignificant coefficient. MWTP for “reject RFS” is -758.47 KRW/liter; thus, choosing RFS implementation gives respondents an additional utility of about 758 KRW/liter.[14]

The RI of each attribute is also calculated. The last column of Table 8 shows that the “reject RFS” attribute is the most important. That is, the respondents put emphasis on choosing the RFS itself even though they do not consider attributes like “increased price of transportation fuels,” “new job creation,” and “reduced GHG (CO_2) emissions.” Meanwhile, the respondents consider the attributes related with the cost increase such as “increased price of transportation fuels” and “increased cost of food” as more important than all the other attributes expect “reject RFS.”

Next, public acceptance of RFS is quantified and forecasted using a simulation study. Based on the estimation results, respondents’ acceptance levels of the RFS, namely choice probability, is calculated using equation (3). As the RFS has not been enforced in South Korea yet, the acceptance level is calculated under a virtual scenario, namely a baseline scenario, consisting of the median level of five suggested attributes. In other

[14] MWTP for “reject RFS” attribute, namely KRW 758/liter is a sizable sum of money considering that cars gasoline’s consumer price on December, 2013 in South Korea is averagely KRW 1,900/liter. It is inferred that this estimation result from the CE methodology is caused by ‘hypothetical bias’ appearing from respondents’ decision making data for an assumed situation listed in the questionnaire, not actual market data. The ‘hypothetical bias’ means a bias of value estimation result, caused by the virtual property of the conjoint survey, and it is judged that this bias is occurred in this analysis.

words, the respondents' choice probability for RFS implementation is calculated under the baseline scenario, in which the increased price of transportation fuels is KRW 60/liter, CO_2 emissions are reduced by 5%, 10,000 new jobs are created annually, cost of food increases by 6%, and fuel efficiency against existing fossil fuels decreases by 5%. The calculation for this baseline scenario shows that 87.94% of overall respondents will accept the RFS.[15] It is inferred that the acceptance level for the RFS is high, because the respondents recognize the necessity for the supply and expansion of renewable energy and perceive it positively.

Next, to examine the changes in acceptance levels, I conduct a simulation by varying the attribute levels from the baseline scenario. The result indicates that the acceptance level varies from 91.2-48.8% when the price of transportation fuels is increased by 0-45%[16] (see Figure 9). In addition, the acceptance level varies from 88.5-83.5% (see Figure 10) and 89.4-86.6% (see Figure 11) when the cost of food and fuel efficiency increase by 0-30% and decrease by 0-15%, respectively.

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[15] The figure, 87.94%, is of course a result elicited from the assumption that all respondents regconize RFS policy.

[16] According to Petronet, the oil information site of Korea National Oil Corporation, the consumer prices of cars gasoline (seq. gasoline) and cars diesel (seq. diesel) in 2012 is averagely 1985.76 KRW/liter and 1806.34 KRW/liter in South Korea, and the demand ratio of gasoline to diesel is 34.42:65.58, so this paper assume that the consumer price of transportation oil that consumers in South Korea feel on average is 1868.10 KRW/liter elicited from a weighted average of gasoline and diesel by each demand.

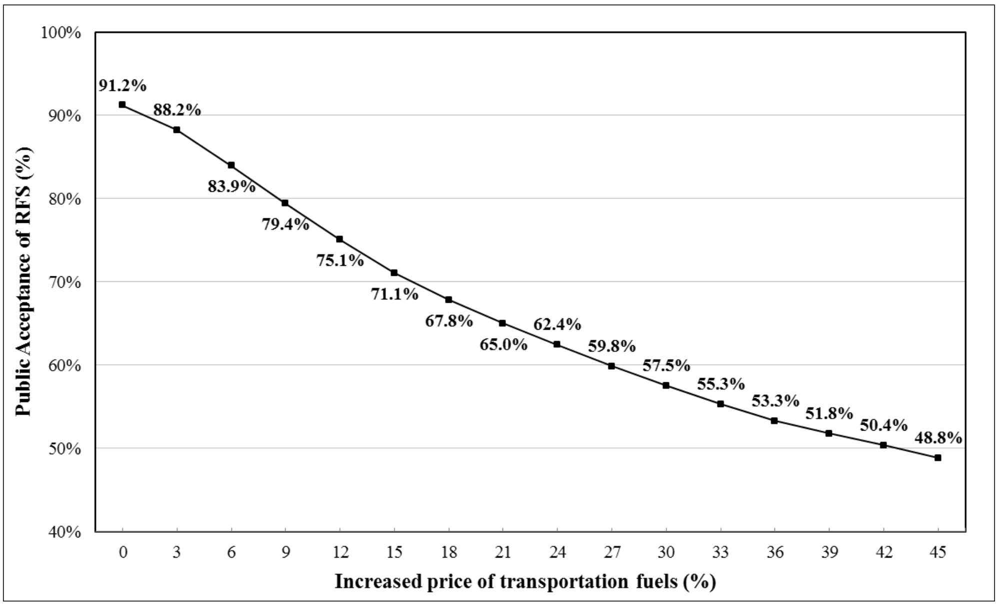

Figure 9. Public acceptance of RFS according to increased price of transportation fuels

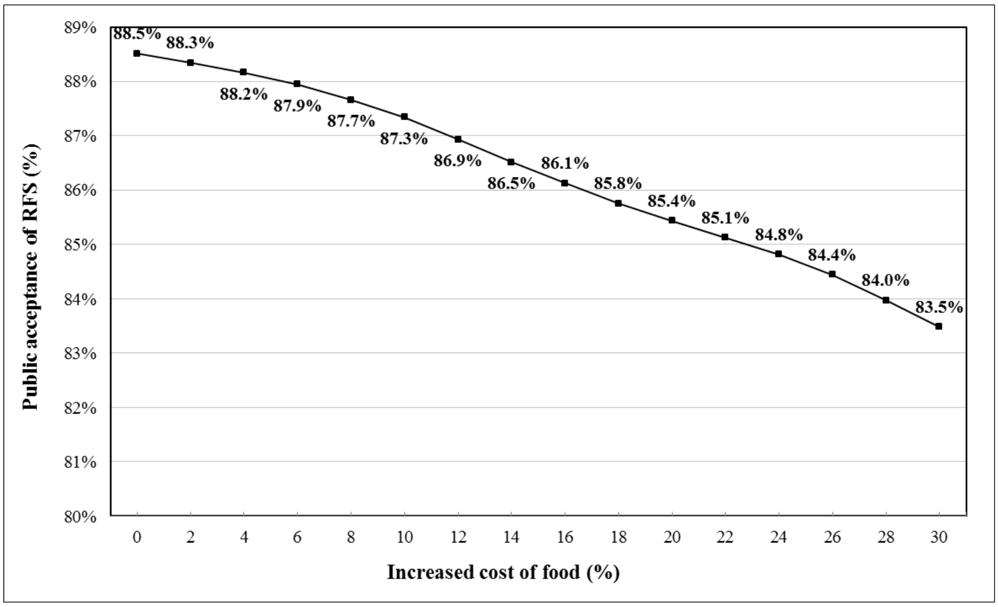

Figure 10. Public acceptance of RFS according to the increased cost of food

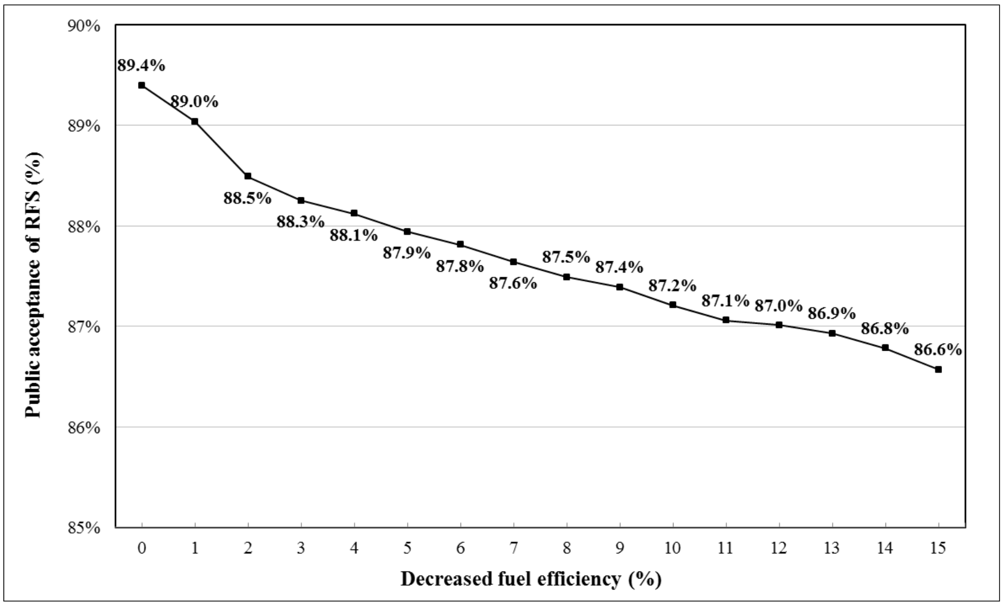

Figure 11. Public acceptance of RFS according to the decreased fuel efficiency

Considering the above simulation results, people react most sensitively to the increased price of transportation fuels. If the prices of transportation fuels and cost of food are each increased by 15% over the baseline scenario and fuel efficiency is decreased by 15% under the baseline scenario, the corresponding acceptance levels decrease by 19.5%, 2.2%, and 2.8%, respectively. This result shows that the increased price of transportation fuels is the most influential attribute in changing public acceptance of the RFS. Figure 9 shows that while the acceptance level corresponding to the baseline scenario is 91.2% when the price of transportation fuels remains unchanged, only a 9% increase in the price causes the level to drop below 80%, and a larger increase of 45% in the price causes the level to drop below 50%. In contrast, the corresponding acceptance levels decrease by only 8.3% and 5.7%, respectively even if the cost of food and fuel efficiency each increase and decrease by around 45%, respectively. In other words, the increased price of transportation fuels has the single most significant impact on variations in acceptance levels. Thus, the differences in each attribute's influence on public acceptance should be considered when designing RFS implementation.

4.2.4 Section Summary

Scheduled to start implementation from 2015 in Korea, the RFS is expected to provide several benefits. However, its implementation may also be accompanied by some negative effects. For its sustainable implementation, therefore, it is important to analyze public preferences for the RFS and assess variations in public acceptance level dependent on policy design before its formal enforcement. This study employed the CE and Bayesian mixed logit model to address this concern. The analysis results provide a quantified simulation of public acceptance of the RFS according to attribute levels.

In relation to the public preferences for the RFS, the high RI of RFS acceptance (67.90%) confirms that the Korean public attaches high value to RFS implementation. This corresponds with the preliminary survey result, namely that 93.2% of respondents agree to increasing the supply of renewable energy. Nevertheless, despite the positive responses to RFS implementation, the public is very sensitive to price attributes such as the increased price of transportation fuels and increased cost of food. In order to enhance public acceptance of the RFS, therefore, the government should persuade the public about the importance of enduring increased costs due to RFS implementation. However, there is no public consensus as to the extent of price increases likely to be induced by RFS implementation in Korea. The Korean government should examine the analysis results from various stakeholders in order to arrive at a public consensus on the expected level of price increase with RFS implementation.

Regarding the quantification of RFS acceptance, the results forecast high acceptance (87.94%) for the baseline scenario, namely an increase of KRW 60/liter in the transportation fuel price, an annual GHG emissions reduction of 5%, the creation of 10,000 new jobs, an increase of 6% in food cost, and a decrease of 5% in fuel efficiency. This high acceptance level is obtained after the respondents fully understood the potential effect of RFS implementation, such as reduced GHG emissions and the creation of new jobs. Thus, the government should actively publicize several positive effects of the RFS in order to enhance its public acceptance. Notably, most current media reports on RFS implementation focus on the expected increase in fuel price. However, it is necessary to employ the media strategically toward publicizing the positive effects of the RFS, because its influence on framing public attitudes toward environmental and energy policies is quite substantial (Delshad and Raymond, 2013). According to the simulation result, except the fuel price, all the other attributes turn out to have little impact on the acceptance level. Different effects of various policy attributes should be considered when completing the detailed design for RFS implementation.

Further studies can make up for the limitations of this research. First, this research analyzed public acceptance of the RFS at a specific time point and not for a certain time period. A time series analysis considering other factors, such as advances in renewable energy technologies, can quantify public acceptance of the RFS over time. Second, for the respondents' convenience, only five RFS attributes were included while composing the choice set in the CE. However, because RFS implementation has other potential impacts, such as reduced dependence on foreign sources of crude oil, increased domestic farm incomes, and changes in the emissions of certain air contaminants, including such impacts as additional attributes in the CE can possibly uncover other meaningful policy implications for RFS design.

4.3 Renewable Heat Obligation: Analysis in the Heating Sector

4.3.1 Research Background

Over the past several decades, most governments have focused on policy instruments related to renewable electricity generation. On the other hand, reducing carbon emissions in the heating sector is also important, because heating and cooling accounts for approximately 40-50% of the global energy demand (Bürger et al., 2008). As renewable heating technologies have become more popular, several governments have promoted the use of renewable energy in the heating sector through a range of policy instruments. Notable examples include the RHO policy directed at building owners in Germany and the RHI policy directed at heat producers in the United Kingdom. The South Korean government is currently finalizing RHO policies and plans to introduce them in 2016.

Compared to the electricity and transport sectors, promoting renewable energy use in the heating sector is much more difficult given the wide variety of stakeholders, ranging from building owners with decentralized small-scale heating units to companies handling district heating (Steinbach et al., 2013). The preferences of various investors have also affected the implementation of policies in the heating sector. The end users (the general public) impacted by the RHO policies in the heating sector may suffer from increased heating expenses related to the increased production cost as heat suppliers invest in renewable heating facilities. Therefore, if the needs and preferences of all stakeholders are not considered in the early design stages, the effectiveness of the RHO could be compromised by stakeholder opposition. Therefore, it is important to encourage voluntary participation and support from the public for the use of renewable energy, which is possible by designing appropriate policies that consider the preferences of the end users.

This section quantitatively analyzes public preferences by estimating their MWTP and the RI of the various attributes of the RHO to be introduced in South Korea in 2016. The analysis results can be used to design effective RHO policies based on the preferences of the end users and to offer guidelines for promoting public acceptance of the RHO.

The government of South Korea has only recently begun to consider RHO implementation. In August 2013, the government announced the "Activation Plan for Renewable Energies," which includes its plan for introducing an RHO for owners of private buildings (other than residential buildings) with a total floor area exceeding

10,000 m^2 in 2016. According to the Plan, such owners are required to use renewable energy for more than 10% of their total heat consumption. Although the government plans to extend this policy from 2030 onwards to buildings with a total floor area exceeding 3,000 m^2 in stages, the details are still under development. Extending the policy to residential buildings and implementing an additional RHO aimed at heat suppliers have also been proposed.

Although RHO implementation will have immediate impacts, entail minimal financial burden, and ensure consistent use of renewable energy for heating, considerable resistance from stakeholders, which might threaten its success, is expected. Therefore, such policies require mechanisms to enhance public acceptance. Moreover, before discussing the other details of the RHO policies, it is important to determine who will be impacted most by their obligations for renewable heating, given that the overall design and effects of implementation can vary by stakeholder. Accordingly, this empirical analysis compares the details and effects of enforcing two different RHO schemes, one intended for heat suppliers, and the other, for building owners (including the owners of residential buildings).

Regarding the RHO intended for building owners, the owners of existing buildings typically receive incentives from the government to use renewable heating, whereas the owners of remodeled or new buildings are generally obligated to use renewable energy. If this obligation were also imposed on the owners of existing buildings, their installation costs would exceed those of new building owners, because existing buildings would likely require some degree of reconstruction to install renewable heating facilities. This immense initial expense is expected to create considerable opposition to RHO enforcement from existing building owners, and these high initial costs may not be offset by the relatively low fuel and maintenance costs associated with renewable heating. Additional social costs might also be incurred toward implementing and monitoring policy compliance by existing building owners. For these reasons, most governments impose the obligation of renewable heating on owners of remodeled and new buildings. Thus, the South Korean government is considering enforcing these obligations only on new building owners.

On the other hand, the RHO intended for new building owners also poses some drawbacks that should be considered. First, building companies, which are the actual buyers of renewable heating systems, may choose systems with a low heating efficiency or those that are ineffective in reducing GHG emissions, because they are more concerned with reducing construction costs rather than whether the system will operate efficiently. Therefore, a quality standard for renewable heating systems should be established and its compliance monitored to ensure the intended effects of the RHO policies. In addition, only a portion of the initial investment can be recouped from the lower fuel and maintenance costs associated with renewable heating, given the declining performance of heating facilities and fluctuating fuel prices with payback periods longer than a year.

In contrast to the RHO intended for building owners, the RHO policy focused on heat suppliers would entail low operation and monitoring costs, because the number of entities subject to the obligation would be small. On the other hand, due to the smaller number of heat suppliers, the effects of RHO implementation would also be limited compared to an RHO policy aimed at building owners. The added investment for renewable facilities may be passed on to heat users by increasing heating charges. In addition, imbalances between supply and demand for renewable energy can lead to instability in the heating supply, inconveniencing some heat users. Considering the above issues, this study evaluated public preferences and their MWTP for these two RHO policies so as to provide guidelines for enhancing their public acceptance.

4.3.2 Data: Design of Choice Experiment

Similar to the previous two empirical analyses of the RPS and the RFS, CEs were carried out for the abovementioned RHO policies aimed at heat suppliers and building owners. Tables 9 and 10 define the attributes that can affect the public acceptance of each RHO. These attributes are related to cost, effects of implementation, and dependent factors for the individuals affected directly by the RHO.

Table 9. Attributes for the choice experiments: RHO for heat suppliers

Attributes (RHO for heat suppliers)	Levels
Increased heating expense (based on an average monthly heating	5% increase (KRW 5,000)
	10% increase (KRW 10,000)

expense of KRW 100,000)	15% increase (KRW 15,000)
Reduced GHG (CO_2) emissions	0.5% per year (3 million ton CO_2-eq)
	1.0 % per year (6 million ton CO_2-eq)
	1.5% per year (9 million ton CO_2-eq)
New job creation	5 thousands per year (0.02% decrease in the unemployment rate)
	10 thousands per year (0.04% decrease in the unemployment rate)
	15 thousands per year (0.06% decrease in the unemployment rate)
Stability of heat energy supply	As stable as present day
	Less stable than present day

Table 10. Attributes for the choice experiments: RHO for building owners

Attributes (RHO for building owners)	**Levels**
Additional installation cost (for 83 m^2)	KRW 6 million
	KRW 7 million
	KRW 8 million
Reduced GHG (CO_2) emissions	0.5% per year (3 million ton CO_2-eq)
	1.0 % per year (6 million ton CO_2-eq)
	1.5% per year (9 million ton CO_2-eq)
New job creation	5 thousands per year (0.02% decrease in the unemployment rate)
	10 thousands per year (0.04% decrease in the unemployment rate)
	15 thousands per year

	(0.06% decrease in the unemployment rate)
Payback period	3 years
	5 years
	7 years
Government subsidy for the initial investment	0% (No subsidy)
	25%
	50%

Issues related to the cost of implementation, including who will bear those costs and how they will be paid for, vary depending on the individual the RHO is imposed on. For the RHO policy aimed at heat suppliers, the heating expense charged to heat consumers can increase as heat suppliers are needed to install renewable heating facilities, and their production costs would rise as a result. Therefore, the attributes related to cost are defined as the increase in heating expense for the end users after enforcing the RHO intended for heat suppliers. According to a study published by the Korea City Gas Association, approximately 75% of Korean households used city gas for heating in 2011, and the monthly average heating expense during winter in Seoul was estimated to be approximately KRW 100,000.[17] Based on this value, the levels of this attribute are set to 5%, 10%, and 15%, assuming that the per household monthly heating expense will also increase by 5%, 10%, and 15% over KRW 100,000, respectively.

Regarding the RHO policy intended for building owners, the owners would have to

[17] The average consumption of gas per household in Seoul was 112 m^3/month during the winter of 2011; thus, the heating expense was calculated as KRW 103,390 = 1.1 × (840 + 12 × 826.84 + 100 × 832.29).

bear all the costs related to the installation of renewable heating facilities. Therefore, the attribute related to cost is defined as the additional installation cost for renewable heating facilities over an area of 83 m^2, which is the average area of a home for a family of four. The installation expenses for solar thermal heating facilities range from approximately KRW 7 million for 49.6 m^2 to KRW 8.3 million for 148.8 m^2, and the installation cost for geothermal heating facilities is KRW 4.4 million for 33.1 m^2. Therefore, the levels of the additional installation cost are set to KRW 6, 7, and 8 million.

An annual reduction in GHG (CO_2) emissions would occur as heating energy is generated from renewable sources instead of fossil fuels. Because this attribute is related to the effects of RHO implementation, which is independent of the subject of the obligation, this attribute is defined identically in both experiments. The levels of this attribute are selected assuming that GHG emissions from heating account for approximately 1/7th to 1/5th the emissions generated from electricity production, based on a database maintained by KEMCO. According to Kydes (2007), if the RPS mandates that power utilities generate 20% of their power from renewable sources – which is double the current mandatory rate in South Korea – CO_2 emissions would decrease by approximately 4%/year. Palmer and Burtraw (2005) predicted that GHG emissions will be reduced by approximately 5.8%/year given the 10% mandatory rate under the RPS. Therefore, the levels of the attribute for reduction of CO_2 emissions are set to 0.5%, 1%, and 1.5%/year assuming that CO_2 emissions will be reduced by 1/7th to 1/5th the emissions under the current mandatory rate in South Korea.

The attribute related to annual new employment is defined as the number of new jobs expected to be created due to the revitalization of the renewable energy market on account of RHO implementation. Similar to the attribute for the reduction of CO_2 emissions, the level of this attribute is defined identically in both experiments, because its value is independent of the subject of the obligation. According the Center for Renewable Energies of KEMCO, 6,000 new jobs/year will be created in the renewable energy market if the number of houses heated by geothermal heating facilities increases to 50,000, which is approximately 10% of the annual housing supply. Based on these data, the levels of new employment are set to 5,000, 10,000, and 15,000/year.

Finally, separate attributes for RHO policies directed at heating suppliers and building owners are also considered. For the RHO directed at heating suppliers, an attribute related to the stability of the heating energy supply is analyzed. This attribute suggests that the heating supply could become unstable, because heat is produced from renewable energy sources instead of fossil fuels and electricity. For example, if heat suppliers use biomass (e.g., wood pellets) for heating, a sudden increase in the demand for biomass when this source is in short supply could destabilize the heat supply. For solar thermal heating facilities, consistent production of heat is not possible under all weather conditions. Therefore, it is expected that the stability of the heat supply will significantly impact the preferences of the end users.

For the RHO directed at building owners, this research analyzes the attribute related to the payback period and to government subsidies for initial investments. The attribute for the payback period refers to the period over which the building owners recoup all installation costs, because they continue to operate renewable heating facilities. Although the installation costs of renewable heating facilities are typically large initially, the annual heating expense might be lower due to the low fuel and maintenance costs. For example, heating from geothermal and solar thermal sources does not entail a fuel cost, and using wood pellets to generate heat can lower costs by 62% compared to heating using fossil fuels (Byun, 2012). Therefore, the levels of the attribute related to the payback period are set to 3, 5, and 7 years.

The attribute related to government subsidies for initial investments reflects the proportion of the subsidy for the installation cost of renewable heating facilities. Currently, the South Korean government pays 50% of the total installation cost of solar thermal and geothermal heating facilities per household through the “Home Subsidy Program.” In Germany, the government matches 12.6% of the initial investment cost of installing solar thermal heating facilities. Therefore, the levels for the subsidy for the installation costs are set to 0 (no subsidy), 25, and 50%.

Other policy attributes could be included because RHO implementation should be evaluated based on a range of criteria, such as the balanced development of individual renewable sources, economic feasibility, securing financial resources, and the likelihood of realization. Typical attributes reflecting such aspects include improvements in domestic energy security, variable heating efficiency, and type of renewable energy used for heating. The exploitation of various renewable energy sources enables a highly energy-importing country, such as South Korea, to improve its national energy security by decreasing primary energy imports. Variations in heating efficiency can vary when substituting conventional fossil fuels for renewables. In addition, consumer preferences can vary by renewable heating sources, such as solar, geothermal, and bioenergy, even though they are all supplied as heat.

On the other hand, including all of these attributes would result in too many attributes per alternative, which can confuse the respondents, obscure their preferences, and give rise to bias in their choices. Therefore, the number of attributes in a choice experiment is limited to 4-5, and the alternatives are composed of those attributes considered to be the most important by policy makers. (Other potential attributes not included in the survey are assumed to have the same level in all alternatives, and the respondents were informed of this assumption before they began answering the survey.)

Based on the combinations of these attributes at the levels described above, the number of possible alternatives for the RHO policies directed at heat suppliers and building owners is 54 and 243, respectively. Eighteen separate orthogonal alternatives are selected for the analysis, assuming that all the interactions between the attributes are negligible (Addelman, 1962), based on fractional factorial designs using the orthogonal plan in SPSS 20. The 18 alternatives are divided into choice sets consisting of 3 alternatives and “no choice” options. In constructing the choice sets, the three alternatives are combined randomly. Some specific choice sets are then rearranged to avoid the existence of apparently superior or inferior alternatives in the choice set that could bias the respondents' choices. In the questionnaire, the respondents were allowed to choose their most preferred alternative in each choice set. The actual choice sets have the same format as those of the RPS and the RFS, which are presented in Figures 4 and Figure 8, respectively.

As in the case of the RPS and the RFS, a professional survey company (Gallup Korea) conducted a consumer survey examining the RHO preferences from August 30-September 19, 2012. Adult respondents (*n* = 500) located in Seoul and other metropolitan cities in South Korea participated in face-to-face interviews. To maintain a participant component ratio representative of the actual population, a sample was drawn using the purposive quota sampling method based on the respondents' ages and genders. Therefore, the respondents' samples and key characteristics are identical to those of the RPS, as seen in Table 3.

4.3.3 Results and Discussion

First, the estimation results of the RHO for heating suppliers are presented as follows. To analyze public preferences for the RHO aimed at heating suppliers, a mixed logit model with Bayesian inference was used to estimate the utility function:

$$U_{nj} = \beta_1 X_{\cos t} + \beta_2 X_{co_2} + \beta_3 X_{employ} + \beta_4 D_{stable} + \beta_5 D_{no-choice} + \varepsilon_{nj} \qquad (16)$$

where X_{cost}, X_{CO2}, and X_{employ} are the levels of increased heating expense, reduced GHG

(CO_2) emissions, and annual creation of new jobs, respectively, resulting from RHO implementation. A dummy variable D_{stable} represents whether a stable supply of renewable heating is possible, where 1 denotes a stable measure with the current use of fossil fuels, and 0, a relatively unstable supply. The dummy variable $D_{no\text{-}choice}$ represents whether a respondent rejects the RHO because he/she does not feel these policies are necessary; 1 denotes consumer rejection, and 0, consumer acceptance.

In general, the parameters in a mixed logit model are assumed to have normal distributions. However, as noted earlier, if a parameter reflects a one-directional preference, it can be assumed to have a lognormal distribution. Among the attributes, a lognormal distribution is assumed for parameters with variables for the heating expense (−) and reduction in CO_2 emissions (+); all other parameters are assumed to have normal distributions.

Table 11 lists the estimation results using the mixed logit model. The mean *b* and variance *W* of the estimates are presented, and the median MWTP and RI of each attribute are calculated based on the estimate distributions. The means and variances of all coefficients are significant at the 95% confidence level.

Table 11. Estimation results: public preferences for RHO for heating suppliers

Attribute	Assumed distribution	Mean	Standard deviation	MWTP	RI (%)
Increased heating expense (1000 KRW/month)	Log-normal	-0.8061***	2.4008***	-	19.57
Reduced GHG (CO_2) emissions (Mt CO_2 eq/year)	Log-normal	0.1470***	3.1712**	0.4250 KRW/10000 tons	2.39
New job creation (10,000 people)	Normal	0.3912**	1.3399***	0.0565 KRW/person	4.95
Stability of heat supply	Normal	2.3288***	1.8113***	5,904 KRW	10.49
Reject RHO	Normal	-13.9437***	4.1143***	-55,167 KRW	62.59

*** Significant at 1% level, ** Significant at 5% level.

According to the estimation results, consumer utility increases with decreases in heating expenses and CO_2 emissions and an increase in the number of new jobs created annually. In addition, a more stable heating energy supply is preferred over an unstable one. The coefficient of the dummy variable for rejecting the RHO was relatively large and negative. Therefore, consumer utility decreases considerably when he/she rejects the RHO for heating suppliers.

The median MWTP was calculated for each attribute based on the estimation results (Table 11). Consumers were willing to pay KRW 42.5 for a reduction of 1 million tons of CO_2 emissions (or KRW 0.4250/10,000 t). The MWTP for each new job created due to RHO implementation was KRW 0.0565. In addition, consumers were willing to pay KRW 5,904 on average for stable heating supplies. Finally, the average Korean consumer was willing to pay KRW 55,167/year for implementing the RHO policies; a respondent's MWTP for rejecting the RHO policies was KRW -55,167. This translates to a monthly MWTP of KRW 4,597.25/household for RHO implementation.

Based on the estimation results, the RI of each attribute representing consumer preferences for RHO implementation aimed at heating suppliers is also calculated (Table 11). The RI of increased heating expenses is the highest (19.57%) among all the attributes, followed by the RI of a stable heat supply (10.49%).

The change in the adoption probability of the RHO with the abovementioned attribute levels is calculated to forecast public acceptance. In the standard scenario, the following are assumed: a 10% increase in monthly heating expenses, a 1% annual reduction in CO_2 emissions, annual creation of 10,000 new jobs, and a stable supply of heating energy. For this standard scenario, it was found that 86.22% of all respondents would accept RHO implementation. This high adoption rate is consistent with the result of respondents willing to adopt an RHO policy (92%) (i.e., the percentage of respondents who did not reject the RHO policy in the CE). The high RHO adoption ratio was partly because many respondents agreed with the necessity of using renewable energy sources and had a positive impression of RHO policies, both of which are indicated by their answers to the preliminary questions.

A number of other scenarios are analyzed to examine changes in the adoption rate with the variations in attribute levels. When the heating expenses, which had the highest RI among the attributes, were increased by 0-30% over the standard scenario, public acceptance decreased from 99.9-60.3% (Figure 12). When the heating expense rose to 49%, the adoption rate decreased to below 50% (49.94%), with more than half the respondents preferring not to implement the RHO.

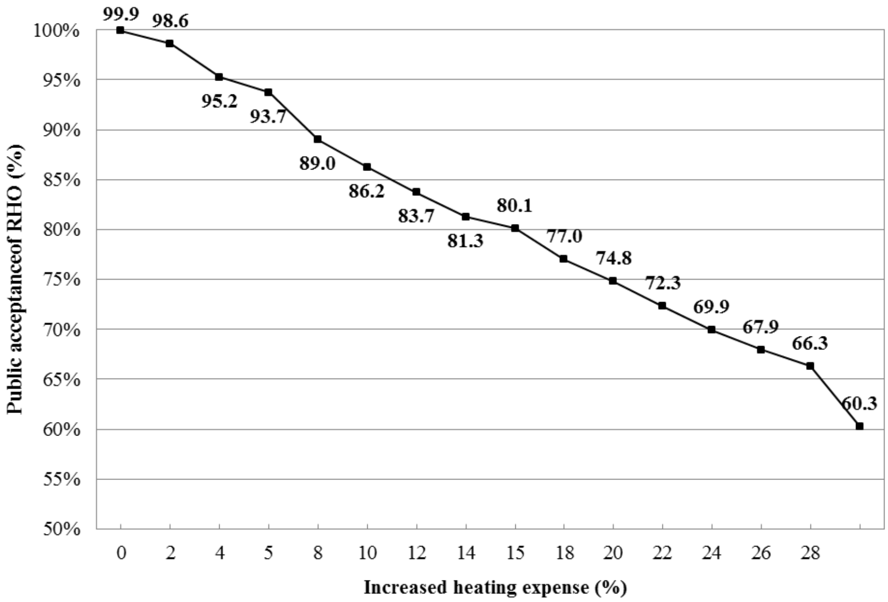

Figure 12. Public acceptance of RHO according to the increased heating expanse

The estimation results of RHO implementation for building owners are as follows. To investigate the public acceptance of the RHO aimed at building owners, a mixed logit model with Bayesian inference is used to estimate the following utility function, equation (17):

$$U_{nj} = \beta_1 X_{\cos t} + \beta_2 X_{co_2} + \beta_3 X_{employ} + \beta_4 X_{payback} + \beta_5 X_{subsidy} + \beta_6 D_{no-choice} + \varepsilon_{nj} \quad (17)$$

where X_{cost}, X_{CO2}, and X_{employ} are the initial installation cost for renewable heating facilities, annual reduction in CO_2 emissions, and annual creation of new jobs, respectively. The parameter $X_{payback}$ reflects the payback period for new facility installation, and $X_{subsidy}$

reflects the size of the government subsidy for the initial investment. The dummy variable $D_{no\text{-}choice}$ represents the rejection of the RHO by the respondents who do not feel these policies are necessary, wherein 1 reflects rejection, and 0, acceptance. A lognormal distribution is assumed for the additional installation cost, reduction in CO_2 emissions, and payback period, and a normal distribution is assumed for all other parameters.

Table 12 presents the estimation results from the survey data with mean values *b* and variances *W*. Both the means and variances of all the coefficients were significant at either the 99% or the 90% confidence levels.

Table 12. Estimation results: public preferences for RHO for building owners

Attribute	Assumed distribution	Mean	Standard deviation	RI (%)
Additional installation cost (million KRW)	Log-normal	-1.0907***	2.8204***	7.59
Reduced GHG (CO_2) emissions (Mt CO_2 eq/year)	Log-normal	0.0331***	0.0548***	1.13
Annual new employment (10,000 people)	Normal	0.3486***	1.1286***	6.17
Payback period (year)	Log-normal	-0.0096***	0.0205***	0.32
Government subsidy for the initial investment (10%)	Normal	0.2143***	0.5287***	13.86
Rejection of RHO	Normal	-14.0100***	6.6901*	70.93

*** Significant at the 1% level, * Significant at the 10% level.

For the RHO directed at building owners, calculating the median MWTP had little effect on policy makers, because the preferences and MWTP of each building owner varied substantially depending on the characteristics of the building they owned, including its type, purpose, area (size), and price. Table 12, therefore, shows only the direction and effect of each attribute on total consumer utility. Consumer utility increased with decreasing installation cost and payback period. Moreover, the number of jobs created and the amount of government subsidies both increased with decreasing CO_2 emissions. Similar to the previous results of RHO implementation for heat suppliers, consumer utility decreased considerably for consumers who rejected the RHO for building owners.

Finally, based on the above results regarding public acceptance of the RHO, we can compare the two RHO schemes for heating suppliers and building owners. Regarding the RHO for heating suppliers, the median Korean consumer's monthly WTP was approximately KRW 4,600. To examine the feasibility of RHO implementation in South Korea, I assume that the additional increase in heating expenses beyond the consumer's WTP would be subsidized by the national treasury. In this case, consumers would pay a maximum of KRW 4,600 even if the total expense of RHO implementation exceeded this amount. Given that the average heating expense per Korean household is approximately KRW 100,000/month and assuming a 10% increase in heating expenses with RHO implementation, the government subsidy per household would be KRW 5,400/month (10,000 − 4,600 = KRW 5,400). According to KOSIS, a total of 2,655,080 households in

2010 used heating energy from a central or district heating system,[18] corresponding to KRW 170 billion in total government subsidies per year.[19] The annual government subsidy would amount to KRW 330 billion if the increase in heating expenses were assumed to be 15% (i.e., the maximum level of the attribute in the discrete choice experiment).[20]

In addition, many households in South Korea do not acquire heating energy from suppliers. If the RHO for heating suppliers is enforced, 14,686,886 households in Korea will enjoy the various benefits of RHO implementation, even though they would not pay for it. In this case, the government could levy taxes of KRW 4,600/month, which is the median WTP for the RHO, on these households to secure the financial resources necessary to support the heating suppliers. In this scenario, the expected financial resources would amount to KRW 810 billion,[21] which would cover the previously calculated expected subsidies for suppliers. Therefore, when imposing RHO regulations on heat suppliers, subsidies should be offered to minimize stakeholder opposition and collect taxes from consumers who are not subject to the obligations to raise revenue to support the subsidies.

On the other hand, the government could subsidize a portion of the installation costs for each new facility to encourage high public acceptance. As indicated earlier, because each building has its own unique characteristics, it is inappropriate to estimate the sizes of

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[18] There were 820,059 and 1,835,021 households with central and district heating systems, respectively.
[19] KRW 5,400/month × 2,655,080 households × 12 months/year = KRW 1.72×10^{11}/year.
[20] KRW 10,400/month × 2,655,080 households × 12 months/year = KRW 3.31×10^{11}/year.
[21] KRW 4,600/month × 14,686,886 households × 12 months/year = KRW 8.11×10^{11}/year.

the subsidies by calculating the owner's average WTP. Instead, the required subsidy is estimated by assuming a situation in which the government offers grants to the primary target specified in the "Activation Plan for Renewable Energies" in the initial stage. To estimate the total installation costs paid for renewable heating and cooling systems, the following are assumed: (i) the government initially (2016-2019) subsidizes a portion of the installation costs for owners of new buildings with total floor areas exceeding 10,000 m^2, (ii) the annual construction area will be approximately 10,000 m^2, and (iii) the average installation cost for renewable heating and cooling systems is approximately KRW 120,000/m^2.[22] According to the Korean Ministry of Trade, Industry, and Energy, the average number of newly constructed buildings with total floor areas exceeding 10,000 m^2 is approximately 700/year. Given these assumptions, the total installation costs paid by building owners for renewable heating and cooling facilities would be approximately KRW 84 billion/year.[23] If the government subsidizes 25 or 50% (i.e., the maximum level in the discrete choice experiment) of this additional installation cost, the total subsidies would reach KRW 21 billion or KRW 42 billion, respectively.

Furthermore, assuming that RHO enforcement will be extended to the residential sector in the future, the government could offer grants to owners of detached or multifamily homes. These individuals are expected to have a low acceptance of the RHO, because their WTP for renewable heat energy is low. To approximate the total installation

[22] Although average installation costs for solar heating and hot water systems are about 55,000–142,000 KRW and for geothermal systems are about KRW 133,000, I used a fixed value of KRW 120,000 for renewable installation costs, because the average cost per unit area will decrease with increasing total building area.

[23] KRW 120,000/m^2 × 10,000 m^2 × 700 = KRW 8.4×10^{11}.

costs that will be paid by the owners of detached or multifamily homes for renewable heating and cooling systems, the following are assumed: (i) annual new constructions for both types of homes would be maintained at levels similar to those of 2012, (ii) the construction area of both types of homes would equal the maximum area, and (iii) all newly constructed homes would use only renewable resources for heating. According to KOSIS, 71,255 construction permits were granted in 2012 in South Korea, 51,232 for detached houses and 20,023 for multifamily housing. According to South Korean construction regulations, the areas of detached and multifamily homes cannot exceed 331 m^2 and 660 m^2, respectively. The average installation cost for renewable heating and cooling systems is approximately KRW 120,000/m^2. Given these assumptions, the total installation cost for renewable heating and cooling facilities in the South Korean residential sector would be approximately KRW 3.6 trillion.[24] If the government subsidizes 25 or 50% (i.e., the maximum level in the conjoint alternatives) of this additional installation cost, the total subsidies are expected to be KRW 900 billion and KRW 1.8 trillion, respectively.

Although this research examines the expected subsidy amounts, comparing the feasibility of the two types of RHO schemes directly using these estimates will be a challenge. For the RHO for building owners, the total cost of implementing the RHO could be much larger than these calculations suggest, because the government may fully subsidize the installation costs for public buildings such as government offices and

[24] KRW 120,000 /m^2 × (331 m^2 × 51,232 + 660 m^2 × 20,023) = KRW 3.6×10^{12}.

schools. The government could minimize its financial burden by exempting rather than subsidizing the obligations of individuals with low acceptance levels. Even if all the obligations are met, it might be a long time before RHO implementation results in visible outcomes, such as GHG reductions or the creation of new jobs, because there would be a substantial delay before a significant percentage of buildings installed renewable heat facilities due to their typically long lifespans. For the RHO directed at heating suppliers, as additional costs for the end consumers increase, public acceptance of the RHO could decline rapidly, leading to strong opposition to the policy. On the other hand, public acceptance could be enhanced by subsidizing costs exceeding the end users' WTP. The WTP was calculated for all consumers, including people with no direct interest in the RHO, because they do not acquire their heat from heating suppliers. The government could collect considerable revenue from these individuals by levying new taxes that are lower than the WTP, contributing to long-term price competitiveness for renewable heat energy.

4.3.4 Section Summary

This section estimated the MWTP and acceptance level of survey respondents to various attributes of the RHO, which is slated to be introduced in South Korea. The average response for a respondent's awareness of the RHO was 1.89 points on a five-point Likert scale, suggesting that most respondents were unaware of the RHO. On the other hand, the acceptance rate of the standard scenario for the RHO policy directed at heating suppliers was 86.22% after the respondents were educated about the advantages and disadvantages of the RHO. These results suggest that the respondents have a positive attitude toward the policy. Therefore, it is important that the South Korean government conduct extensive public relations and educational programs focused on the RHO so that consumers can understand the policy and make educated decisions. Given these results, such educational programs will lead to increased public acceptance and improved effectiveness of the RHO.

Because the most critical attribute for public acceptance was cost (i.e., an increase in heating expenses and initial installation costs for the facilities), cost considerations, including the use of government subsidies, will be critical when designing the RHO. In addition to cost, the respondents also placed high importance on the stability of the heating supply. Therefore, establishing a stable supply system before RHO implementation could be a crucial factor for policy success. In general, policy makers often best understand the attributes on which consumers place a premium and can use these attributes to enhance public acceptance. Hence, policy makers should consider the associated costs and heating supply stability most carefully when designing the RHO.

The production of heat comprises a large share of the total energy demand, accounting for 47% worldwide in 2009. Although there has been a rapid increase in renewable-heat-specific policies since 2005, few states have implemented policies with a strong regulatory component such as an obligation (Beerepoot and Marmion, 2012). Renewable heat obligations are, however, beginning to become more prevalent. In this context, the results of the present study suggest several policy implications for countries other than Korea, particularly those planning to introduce an RHO. First, it is important to promote a better understanding of the positive aspects of RHO, such as reductions in CO_2 emissions or employment creation, to enhance their public acceptance. Current public interest in RHOs, which is focused on the potential increase in the cost of heating, should be redirected to these positive aspects so as to effectively increase public acceptance. Establishing the cost of heating and stability of the heating supply should have priority over others issues when designing an RHO, because public acceptance is greatly affected by these two factors. This study not only presented a detailed methodology for the ex ante analysis of public preferences for a renewable energy policy, but also empirically verified the methodology using real data. Therefore, this research can serve as a foundation for analyzing public preferences for an RHO using individual country data.

This research has some limitations. First, in the discrete choice experiments, the variations in consumer acceptance were analyzed at a specific point in time rather than over a longer period of time. A time series analysis that considers other factors, such as price changes and advances in renewable energy technologies, could improve public acceptance of the RHO. Second, when composing the hypothetical RHO alternatives, to avoid confusion, only 4-6 attributes were included among the many possible attributes. However, other important attributes of the RHO, such as heating efficiency, should also be examined. Third, although the consumers' heterogeneous preferences were noted using the mixed logit model, the structure of that heterogeneity was not described. This was beyond the scope of this study, which focused on deducing policy implications based on the average preferences of the end users. Nevertheless, segmenting the end users using the hierarchical Bayesian model or the latent class model would provide richer information, because the respondents expressed heterogeneous preferences for all attributes.

Chapter 5. An Integrated Approach to Analyze Public Preferences for a Policy Category

5.1 Research Background

Chapter 4 analyzed public acceptance of and public preferences for three individual innovation (renewable energy) policies and forecasted the changes in acceptance levels according to their attribute variations. The results of such analyses can be useful in the process of establishing individual innovation policies. From a broader perspective, however, policy makers often need to know public preference structure for a specific field. In this case, the usefulness of the methodology adopted in chapter 4, which applies to individual policies, is doubtful. In reality, it is necessary to analyze multiple policies in a policy category in terms of a more integrated approach.

Consider the above discussions pertaining to renewable energy policies. Although there is no doubt that the Korean government should design detailed implementation schemes for the individual renewable energy policies, it should simultaneously consider the overall direction for a national renewable energy policy. According to a recent survey, the Korean people ranked renewable energy sources as the most important future resources for electricity generation (Korea Federation for Environmental Movement, 2013). Another survey result also indicated that the overwhelming majority of the Korean people agree to the continuous implementation of the "Green Growth Policy" (Committee on Green Growth, 2013). Thus, the general perception and attitude of the Korean people toward renewable energy itself seems to be positive. In most cases, however, such surveys are done without giving respondents sufficient information about renewable energy, such as the possibility of additional costs incurred by expanding renewable supply. Furthermore, although people generally prefer renewable energy, it is necessary to analyze the types of renewable energy policy they prefer and their perceptions of the possible effects, so as to establish a practical tone for the overall policy.

Various researchers have focused on product category. In particular, both academics and professionals in the field of advertising strategy acknowledge that product category is an important variable (Geuens et al., 2011). Examples include segmenting consumers according to brand preferences both within and across product categories (Russell and Kamakura, 1997), addressing consumer familiarity with a product category (Coupey et al., 1998), and analyzing choice behavior across multiple product categories (Ainslie and Rossi, 1998; Andrews and Currim, 2002).

On the other hand, studies on policy categories have been limited both quantitatively and qualitatively. Examples include suggesting a variety of criteria for policy classification and applying them to several policies (Wies, 1994) and suggesting a new policy typology under new criteria (Hayes, 2007). Most studies, therefore, have paid scant attention to public preferences for a specific policy category. Of course, a number of studies have analyzed individual policies with similar objectives and have then compared them using specific criteria such as effectiveness. However, it is difficult to find studies that have analyzed people’s preferences for a policy category consisting of several similar policies, or in the context of this research, policies having several common attributes.

To provide some insight into such issues, this chapter applies an integrated approach to analyze public preferences for multiple policies in a policy category. I propose a data classification method that can integrate different policy alternatives having a few common attributes, and this method is applied to the three renewable energy policies analyzed in chapter 4. The MVP model described in section 3.3 is used for the empirical analysis. The detailed data classification method and estimation results are described in sections 5.2 and 5.3, respectively.

5.2 Data: Classifying innovation policies into types

To analyze the overall public preference for the renewable energy policy category with the MVP model, it is first necessary to classify the various renewable energy policy alternatives that were presented to the respondents in the CEs. Such a data classification method has an advantage in that it can be applied to policy/product categories (besides the renewable energy policy category) having common attributes. In addition, although this research integrates three sets of choice data generated from the same sample of respondents, this integrated approach can also be applied to integrate different CE data arising from different respondent samples. The proposed method thus presents a considerable advantage.

I analyzed public acceptance of and their preferences for the RPS, RFS, RHO for heat suppliers, and RHO for building owners. In those CEs, the main attributes of the

RPS were assumed to be the increase in electricity bills, reduced GHG (CO_2) emissions, new job creation, annual power outage time, and damaged forest area. Those of the RFS were assumed to be the increased price of transportation fuels, reduced GHG (CO_2) emissions, new job creation, increased cost of food, and decreased fuel efficiency. The main attributes of the RHO for heat suppliers were the increase in heating expense, reduced GHG (CO_2) emissions, new job creation, and stability of heat energy supply. For the RHO for building owners, the main attributes were assumed to be the additional installation cost, reduced GHG (CO_2) emissions, new job creation, payback period, and government subsidy.

Overall, all these renewable energy policies have three common attributes: energy price increase, reduced GHG (CO_2) emissions, and new job creation induced by the implementation of the policies. The other attributes differ by policy and can be regarded as characteristics unique to the implementation of each policy. For the purpose of analysis in this section, therefore, 72 policy alternatives used in the CE surveys are classified into 5 types. Type 1 includes the renewable energy policy alternatives for the lowest increases in energy prices, arguably an important factor governing household economics; corresponding to the RPS, RFS, RHO for heat suppliers, and RHO for building owners, these alternatives are 2%, KRW 20/liter, 5%, and 6 million KRW, respectively. Type 2 includes the renewable energy policy alternatives regarding the largest reductions in GHG (CO_2) emissions, which entail considerable environmental improvement and climate change mitigation; corresponding to the RPS, RFS, RHO for heat suppliers, and RHO for building owners, these alternatives are assumed to reduce 7, 7, 1.5, and 1.5% of GHG emissions, respectively. Type 3 includes the renewable energy policy alternatives creating the largest numbers of new jobs annually, thus making significant contributions to the national economy; corresponding to the RPS, RFS, RHO for heat suppliers, and RHO for building owners, these alternatives would create 3, 1.5, 1.5, and 1.5 million new jobs annually, respectively. Type 4 includes the renewable energy policy alternatives of which unique attributes are superior. Type 5 includes other types of policies. All the abovementioned types, except Type 5, are not mutually exclusive; some renewable energy policy alternatives are included in more than one classification. Because the MVP model used herein considers multiple choice situations, these categories are, thus, deemed to be suitable for the analysis. Table 13 through Table 16 shows how the various alternatives in each policy are classified into these types.

Table 13. Classification of each alternative into types: RPS

Alternative No.	increase in the electricity bills (%/yr)	reduced GHG emissions (%/yr)	new job creation (10,000/yr)	annual power outage time (minutes/yr)	Forest damage (km^2/yr)	Classification used in estimation
RPS A1	2	7	3	50	660	Type 1, 2, 3
RPS A2	6	5	2	10	660	Type 4
RPS A3	6	7	3	30	530	Type 2, 3, 4
RPS B1	10	5	3	10	790	Type 3
RPS B2	10	7	1	30	660	Type 2

RPS B3	6	5	3	50	530	Type 3
RPS C1	2	5	1	30	530	Type 1, 4
RPS C2	2	3	3	10	660	Type 1, 3
RPS C3	10	7	2	10	530	Type 2, 4
RPS D1	10	5	1	50	660	Type 5
RPS D2	10	3	2	50	530	Type 5
RPS D3	6	3	1	50	790	Type 5
RPS E1	10	3	3	30	790	Type 3
RPS E2	6	3	2	30	660	Type 5
RPS E3	2	7	2	50	790	Type 1, 2
RPS F1	2	5	2	30	790	Type 1
RPS F2	2	3	1	10	530	Type 1, 4
RPS F3	6	7	1	10	790	Type 2

Table 14. Classification of each alternative into types: RFS

Alternative No.	increased price of transportation fuels (KRW/yr)	reduced GHG emissions (%/yr)	new job creation (10,000/yr)	increased cost of food (%/yr)	decreased fuel efficiency (%/yr)	Classification used in estimation
RFS A1	60	3	1	10	2	Type 5
RFS A2	100	5	1	6	5	Type 5
RFS A3	100	5	1.5	10	2	Type 3
RFS B1	20	7	1	10	5	Type 1, 2
RFS B2	60	5	0.5	6	2	Type 4
RFS B3	20	5	1.5	2	5	Type 1, 3, 4
RFS C1	20	3	1	6	8	Type 1
RFS C2	100	3	1.5	2	8	Type 3
RFS C3	60	3	1.5	6	5	Type 3
RFS D1	20	3	0.5	2	2	Type 1, 4

RFS D2	60	7	0.5	2	5	Type 2, 4
RFS D3	20	7	1.5	6	2	Type 1, 2, 3, 4
RFS E1	20	5	0.5	10	8	Type1
RFS E2	60	7	1.5	10	8	Type 2, 3
RFS E3	100	7	1	2	2	Type 2, 4
RFS F1	100	3	0.5	10	5	Type 5
RFS F2	60	5	1	2	8	Type 5
RFS F3	100	7	0.5	6	8	Type 2

Table 15. Classification of each alternative into types: RHO for heat suppliers

Alternative No.	increase in heating expense (%/yr)	reduced GHG emissions (%/yr)	new job creation (10,000/yr)	stability of supplying heat energy	Classification used in estimation
RHO1 A1	15	1.5	1.5	Stable	Type 2, 3, 4
RHO1 A2	10	1	1.5	Unstable	Type 3
RHO1 A3	5	0.5	1.5	Unstable	Type 1, 3
RHO1 B1	10	1.5	0.5	Stable	Type 2, 4
RHO1 B2	5	1	1	Unstable	Type 1
RHO1 B3	5	1	0.5	Stable	Type 1, 4
RHO1 C1	5	0.5	0.5	Stable	Type 1, 4
RHO1 C2	10	1.5	1	Unstable	Type 2
RHO1 C3	15	0.5	1	Stable	Type 4
RHO1 D1	10	0.5	1	Stable	Type 4
RHO1 D2	10	1	0.5	Stable	Type 4
RHO1 D3	15	1	1.5	Stable	Type 3, 4
RHO1 E1	15	1	1	Stable	Type 4
RHO1 E2	10	0.5	1.5	Stable	Type 3, 4
RHO1 E3	15	1.5	0.5	Unstable	Type 2

RHO1 F1	5	1.5	1	Stable	Type 1, 2, 4
RHO1 F2	10	0.5	1.5	Unstable	Type 3
RHO1 F3	15	1.5	1.5	Stable	Type 2, 3, 4

Table 16. Classification of each alternative into types: RHO for building owners

Alternative No.	increase in heating expense (million KRW)	reduced GHG emissions (%/yr)	new job creation (10,000/yr)	payback period (year)	governmental subsidy (%)	Classification used in estimation
RHO2 A1	8	1	1.5	7	50	Type 3
RHO2 A2	6	1	0.5	7	25	Type 1
RHO2 A3	7	1	1.5	3	0	Type 3
RHO2 B1	8	0.5	1	7	0	Type 5
RHO2 B2	6	1.5	1	7	50	Type 1, 2
RHO2 B3	8	0.5	0.5	5	25	Type 5
RHO2 C1	8	1	1	3	25	Type 4
RHO2 C2	6	0.5	1.5	5	50	Type 1, 3, 4
RHO2 C3	7	0.5	1	3	50	Type 4
RHO2 D1	7	1.5	1	5	25	Type 2
RHO2 D2	8	1.5	0.5	3	50	Type 2, 4
RHO2 D3	6	1.5	1.5	3	25	Type 1, 2, 3, 4
RHO2 E1	6	0.5	0.5	3	0	Type 1
RHO2 E2	7	0.5	1.5	7	25	Type 3
RHO2 E3	7	1	0.5	5	50	Type 4
RHO2 F1	8	1.5	1.5	5	0	Type 2, 3
RHO2 F2	7	1.5	0.5	7	0	Type 2
RHO2 F3	6	1	1	5	0	Type 1

As previously described in section 4.3, in the Korean context, according to the implementation scheme, the RHO can be intended for heat suppliers or for building owners. Therefore, two different analyses are conducted for each RHO scheme. In the first analysis (Case 1), I integrate and classify the data pertaining to the RPS, RFS, and RHO for heat suppliers, and in the second analysis (Case 2), I integrate and classify the data pertaining to the RPS, RFS, and RHO for building owners.

During the CE surveys, respondents chose the best alternative among the four alternatives in each choice set. Because there are 12 choice sets - 3 choice sets for 4 individual policies - respondents have 12 choice situations. Each choice set includes the "no choice" option, and thus, whether the respondent is likely to accept each policy alternative in practice can be ascertained. The analyses only used the data of alternatives adopted in practice. Using the abovementioned classification of the renewable energy policy alternatives and excluding cases of policy rejection ("no adoption"), Case 1 and Case 2 provide 4,179 and 4,188 choice data, respectively. The distribution of each case by type of renewable energy policy is depicted in Figure 13 (Case 1) and Figure 14 (Case 2).

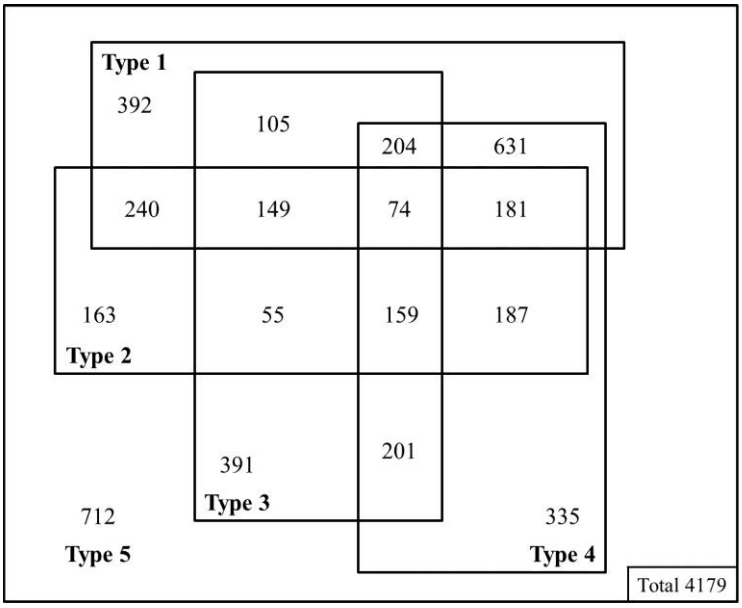

Figure 13. Distribution by classification (type of policy) of respondents: Case 1

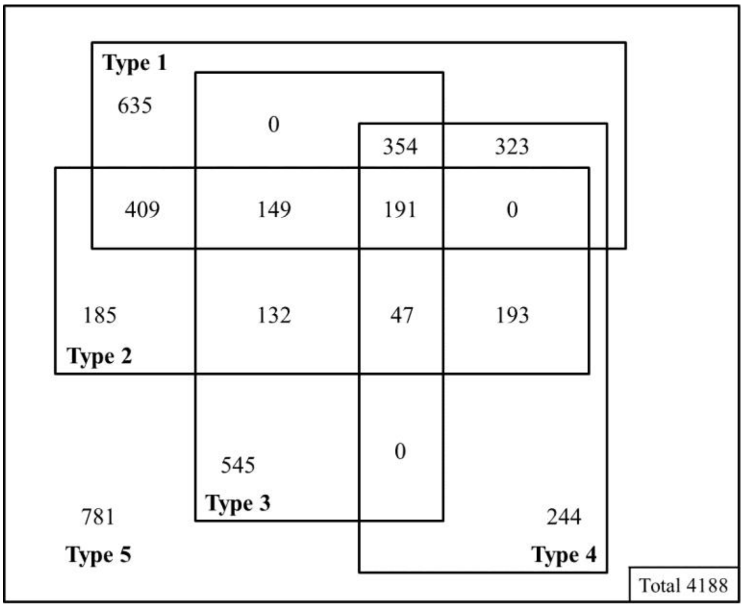

Figure 14. Distribution by classification (type of policy) of respondents: Case 2

5.3 Results and Discussion

The R programming language is used for the estimation. The statistical software package "bayesm" is employed, and the code is adapted to the proposed model. As described in section 3.3, Gibbs sampling, one of the most representative MCMC methods, is used for the estimation. I extract 20,000 draws from the Markov Chain, calculate the mean and quantile of 2,000 draws which are the tenth of all 20,000 draws.

The results of the empirical analysis can be summarized by the estimation result of the alternative specific constants of the five individual renewable energy policy types (α), effects of independent variables (β), and variance-covariance matrix of disturbances that shows the relationships between the alternatives (Σ). The results are described according to the main variables and case types as follows.

Various factors can affect public preference for the renewable energy policy category. Among them, this research regards sociodemographic variables and attitude toward renewable energy/environment as the main factors and focuses on these variables. Therefore, three models are considered. Model A considers sociodemographic variables such as age, gender, education, and income and investigates their effects on the adoption of renewable energy policy. Model B examines the effects of respondents' attitudes toward renewable energy and environmental protection on the adoption of renewable energy policy; specifically, these elements include the degree of agreement on renewables supply expansion, respondent's knowledge level on the three renewable energy policies (the RPS, RFS, and RHO), value assigned by the respondent to the environment, and the respondent's participation in eco-friendly activities The data analysis verifies the existence of high correlations between several sociodemographic variables and attitude variables. Thus, Model A and Model B are separated to solve the multicollinearity problem. Model C considers the ASC variable to analyze the average effect of each alternative. Gender is defined as the dummy variable, with "female" set as the reference. The estimation results of Models A1, B1, and C1 for Case 1 (the RPS, RFS, and RHO for building owners) are shown in Table 17 through Table 19.

Table 17. Estimation result of ASC and socio-demographic variables: Case 1

	Model A1					Model C1
	ASC	Gender	Age	Education	Income	ASC
Type 1 REP	0.029	-0.071	0.002	-0.008	0.000	**-0.065****
Type 2 REP	**-0.503****	**0.082***	0.001	-0.001	0.000	**-0.559****
Type 3 REP	**-0.538****	0.059	0.000	**0.017***	0.000	**-0.465****
Type 4 REP	-0.061	0.032	0.000	0.000	0.000	**-0.071****
Type 5 REP	**-0.770****	-0.075	-0.003	-0.011	0.000	**-0.952****

*: Significant at 5% level

**: Significant at 1% level

Table 18. Estimation result of ASC and attitude variables: Case 1

	Model B1					Model C1
	ASC	Need	Knowledge	Environment	Activity	ASC
Type 1 REP	0.028	-0.064	**-0.062***	0.065	-0.059	**-0.065****
Type 2 REP	**-0.487****	0.056	**0.091****	**-0.086****	0.038	**-0.559****
Type 3 REP	**-0.480****	**0.092***	0.018	**-0.069***	0.104	**-0.465****

Type 4 REP	**-0.261***	0.047	-0.025	0.030	0.049	**-0.071****
Type 5 REP	**-0.867****	-0.054	-0.036	0.043	-0.057	**-0.952****

*: Significant at 5% level

**: Significant at 1% level

Table 19. Variance-Covariance Matrix: Case 1

	Type 1 REP	Type 2 REP	Type 3 REP	Type 4 REP	Type 5 REP
Type 1 REP	**1.000**				
Type 2 REP	**0.168****	**1.000**			
Type 3 REP	**-0.085****	**0.144****	**1.000**		
Type 4 REP	**0.268****	**0.109****	**0.069****	**1.000**	
Type 5 REP	**-0.638****	**-0.483****	**-0.469****	**-0.659****	**1.000**

**: Significant at 1% level

First, for Case 1, wherein the RPS, RFS, and RHO for heat suppliers are implemented, the overall public preference for renewable energy policy type is examined. The results of Model C1 show that the Type 1 renewable energy policy is the most preferred. This result can be intuitively identified from Figure 13, and it is consistent with the result of the mixed logit model indicating the high importance of energy prices in chapter 4. Thus, considering the overall analysis results so far, the public seems to be sensitive to increasing energy prices and assigns considerable importance to the price factor. Next, except the Type 5 policy, which has no distinctive features, the order of public preference for renewable energy policy is Type 4, Type 3, and Type 2. As described above, the Type 2 policy can bring about the largest GHG emissions reduction, which is the main objective of a renewable energy policy. The respondents' low preference for the Type 2 policy shows that a considerable gap exists between the government's objective of policy introduction and public perception. These opposing viewpoints may act as a barrier to policy implementation in the near future.

Next, the effect of sociodemographic variables on the adoption of renewable energy policy is analyzed using Model A1. First, the results of Model A1 show that men significantly prefer the Type 2 renewable energy policy. This is an interesting result, considering previous research that the WTP a premium for renewable energy is relatively higher among women (Wiser, 2007). The model also shows that highly educated people prefer the Type 3 policy. It seems that highly educated people tend to attach importance to the macroeconomic effects arising from renewable energy use and their impact on the country. Other variables, such as age and income level, have no significant effect on public preference for the Case 1 renewable energy policy category.

The results of Model B1 in Table 18 show the relationship between respondents' attitudes toward renewable energy/environment and respondents' choices about policy types. The detailed descriptions of the independent variables in the second row are as follows. First, "Need" denotes the degree of agreement on the need for renewable energy dissemination compared with conventional fossil fuel use. "Know" represents the respondent's knowledge and awareness level about the three renewable energy policies in this empirical analysis. The other two independent variables are environment-related: "Environment" denotes the importance attached by the respondent to environmental protection, whereas “Activity” indicates the respondent’s actual participation in environmental protection issues. First, respondents who strongly support the expansion of renewable energy prefer a policy that can create many new jobs. In addition, respondents with higher knowledge levels tend to disapprove of the Type 1 policy, which would entail the lowest energy price increase. Instead, they prefer the Type 2 policy, which can achieve the largest GHG emissions reductions. Respondents with a high level of knowledge about renewable energy policies are likely to not only be interested in these policies but also to be frequently exposed to related information from the media. This kind of respondent is aware of the need for reducing GHG emissions and tends to regard it as important. Respondents with this characteristic seem to be less concerned about energy price increases. In sum, to secure public support for the Case 1 renewable energy policy category, it is likely that concerted public relations communicating the pros and cons of individual renewable energy policies will be more effective than public relations for renewable energy in general. Respondents who perceive environmental protection as more important do not seem to prefer the Type 2 and Type 3 policies. The result that respondents with higher interest in environmental issues show lower preferences for the Type 2 policy can be explained in two ways. First, several previous studies have shown that the respondent’s attitude toward the environment is not much related to his/her actual participation in environmentally friendly activities; in fact, a considerable gap exists between these two elements (Oskamp et al., 1991; Vining and Ebreo, 1990). Another possible explanation is that people may find it difficult to distinguish which products/services are beneficial to the environment even if they believe in environmental protection.

One of the benefits of using the MVP model is that it estimates the variance-covariance matrix Ω. The variance-covariance matrix reveals complimentary/substitute patterns between/among the renewable energy policy types. However, the complimentary/substitute patterns shown in this study do not perfectly reflect the findings of classical economics about complimentary/substitute relationships. Rather, these results can be interpreted using the possibility theory. For instance, if $\operatorname{cov}\left(\varepsilon_{ij}, \varepsilon_{ik}\right) > 0$, people will choose both alternative *j* and alternative *k*, that is, there is a higher probability of a simultaneous purchase. On the other hand, if $\operatorname{cov}\left(\varepsilon_{ij}, \varepsilon_{ik}\right) < 0$, it implies that the consumer will choose only one alternative, either *j* or *k*. In other words, it can be said that the alternatives have a complimentary/substitute pattern for each other. The results of the variance-covariance matrix using Model C1 are shown in Table 19.

These results show that there is a significantly positive relationship among most types of renewable energy policies. This is because, as the results show, consumers who regard increased energy prices as an important attribute also consider most of the other attributes to be important. The Type 1 and Type 4 policies show the strongest positive relationship among them. This indicates that consumers who are sensitive to an energy price increase will also place adequate emphasis on the unique characteristics of such a policy. Considering that the Type 4 policy is the second most preferred policy after Type

1 (as seen from the estimated ASC of Model C1), the government should pay attention to these two factors in terms of public preferences when designing renewable energy policies. By contrast, there exists a negative relationship between the Type 1 and Type 3 policies. This negative relationship shows the exclusive relationship between household economics (represented by the energy price increase attribute) and national economy (represented by the new job creation attribute) in the respondents' minds. That is, the public generally does not consider both effects simultaneously. In addition, the Type 5 policy has a significantly negative relationship with all the other types of renewable energy policies, because it is mutually exclusive to the other types (see Figure 13). In addition, this can be interpreted from the perspective of preference. For example, while the Type 1 policy includes only the lowest increase in the energy price, the Type 5 policy does not include any policy with this attribute. Thus, if respondents prefer the Type 1 policy, they would not choose the Type 5 policy, because they make their choice based on the energy price only, irrespective of the other attributes.

Next, respondents' preferences for renewable energy policy as a category are examined when the Case 2 (the RPS, RFS, and RHO for building owners) category is introduced. The estimation results of Models A2, B2, and C2 for Case 2 are shown in Table 20 through Table 22.

Table 20. Estimation result of ASC and socio-demographic variables: Case 2

	Model A2	Model C2

	ASC	Gender	Age	Education	Income	ASC
Type 1 REP	-0.094	-0.075	0.001	0.005	0.000	-0.023
Type 2 REP	**-0.446****	0.019	0.000	0.004	0.000	**-0.492****
Type 3 REP	**-0.599****	**0.099***	-0.001	0.011	0.000	**-0.418****
Type 4 REP	**-0.429****	-0.009	0.000	0.006	0.000	**-0.458****
Type 5 REP	**-1.059****	-0.045	-0.002	-0.024	0.000	**-0.851****

*: Significant at 5% level

**: Significant at 1% level

Table 21. Estimation result of ASC and attitude variables: Case 2

	Model B2					Model C2
	ASC	Need	Knowledge	Environment	Activity	ASC
Type 1 REP	**0.317***	**-0.167****	**-0.059****	**0.080***	-0.040	-0.023
Type 2 REP	**-0.330****	0.014	**0.034***	-0.050	0.006	**-0.492****
Type 3 REP	**-0.567****	**0.095***	0.012	-0.056	**0.093***	**-0.418****
Type 4 REP	**-0.657****	0.064	-0.008	0.026	-0.016	**-0.458****
Type 5 REP	**-1.409****	0.018	-0.026	0.008	-0.049	**-0.851****

*: Significant at 5% level

**: Significant at 1% level

Table 22. Variance-Covariance matrix: Case 2

	Type 1 REP	Type 2 REP	Type 3 REP	Type 4 REP	Type 5 REP
Type 1 REP	**1.000**				
Type 2 REP	**0.220****	**1.000**			
Type 3 REP	**0.100****	**0.194****	**1.000**		
Type 4 REP	**0.364****	**0.098****	**0.284****	**1.000**	
Type 5 REP	**-0.733****	**-0.507****	**-0.615****	**-0.635****	**1.000**

**: Significant at 1% level

As in Case 1, respondents' general preferences for renewable energy policies are first examined assuming that the RPS, RFS, and RHO for building owners will be implemented. Like Case 1, the results of Model C2 in Case 2 show that the Type 1 renewable energy policy is the most preferred, but this result is not statistically significant. In the case of the RHO for building owners, it seems that respondents' preferences for the direct price attribute become ambiguous, because the RHO for building owners has indirect price attributes (payback period and government subsidy) as well as direct price attributes. Thus, except for the insignificant Type 1 and the exclusive Type 5 policies, the respondents prefer renewable energy policies in the Case 2 policy category in the following order: Type 3, Type 4, and Type 2. Similar to Case 1, the least preferred policy is the Type 2 policy. However, unlike Case 1, the respondents prefer the Type 3 policy to the Type 4 policy. This implies that the average effect of respondents' preferences for renewable energy policies can partly change according to the type of RHO being introduced.

Next, the effect of sociodemographic variables on the adoption of renewable energy policy is analyzed using Model A2. The results of Model A2 show that men prefer the Type 3 renewable energy policy. Given that Korean men tend to be relatively more active in social terms than Korean women, they seem to assign relatively higher values to employment. Compared with the analysis for Case 1, the overall preference for the Type 3 policy increases and the significance of men's preferences for the Type 3 policy changes in Model C2. This implies that the majority of male respondents tend to choose the Type 3 policy alternative in the CE pertaining to the RHO for building owners. Other variables, such as age, education level, and income level, have no significant effect on respondents' preferences for the Case 2 renewable energy policy category. Therefore, the analysis of the sociodemographic variables suggests that relatively less consideration of response changes is necessary when introducing the RHO for building owners. Moreover, it may be difficult to identify the population to be targeted while promoting the RHO for building owners using the sociodemographic variables.

The results of Model B2 in Table 21 show the effects of respondents' attitudes toward renewable energy and environmental protection pertaining to the Case 2 renewable energy policy category. First, respondents indicating support for the expansion of renewable energy supply prefer the Type 3 policy while they less prefer Type 1 policy. Further, respondents with more knowledge about the three renewable energy policies tend to prefer the Type 2 policy while they less prefer Type 1 policy. The "Knowledge" variable shows consistent results in the sign and significance of coefficients regardless of the policy categories (Case 1 and Case 2), that is, regardless of the RHO type introduced. Thus, in order to ease public resistance incurred by an energy price increase as well as to form a social consensus on GHG emissions reduction, the government should map out efficient strategies to improve public knowledge of renewable energy policies. Regarding the variables measuring respondents' attitudes toward environmental protection, those who think environmental protection is important prefer the Type 1 policy, while those who actually participate in eco-friendly activities prefer the Type 3 policy. This implies that the greater the interest and participation in environmental protection, the greater the preference for a policy type entailing economic benefits (energy prices and new job creation). This is similar to the results for Case 1; the respondents seem to think that the relationship between renewable energy policy implementation and environmental improvement is weak.

The results of the variance-covariance matrix in Table 22 show a significantly positive relationship among all types of renewable energy policies except Type 5. The Type 1 and Type 3 policies show a positive relationship in Case 2 and a negative relationship in Case 1. The trade-off relationship between the Type 1 and Type 3 policies seems to weaken, because the alternatives for the RHO for building owners also have indirect price attributes, as explained above. The Type 1 and Type 4 policies show the strongest positive relationship among policies, similar to Case 1. The Type 5 policy has a significantly negative relationship with all the other types of renewable energy policies, which is of course as expected and similar to the results for Case 1.

Chapter 6. Conclusion

Demand-based innovation policy has received much attention recently. Most of the existing studies on demand-based innovation policy have emphasized the importance of public procurement in order to diffuse target innovation. However, a true demand-oriented innovation policy should consider public needs and their preferences so as to induce sustainable innovation. Though an innovation policy has obvious conveniences and usefulness, it may be confronted with considerable social resistance. Therefore, from the perspective of demand-oriented innovation policy, public acceptance becomes a very important consideration.

Accordingly, this dissertation analyzed public acceptance of an innovation policy with the stated preference technique and quantitatively forecasted the level of public acceptance according to variations in policy attribute levels. To achieve such objectives, stated preference data were obtained via CEs, a kind of CM, and the data were analyzed with a Bayesian mixed logit model to reflect respondents' heterogeneity. Public acceptance of innovation policy was quantified by the choice probability of mixed model.

Although such analysis of public acceptance of individual innovation policies can give information useful for policy implementation, policy makers often need to know the public's preference structure for a certain policy category that is likely to contain several individual measures. Thus, from a broader perspective, it is necessary to analyze the types of innovation policy and effects preferred by the public with a more integrated approach.

This research suggested a data classification method that can integrate different policy alternatives having a few common attributes.

Three renewable energy policies - namely the RPS, RFS, and RHO - were selected for empirical analyses, because they are good examples of innovation policies that can directly and indirectly affect public life, thereby necessitating consideration from the perspective of the end users (the general public). They are also similar in that their purposes and effects overlap. The current research developed a data classification method and an integrated approach that can simultaneously analyze public preferences for several similar policies in the same category.

First, public preferences for the three renewable energy policies were analyzed to forecast levels of public acceptance using CEs. Chapter 4 included analyses of respondents' MWTP for the RPS, RFS, and two types of RHO with specific attributes and simulated public acceptance of each policy with scenario analyses. For the RPS, the simulation results provided implications for improving implementation; households consider the creation of new jobs as the most important policy attribute, followed by increased electricity bills, damage to forests, reduced GHG (CO_2) emissions, and length of power outages. For the RFS, respondents were relatively sensitive to the price increase, while other attributes had little effect on its public acceptance. For the RHO, the results showed that it would be necessary to focus on the cost aspect when designing both types of RHOs, because cost is the most critical issue affecting public acceptance. Furthermore, for the RHO policy aimed at heat suppliers, it is recommended that the government convince end users of the stability of the heat supply, which consumers consider to be an important factor. Such differences between the influences of attributes on public acceptance of each renewable energy policy should be considered when designing the policies.

Second, chapter 5 presented an integrated approach to analyze public preferences for multiple policies in a policy category. A data classification method that can integrate different policy alternatives having a few common attributes was proposed, and this method was applied to the three renewable energy policies. In consequence, various renewable energy policy alternatives were classified into certain types. As the RHO can be intended for either heat suppliers or building owners depending on the implementation scheme, two different analyses were undertaken: Case 1 integrated and classified the data pertaining to the RPS, RFS, and RHO for heat suppliers, while Case 2 did the same for the data pertaining to the RPS, RFS, and RHO for building owners. I considered multiple-choice situations because the renewable energy policy alternatives could have been included in more than one classification. Thus, the MVP model was the most suitable for the analyses. The results of Case 1 and Case 2 showed that, in general, the public seems to be sensitive to increasing energy prices and assigns great importance to the price factor. However, the results also showed that the average effect of respondents' preferences for renewable energy policies can change partly depending on which type of RHO is introduced. In both Case 1 and Case 2, the variable denoting respondents' knowledge about the three renewable energy policies showed consistent results and had a positive effect on respondents choosing eco-friendly policies. Thus, in order to ease public resistance incurred by energy price increases as well as to form a social consensus on GHG emissions reduction, the government should map out efficient strategies to improve public knowledge of renewable energy policies.

The distinct contributions of this dissertation can be summarized into three points. First, this research conducted a detailed analysis of public preference structure for renewable energy policies, while previous studies only focused on eliciting people's aggregate WTP for renewable energy sources. Though assessing WTP for a renewable energy source is significant in itself, it is currently more important to suggest a practical measure to increase public acceptance of renewables and renewable energy policies. Thus, in terms of providing direction and guidance with the design and modification of such policies, the results of this research are more meaningful, as the proposed methodology can examine not only the preference for each policy attribute but also the relative priorities among them. Clearly, previous studies that focused on a mere analysis of WTP suffer from limitations in this regard. Second, this research examined overall public acceptance of renewable energy policy deployment in every renewables subsector, that is, the electric power, transport, and heating sectors. The majority of previous studies that examined public acceptance of renewable energy (actually, the mean WTP for it), tended to focus on the electric power sector (such as solar photovoltaic and wind power) alone. However, as renewable energy can be supplied to various sectors such as transport and heating, simultaneous diffusion in each sector is indispensable for achieving ultimate long-term renewables supply targets. Therefore, for successful policy implementation and to compare the results of individual policy diffusion across sectors, an *ex ante* analysis of renewable energy policies is necessary not only in the electric power sector but also in the transport and heating sectors. This research thus broadens the horizon of policy implications by analyzing and comparing the public acceptance of the RPS in the electric power sector, the RFS in the transport sector, and the RHO in the heating sector. Third, using a more integrated approach, this research suggests a method to simultaneously analyze public preferences for a superordinate policy category. This research is novel in that it analyzed public acceptance of a superordinate policy category while previous research dealt with a single policy only. The additional secondary contributions of this research include the measurement of public acceptance of an innovation policy in more quantitative terms (as a percentage) and the development of a more systematic procedure for applying stated preference data to policy analyses. The framework of this research can be generally applied to any innovation policy relevant to the public, and the integrated data classification method can be applied to any category of policies/products having common attributes.

However, this research also has some limitations. First, the analyses were restricted to the demand side. Thus, it is necessary to conduct a supply-side analysis alongside the demand-side analysis. Moreover, in the analyses of individual innovation policies (chapter 4), variations in public acceptance were analyzed at a specific time point only. Thus, a dynamic decision-making process with intertemporal analysis should be considered in future studies. Another limitation is that only 4-5 of numerous attributes were considered for each innovation policy. Furthermore, additional analyses, such as cost-benefit analysis and expected environmental improvements, can be conducted using the results of the mixed logit model. In Chapter 5, which presented the analysis of the superordinate policy category, the method of alternative type classification is somewhat arbitrary. A more systematic procedure, such as measuring similarity based on alternative attributes, is needed. It may also be advisable to consider the alternative type distribution in each choice set at the CE survey design stage.

In sum, this research contributes significantly to the decision-making process for developing a demand-oriented innovation policy by applying an estimation procedure to quantify public preferences for innovation policy and the level of public acceptance. It is obviously important to consider public acceptance and response to ensure sustainable policy implementation. Additionally, by suggesting an integrated approach to analyze public preferences for a policy category, this research can help policy makers establish a general policy direction with a broader perspective. The framework of this research can be universally applied to any policies affecting the general public. Notably, the integrated data classification method can be applied to any policy/product category having common attributes. Future research is expected to provide a better understanding of demand-oriented innovation policy based on public acceptance.

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Appendix: Survey questionnaires

Gallup

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GMR 2012-140-037 신재생에너지 보급확대 정책 수용도 조사(A형)

				1

안녕하십니까? 저는 시장조사 전문기관인 한국갤럽조사연구소 면접원 ○○○입니다.

한국갤럽조사연구소에서는 **서울대학교 기술경영경제정책 대학원의 의뢰**로 일반국민 여러분을 대상으로 **신재생에너지 및 신재생에너지 정책 관련 인식 및 태도**를 알아보고 있습니다. 본 질문에는 맞고 틀리는 답이 없으며, 이런 의견을 갖고 있는 사람이 몇 퍼센트(%) 라는 식으로 통계를 내는 데에만 사용되며, 그 외의 목적에는 절대로 사용되지 않으니 평소 생각대로 응답해 주시면 됩니다.
또한, 귀하께서 응답해 주신 내용은 통계법(제33조)에 따라 통계목적으로만 이용되며, 귀하의 의견이 철저히 보호됨을 약속드립니다.

바쁘시겠지만, 귀하의 적극적인 협조를 부탁드립니다.

감사합니다.

2012년 9월
한국갤럽조사연구소
박 무 익

한국갤럽조사연구소 김지혜 담당 (02-3702-2668)
한형진 부장 (02-3702-2515)

먼저, 응답자 선정 질문입니다.

SQ1. **성** : 1. 남자 2. 여자

6

SQ2. 실례지만, **귀하의 현재 나이**는 만으로 어떻게 되세요?

7-8 만 _____ 세

SQ3. **지역 Ⅰ** :

9

1. 서울 2. 부산 3. 대구 4. 인천 5. 광주 6. 대전 7. 신도시(경기)

SQ4. **지역 Ⅱ** :

10-12 ____________ (구/군)

다음 페이지부터 응답자 자기기입식으로 진행해 주십시오.

질문 작성시 유의사항

1. 질문지는 **순서대로 응답**해 주십시오. 특별한 언급이 없다면, **모든 질문에 빠짐없이 응답**해 주시기 바랍니다.
2. 질문에 응답하시기 전에 질문 앞에 제시된 **설명문을 잘 읽고, 숙지**하신 후 응답해 주시기 바랍니다.
3. 질문은 **주관식과 객관식으로 구성**되어 있습니다. 주관식 질문 응답은 답란에 **직접 적어주**시고, 객관식 질문은 **제시된 보기 번호에 ○표** 해 주시기 바랍니다. 또한, 질문 항목별로 특별한 언급이 없는 한 **가장 최근을 기준으로 응답**해 주시면 됩니다.

- 1 -

A. 신재생 에너지 평가

■ 신재생에너지 설명문

1. 신재생에너지는 **기존의 화석연료를 변환**시켜 이용하거나 햇빛·물·지열·강수·생물유기체 등을 포함해 **재생 가능한 에너지를 변환**시켜 이용하는 에너지로서 ① **기존 화석연료를 변환시켜 이용하는 신에너지**와 ② **재생가능한 자연적 에너지원을 변환시켜 사용하는 재생에너지**로 구분됩니다. 현재 신재생에너지는 **갑작스러운 전력공급 중단 등 급박한 상황에 대응**하기 위한 수단으로 주로 이용되며, **매년 지속적으로 생산량이 증가**하여, 2010년도에는 전체 1차 에너지 공급량 중 2.61%의 비중을 차지하고 있습니다.
2. 신재생에너지는 화석에너지의 고갈과 환경문제의 대두, 최근 유가의 불안정과 기후변화 협약의 규제 대응 등으로 **필요성이 증가하는 추세**에 있으며, **친환경적이며 고갈의 우려가 없어** 차세대 에너지로서 이목이 집중 되고 있습니다. 특히 에너지 소비와 온실가스 배출이 많으면서도 새로운 에너지원 확보율이 낮은 우리나라는 신재생에너지에 대한 관심이 굉장히 높습니다. **우리나라의 에너지 해외의존도는 96% 수준**입니다.
3. 우리나라는 신재생에너지를 **3개 신에너지와 8개 재생에너지로 정의**하고 있으며, 그 내용은 다음과 같습니다.

[신재생 에너지 분류표]

연료전지	태양열	태양광	바이오에너지
수소, 메탄 및 메탄올 등을 연료로 이용한 전기 생산	태양의 열에너지를 이용한 에너지 생산	태양의 빛 에너지를 이용한 에너지 생산	광합성 유기물 및 해당 유기물을 소비하여 생성되는 생물 유기체(바이오매스)의 에너지
석탄가스화/ 액화	풍력에너지	수력에너지	폐기물에너지
석탄 등 저급 원료를 이용한 가스 제조 및 전기 생산	바람에너지를 이용한 전기 생산	강이나 호수 등 물 흐름 운동에너지를 이용한 전기 생산	폐기물 오일화, 성형고체 연료 제조, 가스제조 및 소각에 의한 열 회수 등 가공처리를 통한 에너지
수소에너지	지열에너지	해양에너지	
수소 연소시 발생하는 폭발력을 이용한 에너지 생산 또는 수소 재분해를 통한 에너지 생산	지하 뜨거운 물(온천)과 돌(마그마)을 포함한 땅이 가지고 있는 에너지	해양의 조수, 파도, 해류, 온도차 등을 이용한 전기나 열 생산	

문1-1. 귀하께서는 위에 제시한 각각의 신재생에너지에 대해 **어느 정도 알고**계십니까? **해당 번호에 O표**해 주십시오.

	전혀 모른다	모르는 편이다	보통 이다	아는 편이다	매우 잘 안다	
1. 연료전지	1	2	3	4	5	13
2. 석탄 가스화/액화	1	2	3	4	5	14
3. 수소 에너지	1	2	3	4	5	15
4. 태양열	1	2	3	4	5	16
5. 태양광	1	2	3	4	5	17
6. 바이오에너지	1	2	3	4	5	18
7. 풍력에너지	1	2	3	4	5	19
8. 수력에너지	1	2	3	4	5	20
9. 폐기물에너지	1	2	3	4	5	21
10. 지열에너지	1	2	3	4	5	22
11. 해양에너지	1	2	3	4	5	23

문1-2. 그럼, 귀하께서 생각하시기에 **가장 유용한 신재생에너지는 무엇**입니까? **그 다음 유용한 신재생에너지는 무엇**입니까? **다음 답란에 순서대로 3개까지 응답**해 주십시오.

1위	24-25	2위	26-27	3위	28-29

1. 연료전지
2. 석탄 가스화/액화
3. 수소 에너지
4. 태양열
5. 태양광
6. 바이오에너지
7. 풍력에너지
8. 수력에너지
9. 폐기물에너지
10. 지열에너지
11. 해양에너지

문1-3. 귀하께서는 석유나 석탄 등 기존 화석연료 대비 **신재생 에너지의 보급 및 확대**가 **어느 정도 필요**하다고 생각하십니까?
30

전혀 필요하지 않다	필요하지 않은 편이다	보통이다	필요한 편이다	매우 필요하다
1	2	3	4	5

문1-3-1. **(문1-3-1.은 문1-3.에서 응답하신 이유에 대한 질문입니다.)**
31-33 그럼, 그렇게 생각하시는 **가장 큰 이유는** 무엇입니까? **구체적으로 응답**해 주십시오.

답란 : ____________________

문1-4. 정부는 2030년까지 전체 에너지 중, **신재생에너지 공급 목표**를 정하였습니다. 귀하께서는 이 사실을 알고 계셨습니까?
34

1. 잘 알고 있다
2. 잘은 모르나, 들어본 적은 있다
3. 전혀 모른다 → **문1-4-2.로 가십시오**

문1-4-1. 그럼, 귀하께서는 2030년까지 **정부의 신재생에너지 공급 목표**를 전체 에너지 중 몇 퍼센트(%)로 알고 계십니까?

35-37 ________%

문1-4-2. 그럼, 귀하께서는 2030년까지의 **신재생에너지 공급비율**을 전체 에너지 중 몇 퍼센트(%)로 하는 것이 적정하다고 생각하십니까?

38-40 ________%

문1-5. 귀하께서는 신재생에너지 관련 다음 각 항목에 대해 **어떻게 생각**하십니까? **해당 번호에 ○표**해 주십시오.

일반적으로 신재생 에너지는...

1. 친환경적이다 (환경오염이 감소된다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	41
2. 발전효율이 높다 (에너지 생산성이 높다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	42
3. 안정적인 자원 확보가 가능하다 (반영구적 사용)	1. 그렇다	2. 아니다	3. 잘 모르겠다	43
4. 전력 생산단가가 낮다 (에너지 가격이 싸다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	44
5. 에너지 수급에 도움이 된다 (수입의존도를 낮춘다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	45
6. 일자리 창출 및 수출상품화가 가능하다	1. 그렇다	2. 아니다	3. 잘 모르겠다	46
7. 용량이 많다 (한 번에 많은 에너지를 생산한다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	47
8. 가동률이 높다 (성능이 좋다)	1. 그렇다	2. 아니다	3. 잘 모르겠다	48

B. 신재생에너지 정책 평가

■ 신재생에너지 정책 설명문

개인보조 정책	1. **그린홈 100만호 보급사업** 태양광, 태양열, 지열, 소형풍력, 연료전지 등 신·재생에너지원을 주택에 설치할 경우, 설치 기준단가의 일부를 정부가 지원 2. **일반보급 보조사업** 일반건물·시설물 등에 자가 사용을 목적으로 신재생에너지 설비 설치를 희망하는 경우, 설치비의 일정부분을 지원 (태양광 : 기준 단가의 40% 이내, 태양열, 지열, 바이오, 소형풍력, : 기준단가의 50% 이내, 연료전지 : 기준단가의 75% 등)
생산기업 금융보조 정책	3. **신재생에너지 금융지원** 신재생에너지 설비 제조업자의 시설 설치, 제품 생산 공정라인, 사업 운영자금 등에 장기적인 금융지원 (생산자금 및 시설자금 : 100억원 내, 5년 거치 10년 분할상환, 운전자금 : 10억원 내, 1년 거치 2년 분할상환 등)
의무화 제도	4. **신재생에너지 설치 의무화 제도** 공공기관이 신·증·개축하는 연면적 1,000m² 이상의 건물에 대해, 예상 에너지 사용량의 10% 이상을 신재생에너지 설비 설치에 투자하도록 의무화 5. **신재생에너지 공급의무화 제도 (신재생에너지 의무할당 제도 ; RPS)** 한국수자원지력, 지역난방공사, 수자원공사, 포스코파워 등 설비규모 500MW 이상의 발전사업자 및 수자원공사, 지역난방공사가 총 발전량 중 일정량 이상을 신재생에너지 전력으로 공급토록 의무화하는 제도 (현재 의무비율 2%임.) 6. **신재생 열에너지 공급의무화 제도** (RHO) 일정 규모 이상의 신·증·개축 건축물 또는 집단 에너지 등 열공급 사업자를 대상으로 일정 비율 이상의 신재생 열에너지 (태양열·지열·바이오 등)를 의무적으로 공급하도록 하는 제도 (이르면 2014 또는 2015년에 도입방안을 논의 중에 있음.) 7. **신재생 연료 혼합의무화 제도** (RFS) 정유회사(SK에너지, GS칼텍스, 에쓰오일과 현대오일뱅크)와 석유 수출입 업체 등 자동차 연료 공급업체가 바이오디젤, 바이오에탄올 또는 바이오가스 등 신재생연료를 일정량 이상 공급하도록 의무화하는 제도 (현재 미국, 영국과 독일 등에서 운영 중이며, 우리나라는 도입방안을 연구중에 있음.)

문2-1. 귀하께서는 앞에 제시한 각각의 신재생에너지 정책에 대해 **어느 정도 알고 계십니까? 해당되는 번호에 ○표**해 주십시오.

	전혀 모른다	모르는 편이다	보통이다	아는 편이다	매우 잘 안다	
	1	2	3	4	5	
1. 그린홈 100만호 보급사업 ·························	1	2	3	4	5	49
2. 일반보급 보조사업 ·························	1	2	3	4	5	50
3. 신재생에너지 금융지원 ·························	1	2	3	4	5	51
4. 신재생에너지 설치 의무화 제도 ·························	1	2	3	4	5	52
5. 신재생에너지 공급 의무화 제도(RPS) ·························	1	2	3	4	5	53
6. 신재생 열에너지 공급 의무화 제도(RHO) ·························	1	2	3	4	5	54
7. 신재생연료 혼합 의무화 제도(RFS) ·························	1	2	3	4	5	55

문2-2. 앞에 제시한 각각의 신재생에너지 정책이 **어느 정도 필요하다고 생각**하십니까? **해당되는 번호에 ○표**해 주십시오.

	전혀 필요하지 않다	필요하지 않은 편이다	보통이다	필요한 편이다	매우 필요하다	
	1	2	3	4	5	
1. 그린홈 100만호 보급사업 ·························	1	2	3	4	5	56
2. 일반보급 보조사업 ·························	1	2	3	4	5	57
3. 신재생에너지 금융지원 ·························	1	2	3	4	5	58
4. 신재생에너지 설치 의무화 제도 ·························	1	2	3	4	5	59
5. 신재생에너지 공급 의무화 제도(RPS) ·························	1	2	3	4	5	60
6. 신재생 열에너지 공급 의무화 제도(RHO) ·························	1	2	3	4	5	61
7. 신재생연료 혼합 의무화 제도(RFS) ·························	1	2	3	4	5	62

문2-3. 그럼, 신재생에너지 관련 정부정책 중, 귀하께서 생각하시기에 **가장 중요한 정책**은 무엇입니까? 그 다음 중요한 **정책**은 무엇입니까? **중요한 정책 순서대로 다음 답란에 순서대로 3개까지 응답**해 주십시오.

1위	63-64	2위	65-66	3위	67-68

1. 그린홈 100만호 보급사업
2. 일반보급 보조사업
3. 신재생에너지 금융지원
4. 신재생에너지 설치 의무화 제도
5. 신재생에너지 공급 의무화 제도(RPS)
6. 신재생 열에너지 공급 의무화 제도(RHO)
7. 신재생연료 혼합 의무화 제도(RFS)
8. 기타 (적어 주십시오 : ______________)

문2-3-1. **(문2-3-1.은 문2-3.에서 가장 중요하다고 응답하신 정책에 대한 질문입니다.)**
그럼, 귀하께서 해당 정책을 **가장 중요하다고 응답하신 가장 큰 이유**는 무엇입니까? **구체적으로 하나만 응답**해 주십시오.

69-71 답란 : ______________________________

문2-4. 귀하께서는 환경 보호가 우리의 삶에 **어느 정도 중요**하다고 생각하십니까?
72

전혀 중요하지 않다	중요하지 않은 편이다	보통이다	중요한 편이다	매우 중요하다
1	2	3	4	5

문2-5. 귀하께서는 다음에 제시된 환경관련 마크에 대해 **어느 정도 알고**계십니까? 환경마크를 보시고 **해당 번호에 O표**해 주십시오.

	전혀 모른다	모르는 편이다	보통이다	잘 아는 편이다	매우 잘 안다	
1. 재활용 가능 마크 (이 종이는 재활용이 가능합니다.)	1	2	3	4	5	73
2. 에너지소비효율등급 마크	1	2	3	4	5	74
3. 분리배출 마크 (분리배출 분리배출 분리배출 분리배출 분리배출 분리배출)	1	2	3	4	5	75
4. 환경표지(환경마크) 인증마크	1	2	3	4	5	76
5. 우수재활용(GR)인증 마크 (Good Recycled)	1	2	3	4	5	77
6. 환경성적표지인증 마크 (EDP)	1	2	3	4	5	78
7. 신재생에너지 마크 (신·재생에너지 New & Renewable Energy)	1	2	3	4	5	79

문2-6. 이러한 환경관련 마크가 귀하의 상품 구매에 **어느 정도 영향**을 미친다고 생각하십니까?
80

전혀 중요하지 않다	중요하지 않은 편이다	보통이다	중요한 편이다	매우 중요하다
1	2	3	4	5

D. 신재생에너지 공급 의무화(RPS) 정책 수용도 조사

다음은 신재생에너지 공급의무화(RPS) 정책에 대한 질문입니다. 먼저, 아래 설명을 잘 읽어 주시기 바랍니다.

신재생에너지 공급의무화(RPS) 정책 : 전기 분야
① 배경 : 높은 발전단가로 경제성이 매우 취약하여 신재생에너지 보급 및 확대가 더딘 상황에 대한 해결방안
② 내용 : 일정규모 이상의 발전설비를 보유한 발전 사업자(한국수자원자력 등 총 14개 사업자)에게 총 발전량의 일정량 이상을 신재생에너지로 생산한 전력을 공급하도록 의무화한 제도로, 의무량 미달시 과징금을 부과함 (2012년부터 시행)
③ 장점 : 온실가스 배출 감축, 신재생에너지 산업의 성장으로 인한 고용창출 및 에너지 수입 감소에 따른 에너지 자립도 향상 등
④ 단점 : 정전 가능성 증가, 산림훼손 문제 및 전기요금 상승으로 인한 소비자 부담 가중 문제 등

문4-1. 귀 댁의 **월 평균 전기요금**은 대략 얼마나 됩니까? (※ 일반적으로 4인 가족 월 전기요금은 평균 4만5천원 수준입니다.)
C05-8

월 평균 전기요금은 대략 ☐백 ☐십 ☐만 ☐천원 수준임.

문4-2. 그럼, 귀하께서 생각하시기에 신재생에너지 공급 의무화(RPS) 정책의 대상으로 **가장 적합한 신재생에너지**는 무엇입니까? 다음 답란에 **순서대로 3개까지 응답**해 주십시오.

1위	9-10	2위	11-12	3위	13-14

1. 연료전지
2. 석탄 가스화/액화
3. 수소 에너지
4. 태양열
5. 태양광
6. 바이오에너지
7. 풍력에너지
8. 수력에너지
9. 폐기물에너지
10. 지열에너지
11. 해양에너지

문4-3. 신재생에너지 공급의무화(RPS) 정책이 본격 시행되면 기존 대비 발전단가가 높은 신재생에너지원 사용 비율이 높아지게 되며,
15
귀 댁에서 사용하는 **전기요금이 인상될 수** 있습니다. 이러한 전기요금 인상분을 반영하는 방법은 '**전기요금 총괄원가에 반영**'하는 방법과 '**신재생에너지 관련 전기요금 항목을 신설**'하는 방법 등 2가지가 있습니다.

전기요금 총괄원가에 반영	기존에 부담하는 전기요금(고지서)과 형식상의 차이는 없으며, 일정 정도의 전기요금 부과 금액이 상승함	두 방식 간 요금차이는 없음
신재생에너지 관련 전기요금 항목 신설	신재생에너지 공급의무화(RPS) 제도 의무이행 비용 등의 항목을 기존 전기요금에 추가하여 별도로 징수함	

귀하께서는 전기요금 총괄원가에 반영하는 방법과 신재생에너지 관련 전기요금 항목을 신설하는 방법 중, **무엇을 더 선호**하십니까?

1. 전기요금 총괄원가에 반영
2. 신재생에너지 관련 전기요금 항목 신설
3. 어떤 방식도 상관없다

다음은 신재생에너지 공급의무화(RPS) 정책 유형별 선호도에 대한 질문입니다.

지금부터 각 질문별로 4가지(비선택 포함) 유형의 신재생에너지 공급의무화(RPS) 정책이 동시에 제시되며, 제시된 신재생에너지 공급의무화(RPS) 정책은 다음과 같이 5가지 특성을 조합하여 만든 서로 다른 유형의 정책입니다. 우선, 아래 신재생에너지 공급의무화(RPS) 정책의 5가지 특성 설명을 잘 숙지해 주시기 바랍니다.

■ 신재생에너지 공급의무화(RPS) 정책 속성 및 수준 설명문

속성		속성 설명 및 수준
1. 전기요금 상승	설명	· 발전 사업자는 신재생에너지 공급 의무비율을 충족시키기 위해 발전단가가 높은 신재생 에너지원 발전량을 늘리게 되며, 이에 따라 전체적인 발전 비용이 증가함. · 발전 비용 증가로, 소비자의 전기요금이 일정부분 인상됨.
	수준 (3개)	① 2% 상승 (월 전기료 5만원 기준, 1,000원 추가 부담) ② 6% 상승 (월 전기료 5만원 기준, 3,000원 추가 부담) ③ 10% 상승 (월 전기료 5만원 기준, 5,000원 추가 부담)
2. 온실가스 (CO_2) 배출 감소량	설명	· 신재생에너지 공급의무화(RPS) 정책에 따라 발전 사업자는 전체 발전량 중, 일정비율을 온실가스 배출량이 적은 신재생에너지원으로 구성해야 함. · 온실가스 배출량이 감소하면, 기상재해, 생태계 파괴, 대기오염이 줄어들 뿐만 아니라 대기오염 감소로 인한 기관지, 호흡기 및 눈, 피부 질병 감소 등의 국민건강증진 효과도 가져올 것으로 기대됨.
	수준 (3개)	① 3% 감소 /년 (1,800만톤 CO_2 eq 감소) ② 5% 감소 /년 (3,000만톤 CO_2 eq 감소) ③ 7% 감소 /년 (4,200만톤 CO_2 eq 감소) *※eq는 이산화탄소 환산 배출량 단위임.*
3. 고용창출 효과 (실업률 감소)	설명	· 발전 사업자는 신재생에너지원을 도입해야하므로, 신재생에너지 산업이 성장, 확대되는 효과를 가져오게 되며, 신재생에너지 관련 R&D인력, 관리인력 등에 대한 고용이 창출되고 실업률이 감소하는 효과가 나타날 것으로 예상됨.
	수준 (3개)	① 1만명 추가 고용창출 /년 (실업률 0.04% 감소) ② 2만명 추가 고용창출 /년 (실업률 0.08% 감소) ③ 3만명 추가 고용창출 /년 (실업률 0.12% 감소)
4. 연간 정전시간	설명	· 신재생에너지 발전설비는 발전단가가 높고 건설 기간이 길 뿐만 아니라, 기후환경 변화에 따라 전력 공급 지장을 초래하여 공급 불확실성이 기존 화석연료에 비해 높음. · 따라서, 신재생에너지 비율이 높아지면 전력수급에 적절히 대응을 하지 못하여 정전 발생 가능성이 일정 부분 높아질 수 있음.
	수준 (3개)	① 총 10분 내외 /년 ② 총 30분 내외 /년 ③ 총 50분 내외 /년
5. 산림훼손 (부지문제)	설명	· 신재생에너지원 발전은 기존 발전방식 대비 넓은 부지를 필요로 함. 따라서, 신재생에너지 발전량 확대는 산림이 훼손되는 결과를 가져올 수 있음. · 예를 들면, 100만 kW 발전을 위해서 태양광은 약 1천만평(여의도 면적의 11.5배), 풍력은 약 5천만평(여의도 면적의 57.5배), 원자력은 22.8만평(여의도 면적의 0.26배)의 면적을 필요로 함.
	수준 (3개)	① 1억 6천만평(530km^2) 산림훼손 /년 (여의도 면적의 180배) ② 2억평(660km^2) 산림훼손 /년 (여의도 면적의 230배) ③ 2억 4천만평(790km^2) 산림훼손 /년 (여의도 면적의 270배)

지금부터 설명드린 5가지 특성을 조합하여 구성한 **3가지 유형의 신재생에너지 공급의무화(RPS) 정책이 동시에 제시**됩니다.
귀하께서는...
① 우선, 제시된 **3가지 유형**의 신재생에너지 공급의무화(RPS) 정책 중, **선호하는 순서대로 순위를 응답**해 주시고,
② 비선택 포함한, **4가지 유형**의 신재생에너지 공급의무화(RPS) 정책 중, **가장 선호하는 정책 하나에 O표**해 주시면 됩니다.
※ 제시한 5개의 속성 이외의 **모든 다른 속성은 서로 동일한 것으로 가정**하고 응답해 주십시오.

문5. 다음 제시된 신재생에너지 공급의무화(RPS) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 O표**해 주십시오.

■ **신재생에너지 공급의무화(RPS) 정책 선호도 질문 1**

정책 특성	정책 A	정책 B	정책 C	비선택
1. 전기요금 상승	2% 상승 (월 전기료 5만원 기준, 1,000원 추가 부담)	6% 상승 (월 전기료 5만원 기준, 3,000원 추가 부담)	6% 상승 (월 전기료 5만원 기준, 3,000원 추가 부담)	선택하지 않음 (정책 불필요)
2. 온실가스(CO2) 배출 감소량	7% 감소 /년 (4,200만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	7% 감소 /년 (4,200만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	3만명 추가 고용창출 /년 (실업률 0.12% 감소)	2만명 추가 고용창출 /년 (실업률 0.08% 감소)	3만명 추가 고용창출 /년 (실업률 0.12% 감소)	
4. 연간 정전시간	총 50분 내외 /년	총 10분 내외 /년	총 30분 내외 /년	
5. 산림훼손(부지문제)	2억평 (660km2) 산림훼손 /년 (여의도 면적의 230배)	2억평 (660km2) 산림훼손 /년 (여의도 면적의 230배)	1억 6천만평 (530km2) 산림훼손 /년 (여의도 면적의 180배)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 19	**정책 A**	**정책 B**	**정책 C**	**비선택**

문5. 다음 제시된 신재생에너지 공급의무화(RPS) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 ○표**해 주십시오.

■ 신재생에너지 공급의무화(RPS) 정책 선호도 질문 2

정책 특성	정책 A	정책 B	정책 C	비선택
1. **전기요금 상승**	10% 상승 (월 전기료 5만원 기준, 5,000원 추가 부담)	10% 상승 (월 전기료 5만원 기준, 5,000원 추가 부담)	6% 상승 (월 전기료 5만원 기준, 3,000원 추가 부담)	
2. **온실가스(CO2) 배출 감소량**	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	7% 감소 /년 (4,200만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	
3. **고용창출 효과(실업률 감소)**	3만명 추가 고용창출 /년 (실업률 0.12% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	3만명 추가 고용창출 /년 (실업률 0.12% 감소)	선택하지 않음 (정책 불필요)
4. **연간 정전시간**	총 10분 내외 /년	총 30분 내외 /년	총 50분 내외 /년	
5. **산림훼손(부지문제)**	2억 4천만평 (790km2) 산림훼손 /년 (여의도 면적의 270배)	2억평 (660km2) 산림훼손 /년 (여의도 면적의 230배)	1억 6천만평 (530km2) 산림훼손 /년 (여의도 면적의 180배)	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) [23]	**정책 A**	**정책 B**	**정책 C**	**비선택**

■ 신재생에너지 공급의무화(RPS) 정책 선호도 질문 3

정책 특성	정책 A	정책 B	정책 C	비선택
1. **전기요금 상승**	2% 상승 (월 전기료 5만원 기준, 1,000원 추가 부담)	2% 상승 (월 전기료 5만원 기준, 1,000원 추가 부담)	10% 상승 (월 전기료 5만원 기준, 5,000원 추가 부담)	
2. **온실가스(CO2) 배출 감소량**	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	3% 감소 /년 (1,800만 톤 CO2 eq 감소)	7% 감소 /년 (4,200만 톤 CO2 eq 감소)	
3. **고용창출 효과(실업률 감소)**	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	3만명 추가 고용창출 /년 (실업률 0.12% 감소)	2만명 추가 고용창출 /년 (실업률 0.08% 감소)	선택하지 않음 (정책 불필요)
4. **연간 정전시간**	총 30분 내외 /년	총 10분 내외 /년	총 10분 내외 /년	
5. **산림훼손(부지문제)**	1억 6천만평 (530km2) 산림훼손 /년 (여의도 면적의 180배)	2억평 (660km2) 산림훼손 /년 (여의도 면적의 230배)	1억 6천만평 (530km2) 산림훼손 /년 (여의도 면적의 180배)	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) [27]	**정책 A**	**정책 B**	**정책 C**	**비선택**

E. 신재생연료 공급의무화(RFS) 정책 수용도 조사

다음은 신재생연료 공급의무화(RFS) 정책에 대한 질문입니다. 먼저, 아래 설명을 잘 읽어 주시기 바랍니다.

신재생연료 공급의무화(RFS) 정책 : 운송연료 분야

① 배경 : 화석연료 소비의 증가로 지구온난화 문제가 심각히 대두되고 있으며, 이에 대응하기 위한 신재생에너지 보급촉진 정책

② 내용 : 바이오에탄올, 바이오디젤 등 바이오 연료를 화석연료에 일정비율 이상 의무적으로 혼합하여 사용하도록 하는 제도로, 정유회사와 석유 수출입 업체 등 자동차 연료 공급업체를 대상으로 주로 바이오에탄올, 바이오디젤, 바이오가스를 각각 휘발유, 경유, 천연가스에 혼합하여 사용하도록 의무화하는 제도입니다.(우리나라는 2014년 이후 시행을 검토 중이며, 미국 및 유럽의 여러 국가에서는 현재 시행 중임)

③ 장점 : 바이오 연료 생산 과정의 친환경성으로, 온실가스 배출 감축효과, 바이오 연료 산업의 성장으로 인한 고용창출 효과, 화석연료 수입 감소에 따른 에너지 안보 증가 등의 긍정적인 효과 등

④ 단점 : 바이오 연료는 옥수수, 콩, 사탕수수 등의 농작물을 주원료로 하므로, 제도가 시행되면 농작물에 대한 추가 수요가 발생하여 설탕 및 농산물 가격 상승으로 식료품비 지출이 증가하며, 연료 생산비용 상승으로 연료 가격이 상승하여 운송요금 등이 오름

문7-1. 외식비를 제외한, 귀하 가구의 **월 식료품비**는 대략 얼마나 됩니까?
37-40 (※ 일반적으로 4인 가족의 월 식료품비는 평균 30만원 수준입니다.)

월 평균 식료품비는 대략 ☐ 백 ☐ 십 ☐ 만 ☐ 천원 수준임.

문7-2. 그럼, 귀하 가구의 월 식료품비 중, **채소/해조류 및 곡류/식빵 품목에 지출하는 비용**은 대략 얼마나 됩니까?
41-44 (※ 일반적으로 4인 가족의 월 채소/해조류 및 곡류/식빵 품목 지출 비용은 평균 10만원 수준입니다.)

월 평균 대략 ☐ 백 ☐ 십 ☐ 만 ☐ 천원 수준임.

문7-3. 귀하 가구의 **월 교통비(자동차 유류비, 대중교통 요금 등)**는 대략 얼마나 됩니까?
45-48 (※ 일반적으로 4인 가족의 월 교통비는 평균 26만원 수준입니다.)

월 평균 교통비는 대략 ☐ 백 ☐ 십 ☐ 만 ☐ 천원 수준임.

다음은 신재생연료 공급의무화(RFS) 정책 유형별 선호도에 대한 질문입니다.

지금부터 각 질문별로 4가지(비선택 포함) 유형의 신재생연료 공급의무화(RFS) 정책이 동시에 제시되며, 제시된 신재생연료 공급의무화(RFS) 정책은 다음과 같이 **5가지 특성을 조합하여 만든 서로 다른 유형의 정책**입니다. 우선, 아래 신재생에너지 연료 의무화(RFS) 정책의 5가지 특성 설명을 잘 숙지해 주시기 바랍니다.

▣ 신재생연료 공급의무화(RFS) 정책 속성 및 수준 설명문

속성		속성 설명 및 수준
1. (운송)요금 상승	설명	• 바이오 연료를 사용함에 따라 (운송) 요금이 오르는 수준을 의미함. • 바이오 연료의 생산 원가는 주원료인 옥수수 등을 비롯한 각종 식량 가격 및 가공 비용에 의해 결정되며, 일반적으로 주원료 가격과 가공 비용이 높아 생산 원가가 기존 화석 연료에 비해 높은 편임. (이러한 비용은 소비자가 부담하게 되어, (운송) 요금이 현재 수준에 비해 높아질 수 있음.)
	수준 (3개)	① 20원 상승 /리터 ② 60원 상승 /리터 ③ 100원 상승 /리터
2. 온실가스 (CO2) 배출 감소량	설명	• 바이오 연료를 혼합 사용했을 시 감축되는 온실가스 비율을 의미함. • 공기 중 온실가스 및 대기오염 물질이 감소하게 되면 기상재해, 생태계 파괴가 줄어들 뿐만 아니라 기관지염, 폐렴 등의 각종 호흡기 질환과 눈 및 피부 질환 발생률을 낮출 수 있음.
	수준 (3개)	① 3% 감소 /년(1,800만톤 CO2 eq 감소) ② 5% 감소 /년(3,000만톤 CO2 eq 감소) ③ 7% 감소 /년(4,200만톤 CO2 eq 감소) *※eq는 이산화탄소 환산 배출량 단위임.*
3. 고용창출 효과 (실업률 감소)	설명	• 제도 시행으로 예상되는 연간일자리 창출 수준을 의미함. • 바이오 연료에 대한 수요가 증가함에 따라, 주원료인 옥수수, 유채 등의 식물 재배와 가공 과정에 투입될 추가 인력이 필요하게 되는 등 관련 산업이 활성화되어 일자리가 창출되고 실업률이 감소하는 결과를 기대할 수 있음.
	수준 (3개)	① 0.5만명 추가 고용창출 /년(실업률 0.02% 감소) ② 1.0만명 추가 고용창출 /년(실업률 0.04% 감소) ③ 1.5만명 추가 고용창출 /년(실업률 0.06% 감소)
4. 농작물 가격 상승으로 인한 식료품비 지출 (채소/곡류) 증가	설명	• 제도를 시행함으로써 식료품비 지출이 증가하는 정도를 의미함. • 바이오 연료의 주원료는 옥수수, 콩, 사탕수수 등의 농작물으로, 바이오 연료 생산으로 농작물에 대한 추가 수요가 발생하여 농작물 및 설탕 가격이 상승할 가능성이 있음.
	수준 (3개)	① 2% 상승(월 10만원 기준, 2천원 추가 부담) ② 6% 상승(월 10만원 기준, 6천원 추가 부담) ③ 10% 상승(월 10만원 기준, 1만원 추가 부담)
5. 기존대비 연료 효율	설명	• 기존 화석 연료 대비 바이오 연료의 리터당 연료 효율 수준을 의미함. • 현재 기술 수준으로는 화석연료 대비 바이오 연료의 효율이 낮아 일정정도 연비가 떨어질 수 있음.
	수준 (3개)	① 2% 감소 (기존 대비 연료효율 2% 낮음) ② 5% 감소 (기존 대비 연료효율 5% 낮음) ③ 8% 감소 (기존 대비 연료효율 8% 낮음)

지금부터 설명드린 5가지 특성을 조합하여 구성한 **3가지 유형의 신재생연료 공급의무화(RFS) 정책이 동시에 제시**됩니다.
귀하께서는...
① 우선, 제시된 **3가지 유형**의 신재생연료 공급의무화(RFS) 정책 중, **선호하는 순서대로 순위를 응답**해 주시고,
② 비선택 포함한, **4가지 유형**의 신재생연료 공급의무화(RFS) 정책 중, **가장 선호하는 정책 하나에 O표**해 주시면 됩니다.
※ 5개의 속성 이외의 **모든 다른 속성은 서로 동일한 것으로 가정**하고 응답해 주십시오.

문8. 다음 제시된 신재생연료 공급의무화(RFS) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 O표**해 주십시오.

■ 신재생연료 공급의무화(RFS) 정책 선호도 질문 1

정책 특성	정책 A	정책 B	정책 C	비선택
1. (운송) 요금 상승	60원 상승 /리터	100원 상승 /리터	100원 상승/리터	선택하지 않음 (정책 불필요)
2. 온실가스(CO2) 배출 감소량	3% 감소 /년 (1,800만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	
4. 농작물 가격 상승으로 인한 식료품비(채소/곡류) 지출증가	10% 상승 (월 10만원 기준, 10,000원 추가 부담)	6% 상승 (월 10만원 기준, 6,000원 추가 부담)	10% 상승 (월 10만원 기준, 10,000원 추가 부담)	
5. 기존 대비 연료 효율	2% 감소 (기존 대비 연료효율 2% 낮음)	5% 감소 (기존 대비 연료효율 5% 낮음)	2% 감소 (기존 대비 연료효율 2% 낮음)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 52	**정책 A**	**정책 B**	**정책 C**	**비선택**

■ 신재생연료 공급의무화(RFS) 정책 선호도 질문 2

정책 특성	정책 A	정책 B	정책 C	비선택
1. (운송) 요금 상승	20원 상승 /리터	60원 상승 /리터	20원 상승 /리터	선택하지 않음 (정책 불필요)
2. 온실가스(CO2) 배출 감소량	7% 감소 /년 (4,200만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	5% 감소 /년 (3,000만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	0.5만명 추가 고용 창출 /년 (실업률 0.02% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	
4. 농작물 가격 상승으로 인한 식료품비(채소/곡류) 지출증가	10% 상승 (월 10만원 기준, 10,000원 추가 부담)	6% 상승 (월 10만원 기준, 6,000원 추가 부담)	2% 상승 (월 10만원 기준, 2,000원 추가 부담)	
5. 기존 대비 연료 효율	5% 감소 (기존 대비 연료효율 5% 낮음)	2% 감소 (기존 대비 연료효율 2% 낮음)	5% 감소 (기존 대비 연료효율 5% 낮음)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 56	**정책 A**	**정책 B**	**정책 C**	**비선택**

문8. 다음 제시된 신재생연료 공급의무화(RFS) 정책 중 귀하께서 ① **선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 ○표**해 주십시오.

▣ 신재생연료 공급의무화(RFS) 정책 선호도 질문 3

정책 특성	정책 A	정책 B	정책 C	비선택
1. (운송) 요금 상승	20원 상승 /리터	100원 상승 /리터	60원 상승 /리터	선택하지 않음 (정책 불필요)
2. 온실가스(CO_2) 배출 감소량	3% 감소 /년 (1,800만 톤 CO_2 eq 감소)	3% 감소 /년 (1,800만 톤 CO_2 eq 감소)	3% 감소 /년 (1,800만 톤 CO_2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	
4. 농작물 가격 상승으로 인한 식료품비(채소/곡류) 지출증가	6% 상승 (월 10만원 기준, 6,000원 추가 부담)	2% 상승 (월 10만원 기준, 2,000원 추가 부담)	6% 상승 (월 10만원 기준, 6,000원 추가 부담)	
5. 기존 대비 연료 효율	8% 감소 (기존 대비 연료효율 8% 낮음)	8% 감소 (기존 대비 연료효율 8% 낮음)	5% 감소 (기존 대비 연료효율 5% 낮음)	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) 60	**정책 A**	**정책 B**	**정책 C**	**비선택**

F. 신재생 열에너지 공급의무화(RHO) 정책 수용도 조사

다음은 신재생 열에너지 공급의무화(RHO) 정책에 대한 질문입니다. 먼저, 아래 설명을 잘 읽어 주시기 바랍니다.

신재생 열에너지 공급의무화(RHO) 정책 : 난방 분야

① 냉·난방 등 열에너지 생산 시, 태양열, 지열, 바이오에너지 등의 신재생 에너지를 일정량 이상 사용하도록 하는 제도

② 현재 대부분의 냉·난방 시스템은 주로 가스나 등유, 전기 등의 에너지원을 이용하고 있지만, 신재생 열에너지 공급의무화 정책이 시행될 경우 의무대상에 해당되는 사업자는 기존 사용 에너지원을 이용한 냉·난방 시스템과 신재생 에너지원을 이용한 냉·난방 시스템을 모두 갖추어야 합니다. (독일에서 2009년부터 시행되고 있고, 최근 우리나라 정부 역시 도시가스 사업자, 지역난방공사 등 난방사업자에게 공급 의무를 부과하는 안과 일정크기 이상 건물의 소유주에게 의무를 부과하는 안 중 어떤 것을 시행할지에 대해 검토하고 있음.)

③ 난방사업자에게 공급 의무를 부과하는 경우, 신재생 에너지를 이용한 냉·난방 시스템 설치를 위한 비용이 도시가스 및 지역난방을 공급받는 최종 소비자에게 전가되어 난방요금이 상승할 수 있습니다.

④ 건물 소유주에게 공급의무를 부과하는 경우, 건물 소유주가 신재생 에너지를 이용한 냉·난방 시스템 설치비용을 전담하게 됩니다.

문10. 귀하의 가구의 **월 평균 난방비용**은 대략 얼마나 됩니까?

D05-8 (※ 일반적으로 4인 가족 기준 월 난방비용은 평균 10만원 수준입니다.)

월 평균 난방비는 대략 ☐ 백 ☐ 십 ☐ 만 ☐ 천원 수준임.

먼저, 난방사업자에게 의무가 부과되는 신재생 열에너지 공급의무화(RHO) 정책 유형별 선호도에 대한 질문입니다.

지금부터 각 질문별로 4가지(비선택 포함) 유형의 신재생 열에너지 공급의무화(RHO) 정책이 동시에 제시되며, 제시된 신재생 열에너지 공급의무화(RHO) 정책은 다음과 같이 4가지 특성을 조합하여 만든 서로 다른 유형의 정책입니다. 우선, 아래 신재생 열에너지 공급의무화(RHO) 정책의 5가지 특성 설명을 잘 숙지해 주시기 바랍니다.

■ 신재생 열에너지 공급의무화(RHO) 정책 속성 및 수준 설명문

속성		속성 설명 및 수준
1. 난방비 상승	설명	- 난방사업자로부터 난방을 공급받는 가정 및 상업건물의 난방요금이 오르는 정도를 의미함. - 도시가스 사업자, 지역난방공사가 신재생 에너지원을 이용한 냉·난방 시스템을 의무적으로 갖추게 됨에 따라 추가적인 설비 투자비용이 발생할 수 있으며, 따라서, 열 생산비용이 증가되므로, 난방을 공급받는 소비자가 내야 하는 요금이 현재 수준에서 증가할 수 있음.
	수준 (3개)	① 5% 상승 /월 (월 10만원 기준 5,000원 상승) ② 10% 상승 /월 (월 10만원 기준 10,000원 상승) ③ 15% 상승 /월 (월 10만원 기준 15,000원 상승)
2. 온실가스 (CO2) 배출 감소량	설명	- 난방에서 신재생에너지를 의무적으로 사용함에 따라 연간 온실가스 배출이 감소하는 정도를 의미함. - 온실가스 배출이 감소하면 지구 온난화 및 기후변화 속도를 경감할 수 있으며, 대기오염으로 인한 질병이 감소하는 등 국민 개개인의 건강이 증대되는 효과를 기대할 수 있음.
	수준 (3개)	① 0.5% 감소 /년(300만톤 CO2 eq 감소) ② 1.0% 감소 /년(600만톤 CO2 eq 감소) ③ 1.5% 감소 /년(900만톤 CO2 eq 감소) *※eq는 이산화탄소 환산 배출량 단위임.*
3. 고용창출 효과 (실업률 감소)	설명	- 신재생 에너지에 대한 수요가 증대됨에 따라, 신재생에너지 시장 활성화와 신산업 창출로 인해 기대되는 연간 일자리 창출수준을 의미함. - 매년 일자리가 새로 생김에 따라 실업률이 감소하는 결과를 기대할 수 있음.
	수준 (3개)	① 0.5만명 추가 고용창출 /년(실업률 0.02% 감소) ② 1.0만명 추가 고용창출 /년(실업률 0.04% 감소) ③ 1.5만명 추가 고용창출 /년(실업률 0.06% 감소)
4. 난방 에너지원의 안정적 공급	설명	- 신재생 난방에너지원의 연료 수급 문제로 인해 난방이 불안정해질 가능성이 있음. - 예를 들어, 특정 신재생에너지원의 수요가 폭등하면 공급량 부족이 발생할 수 있어 제때에 연료를 공급받지 못할 가능성이 존재함.
	수준 (2개)	① 안정 (기존과 같이 안정적으로 연료를 공급받을 수 있는 상황) ② 불안정 (기존에 비해 연료 공급에 문제가 발생해 가끔 난방이 중단될 수 있는 상황)

지금부터 설명드린 4가지 특성을 조합하여 구성한 **3가지 유형의 신재생 열에너지 공급의무화(RHO) 정책이 동시에 제시**됩니다.
귀하께서는...
① 우선, 제시된 **3가지 유형**의 신재생 열에너지 공급의무화(RHO) 정책 중, **선호하는 순서대로 순위를 응답**해 주시고,
② 비선택 포함한, **4가지 유형**의 신재생 열에너지 공급의무화(RHO) 정책 중, **가장 선호하는 정책 하나에 ○표**해 주시면 됩니다.
※ 4개의 속성 이외의 **모든 다른 속성은 서로 동일한 것으로 가정**하고 응답해 주십시오.

문11. 다음 제시된 신재생 열에너지 공급의무화(RHO) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 ○표**해 주십시오.

■ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 1

정책 특성	정책 A	정책 B	정책 C	비선택
1. 난방비 상승	15% 상승 /월 (10만원 기준, 15,000원 상승)	10% 상승 /월 (10만원 기준, 10,000원 상승)	5% 상승 /월 (10만원 기준, 5,000원 상승)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	1.5% 감소 /년 (900만 톤 CO2 eq 감소)	1% 감소 /년 (600만 톤 CO2 eq 감소)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	
4. 난방에너지원의 안정적 공급	안정	불안정	불안정	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) 12	정책 A	정책 B	정책 C	비선택

■ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 2

정책 특성	정책 A	정책 B	정책 C	비선택
1. 난방비 상승	10% 상승 /월 (10만원 기준, 10,000원 상승)	5% 상승 /월 (10만원 기준, 5,000원 상승)	5% 상승 /월 (10만원 기준, 5,000원 상승)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	1.5% 감소 /년 (900만 톤 CO2 eq 감소)	1% 감소 /년 (600만 톤 CO2 eq 감소)	1% 감소 /년 (600만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	0.5만명 추가 고용창출 /년 (실업률 0.02% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	0.5만명 추가 고용창출 /년 (실업률 0.02% 감소)	
4. 난방에너지원의 안정적 공급	안정	불안정	안정	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) 16	정책 A	정책 B	정책 C	비선택

■ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 3

정책 특성	정책 A	정책 B	정책 C	비선택
1. 난방비 상승	5% 상승 /월 (10만원 기준, 5,000원 상승)	10% 상승 /월 (10만원 기준, 10,000원 상승)	15% 상승 /월 (10만원 기준, 15,000원 상승)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	1.5% 감소 /년 (900만 톤 CO2 eq 감소)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	0.5만명 추가 고용창출 /년 (실업률 0.02% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	
4. 난방에너지원의 안정적 공급	안정	불안정	안정	
가장 선호하는 정책 (4개 정책중, 하나에 ○표) 20	정책 A	정책 B	정책 C	비선택

다음은 건물주에게 의무가 부과되는 신재생 열에너지 공급의무화(RHO) 정책 유형별 선호도에 대한 질문입니다.

지금부터 각 질문별로 4가지(비선택 포함) 유형의 신재생 열에너지 공급의무화(RHO) 정책이 동시에 제시되며, 제시된 신재생 열에너지 공급의무화(RHO) 정책은 다음과 같이 5가지 특성을 조합하여 만든 서로 다른 유형의 정책입니다. 우선, 아래 신재생 열에너지 공급의무화(RHO) 정책의 5가지 특성 설명을 잘 숙지해 주시기 바랍니다.

▣ 신재생 열에너지 공급의무화(RHO) 정책 속성 및 수준 설명문

속성		속성 설명 및 수준
1. (난방시설) 추가설치 비용	설명	- 건물주가 신재생 에너지를 이용한 냉·난방 시스템을 설치하기 위해 추가로 들어야 하는 비용을 25평 (약 83m²) 기준으로 환산한 금액임.
	수준 (3개)	① 600만원(25평; 83m² 기준) ② 700만원(25평; 83m² 기준) ③ 800만원(25평; 83m² 기준)
2. 온실가스 (CO2) 배출 감소량	설명	- 신재생에너지를 의무적으로 사용함에 따라 연간 온실가스 배출이 감소하는 정도를 의미함. - 온실가스 배출이 감소하면 지구 온난화 및 기후변화 속도를 경감할 수 있으며, 대기오염으로 인한 질병이 감소하는 등 국민 개개인의 건강이 증대되는 효과를 기대할 수 있음.
	수준 (3개)	① 0.5% 감소 /년(300만톤 CO2 eq 감소) ② 1.0% 감소 /년(600만톤 CO2 eq 감소) ③ 1.5% 감소 /년(900만톤 CO2 eq 감소) *※eq는 이산화탄소 환산 배출량 단위임*
3. 고용창출 효과 (실업률 감소)	설명	- 신재생 에너지 수요가 증대됨에 따라, 신재생에너지 시장 활성화와 신산업 창출로 인해 기대되는 연간 일자리 창출 수준을 의미함.
	수준 (3개)	① 0.5만명 추가 고용창출 /년(실업률 0.02% 감소) ② 1.0만명 추가 고용창출 /년(실업률 0.04% 감소) ③ 1.5만명 추가 고용창출 /년(실업률 0.06% 감소)
5. 투자비용 회수기간 (Payback period)	설명	- 신재생 에너지 이용 난방을 지속함에 따라 초기설비 투자비용을 회수하는데 걸리는 기간을 의미함. - 신재생 에너지를 이용한 난방설비를 갖추기 위해서는 설비 투자비용을 추가적으로 들여야 하지만, 신재생에너지 이용시 난방효율 상승으로 인해 장기적으로는 난방비가 감소하므로 일정 기간이 흐르면 설비투자비용을 회수할 수 있음.
	수준 (3개)	① 3년 ② 5년 ③ 7년
6. 초기 투자비용 보조금 수준	설명	- 신재생 에너지를 이용한 난방시스템 설치비용 중 국가가 보조금을 통해 지원하는 정도를 의미함.
	수준 (3개)	① 0%(보조금 없음) ② 25%(25평 기준 800만원 투자비 중 200만원 지원) ③ 50%(25평 기준 800만원 투자비 중 400만원 지원)

지금부터 설명드린 5가지 특성을 조합하여 구성한 **3가지 유형의 신재생 열에너지 공급의무화(RHO) 정책이 동시에 제시**됩니다.
귀하께서는...
① 우선, 제시된 **3가지 유형**의 신재생 열에너지 공급의무화(RHO) 정책 중, **선호하는 순서대로 순위를 응답**해 주시고,
② 비선택 포함한, **4가지 유형**의 신재생 열에너지 공급의무화(RHO) 정책 중, **가장 선호하는 정책 하나에 O표**해 주시면 됩니다.
※ 5개의 속성 이외의 **모든 다른 속성은 서로 동일한 것으로 가정**하고 응답해 주십시오.

문12. 다음 제시된 신재생 열에너지 공급의무화(RHO) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 O표**해 주십시오.

▣ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 1

정책 특성	정책 A	정책 B	정책 C	비선택
1. (난방시설)추가설치 비용	800만원 (25평, 83m²기준)	600만원 (25평, 83m²기준)	700만원 (25평, 83m²기준)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	1% 감소 /년 (600만 톤 CO2 eq 감소)	1% 감소 /년 (600만 톤 CO2 eq 감소)	1% 감소 /년 (600만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	0.5만명 추가 고용창출 /년 (실업률 0.02% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	
5. 투자비용 회수 기간	7년	7년	3년	
6. 초기 투자비용 보조금 수준	50% (25평 기준 800만원 투자비 중 400만원)	25% (25평 기준 800만원 투자비 중 200만원)	0% (보조금 없음)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 24	**정책 A**	**정책 B**	**정책 C**	**비선택**

▣ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 2

정책 특성	정책 A	정책 B	정책 C	비선택
1. (난방시설)추가설치 비용	800만원 (25평, 83m²기준)	600만원 (25평, 83m²기준)	800만원 (25평, 83m²기준)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	1.5% 감소 /년 (900만 톤 CO2 eq 감소)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	0.5만명 추가 고용창출 /년 (실업률 0.02% 감소)	
5. 투자비용 회수 기간	7년	7년	5년	
6. 초기 투자비용 보조금 수준	0% (보조금 없음)	50% (25평 기준 800만원 투자비 중 400만원)	25% (25평 기준 800만원 투자비 중 200만원)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 28	**정책 A**	**정책 B**	**정책 C**	**비선택**

문12. 다음 제시된 신재생 열에너지 공급의무화(RHO) 정책 중 귀하께서 **① 선호하는 순서대로 순위를 1위부터 3위까지 응답**해 주시고, 그 중, **가장 선호하는 정책 하나에 O표**해 주십시오.

▣ 신재생 열에너지 공급의무화(RHO) 정책 선호도 질문 3

정책 특성	정책 A	정책 B	정책 C	비선택
1. (난방시설)추가설치 비용	800만원 (25평, 83m²기준)	600만원 (25평, 83m²기준)	700만원 (25평, 83m²기준)	선택하지 않음 (정책 불필요)
2. 온실가스 배출 감소량(CO2)	1% 감소 /년 (600만 톤 CO2 eq 감소)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	0.5% 감소 /년 (300만 톤 CO2 eq 감소)	
3. 고용창출 효과(실업률 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	1.5만명 추가 고용창출 /년 (실업률 0.06% 감소)	1만명 추가 고용창출 /년 (실업률 0.04% 감소)	
5. 투자비용 회수 기간	3년	5년	3년	
6. 초기 투자비용 보조금 수준	25% (25평 기준 800만원 투자비 중 200만원)	50% (25평 기준 800만원 투자비 중 400만원)	50% (25평 기준 800만원 투자비 중 400만원)	
가장 선호하는 정책 (4개 정책중, 하나에 O표) 32	**정책 A**	**정책 B**	**정책 C**	**비선택**

G. 응답자 특성 (자료분류용 질문)

D1. 귀하께서는 귀댁의 **가구주 또는 가구주 부인**되십니까?
44

1. 가구주　　2. 가구주 부인　　3. 둘 다 아님

D2. 실례지만, **귀하의 직업**은 무엇입니까?
45-46

1. 자영업 (종업원 9명이하 소규모업소 주인/가족종사자)
2. 판매/서비스직 (상점점원, 세일즈맨 등)
3. 기능/숙련공 (운전사, 선반/목공, 숙련공 등)
4. 일반작업직 (토목 현장작업/청소/수위/육체노동 등)
5. 사무/기술직 (일반회사 사무직/기술직, 교사 등)
6. 경영/관리직 (5급 이상 공무원/기업체 부장 이상 등)
7. 전문/자유직 (대학교수/의사/변호사/예술가/종교가 등)
8. 전업주부
9. 학생
10. 무직
11. 기타 (적어 주십시오 : ____________________)

D3. 실례지만, 귀하께서는 **학교**를 어디까지 마치셨습니까?
47

1. 초등학교 졸업 이하　　2. 중학교 졸업　　3. 고등학교 졸업
4. 대학 재학/졸업　　5. 대학원 재학/졸업 이상

D4. 귀하께서는 **환경단체 또는 환경보호(에너지절약) 관련된 행사 등에 기부 또는 참여한 경험**이 있으십니까?
48

전혀 없다	거의 없다	보통이다	가끔 한다	자주 한다
1	2	3	4	5

D5. ① 현재 귀하와 **함께 살고 계신 가족**은 모두 몇 명입니까? 응답자 본인을 포함한 가족 수를 응답해 주십시오.
② 그럼, 그 중 **소득이 있는 가족**은 모두 몇 명입니까?
③ 귀하와 함께 살고 계신 가족 중, **65세 이상, 초중고생이나 미취학아동**은 각각 몇 명이나 됩니까?

구분		응답란
① 같이 살고 있는 가족 수 (응답자 본인 포함)		명 53
② 소득이 있는 가족 수		명 54
③ 기타 가족구성	- 65세 이상 가족 수	명 55
	- 초중고생 가족 수	명 56
	- 미취학 아동 가족 수	명 57

다음 D6.~D7-1.은 **귀 댁의 소득과 지출구조**에 따른 (앞서 응답하신) **신재생 에너지 정책별 지출의향에 대해 분석**하기 위한 질문으로, 다른 용도로는 절대 사용되지 않으니, 잘 모르시더라도 **대략적으로라도 응답** 부탁드립니다.

D6. 현재 귀 댁의 **월평균 소득 수준**은 얼마나 됩니까? 보너스, 이자수입 등 모든 수입을 합해서 다음 보기중 응답해 주십시오.
58-59

1. 월 99만원 이하
2. 월 100 - 199만원
3. 월 200 - 299만원
4. 월 300 - 399만원
5. 월 400 - 499만원
6. 월 500 - 599만원
7. 월 600 - 699만원
8. 월 700 - 799만원
9. 월 800 - 899만원
10. 월 900 - 999만원
11. 월 1,000만원 이상

D6-1. 그럼, 귀 댁의 월평균 소득 수준은 **구체적으로 얼마**나 됩니까? 앞에서 응답하신 소득 수준을 **구체적인 금액으로 응답**해 주십시오.
60-62

월 평균 소득수준 : ☐ 천 ☐ 백 ☐ 십 만원 정도

D7. 현재 귀 댁의 **월평균 지출 수준**은 얼마나 됩니까? 보너스, 저축은 제외한 **순수한 지출 수준**을 다음 보기중 응답해 주십시오.
63-64

1. 월 99만원 이하
2. 월 100 - 199만원
3. 월 200 - 299만원
4. 월 300 - 399만원
5. 월 400 - 499만원
6. 월 500 - 599만원
7. 월 600 - 699만원
8. 월 700 - 799만원
9. 월 800 - 899만원
10. 월 900 - 999만원
11. 월 1,000만원 이상

D7-1. 그럼, 귀 댁의 월평균 지출 수준은 **구체적으로 얼마**나 됩니까? 앞에서 응답하신 지출 수준을 **구체적인 금액으로 응답**해 주십시오.
65-67

월 평균 지출수준 : ☐ 천 ☐ 백 ☐ 십 만원 정도

D8. 귀하께서 살고 계신 **주택**은 다음 중 어디에 해당됩니까?
68-69

1. 단독주택
2. 다가구주택
3. 다세대/연립주택/빌라
4. 아파트
5. 오피스텔/상가주택
6. 기타 (적어 주십시오 : ____________)

D9. 귀하께서 살고 계신 **주택의 보유 형태**는 다음 중 어디에 해당됩니까?
70

1. 자가
2. 전세
3. 월세
4. 기타 (적어 주십시오 : ____________)

D10. 귀 댁에 **자가용을 보유**하고 계십니까? 영업용 차량이 아닌, 일반 승용차 기준으로 응답해 주십시오.
71

1. 예 (보유)
2. 아니오 (비보유) → **조사종료.끝까지 응답해 주셔서 대단히 감사합니다**

D10-1. 귀하께서는 자가용을 **직접 운전**하십니까? 영업용 차량이 아닌, 일반 승용차 기준으로 응답해 주십시오.
72

1. 예(운전)
2. 아니오(비운전)

Abstract (Korean)

혁신 활동은 빠르게 변화하는 현대 사회에서 적응하고 생존하기 위한 필수적이고도 확실한 요소이다. 혁신 정책은 이와 같은 혁신활동을 유발 및 촉진하기 위한 핵심 요인으로 간주되어 왔다. 지금까지 대부분의 혁신 정책은 공급 측면에 초점을 맞추어 신기술을 창출하고 확산시키는 데 주력해왔다. 그러나 근래에 들어 혁신의 원천으로서 수요의 역할이 주목 받게 됨에 따라 수요 지향형 혁신 정책의 중요성이 날로 강조되고 있다. 이러한 수요 지향형 혁신 정책의 관점에서, 국민수용성은 매우 중요한 고려사항이다. 왜냐하면 비록 해당 혁신 정책의 효과성과 유용성이 명확하더라도, 사회적 저항에 직면해 정책 추진이 지연 또는 무산될 수 있기 때문이다.

이러한 혁신 정책에 대한 국민수용성의 관점에서, 본 연구의 목적은 크게 두 가지이다. 첫째, 혁신 정책에 대한 사람들의 선호를 정량적으로 분석하고, 정책 속성 수준의 변화에 따른 국민수용성 수준을 예측한다. 이를 위해 선택 실험으로부터 획득한 진술선호 자료를 이산선택 모형의 일종인 혼합로짓 모형(mixed logit model)을 통해 분석한다. 둘째, 하나의 정책 범주 내에 포함되는 복수의 유사 정책들에 대한 사람들의 선호를 분석할 수 있는 통합적인 접근법을 제시하고 이를 실증분석에 적용한다. 많은 경우, 특정 부문의 포괄적인 정책 기조를 결정하기 위해선 정책 범주에 대한 사람들의 선호 구조를 이해할 필요가 있다. 이를 위해 본 연구는 개별 정책들에 대한 다양한 선택 실험 자료들을 통합한 후 타입 별로 분류하는 자료 분류 방법을

제안한다. 분류된 자료는 마찬가지로 이산선택 모형의 일종인 다변량 프로빗 모형(multivariate probit model)을 통해 분석한다.

실증 분석은 세 개의 신재생에너지 정책인 신재생에너지 공급의무화 제도 (RPS), 신재생연료 혼합의무화 제도 (RFS), 신재생열에너지 공급의무화 제도 (RHO)에 대해 수행되었다. 이 중 RHO는 열(생산)공급자에게 의무를 부과하는 방식(RHO 1안)과 신규건축물주에게 의무를 부과하는 방안(RHO 2안) 이렇게 두 가지 방식이 존재한다. 본 정책들은 전력, 수송, 난방 분야 내의 대표적인 신재생에너지 정책이다.

혼합 로짓 모형을 통한 개별 정책에 대한 국민수용성 및 선호 분석 결과는 다음과 같다. 응답자들은 정책 내의 가격 속성에 큰 중요성을 부여하고 있으며, 따라서 본 속성은 높은 국민수용성을 유지하기 위해 결정적인 역할을 한다. RPS의 경우, 전기요금 상승이 6% 이내로 억제될 경우 89.5%의 수용성 수준을 유지할 것으로 예측된다. RFS에 대한 수용성은 수송용 연료 가격이 0에서 45%까지 상승하면 91.2%에서 48.8%로 하락한다. RHO 1안의 경우, 난방 요금이 30% 상승하면 국민수용성은 60% 정도 수준일 것으로 나타났다. 국민수용성에 상당 부분 영향을 미칠 수 있는 기타 속성들은 고용창출(RPS), 난방공급 안정성(RHO 1안), 초기설치 보조금(RHO 2안)인 것으로 분석되었다. RFS의 경우 여타 속성의 중요성은 상대적으로 낮은 것으로 나타났다.

다변량 프로빗 모형을 통한 정책 범주에 대한 선호 분석 결과는 다음과 같다. 응답자들은 전반적으로 가격 상승이 작은 정책을 선호하는 것으로

보이며 따라서 에너지 가격 상승에 민감하게 반응하는 것으로 나타났다. 또한 신재생에너지 정책에 대한 사람들의 평균적인 선호도는 RHO 도입 방식(1안 또는 2안)에 따라 부분적으로 변할 수 있다. 실증 분석의 대상인 세 가지 신재생에너지 정책에 대한 응답자의 지식 수준과 환경친화적인 정책 타입 간에는 정의 관계에 있는 반면, 응답자의 환경 보호에 대한 태도는 그렇지 않은 것으로 나타났다. 따라서 신재생에너지 정책 도입에 따른 에너지 가격 상승에 대한 사회적 저항을 완화시키려면, 포괄적인 환경 보호에 대한 홍보보다는 해당 신재생에너지 정책에 대한 국민들의 이해도를 높일 수 있는 구체적인 전략 마련이 필요하다.

결론적으로 본 연구는 계량경제학적 방법론을 통해 혁신 정책에 대한 국민수용성을 정량화하는 동시에, 개별 정책들의 상위 개념인 정책 범주에 대한 사람들의 선호를 통합적으로 분석하였다. 본 연구의 프레임워크는 일반 대중에게 영향을 미치는 어떠한 혁신 정책에도 적용될 수 있다. 특히 자료 통합 및 분류법은 공통된 속성을 공유하는 어떠한 정책군 또는 제품군에도 적용될 수 있다는 장점을 지닌다.

주요어 : 혁신 정책, 국민 수용성, 진술 선호 기법, 선택 실험, 이산 선택 모형, 신재생에너지 정책
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