Master's Thesis in Business Administration

Preference Analysis on Electric Power Transmission Line Installation

- Focusing on the Heterogeneity of S. Korean Residents -

소비자의 이질성을 반영한 사회기반 시설의 선호 분석
: 한국의 송전선로 건설을 중심으로

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Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

Ji Hyun Kim

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지도교수 이종수

이 논문을 경영학석사학위 논문으로 제출함

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서울대학교 대학원

협동과정 기술경영경제정책 전공

김　　지　　현

김지현의 경영학석사학위 논문을 인준함

2017 년 7 월

위 원 장 ＿＿구 윤 모＿＿(인)

부위원장 ＿＿이 종 수＿＿(인)

위　　원 ＿＿신 정 우＿＿(인)

Abstract

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Kim Ji Hyun
Technology Management, Economics, and Policy Program
The Graduate School
Seoul National University

There are two primary methods of transmitting electricity: building transmission towers on mountainsides and/or in big fields, or installing high voltage transmission cables and distribution lines underground. Evidently, the growing demand for electricity and the difficulty of developing new electricity sources have augmented the need for transmission capabilities, which is best achieved by transmission at very high voltages. The benefit of grounding wires is that transmission towers – which are huge and hateful at sight – become unnecessary, and the surrounding landscape and the city scenery becomes more likable. However, the cost is much higher than for tower installation due to the necessity of having to construct and manage concrete tunnels underground for the wires to run through. Consequently, underground work has primarily been concentrated in large cities with high population density, leaving rural cities, especially those with budget constraints, relatively neglected.

This disparity has yielded arguments that when pursuing governmental projects that can lead to controversies, they must be promoted and implemented in ways that can minimize the imbalance between conflicting stakes and regional conditions.

In this paper, citizens' preference for power transmission cable installations in South Korea are analyzed, with a focus on individuals' innate and residential heterogeneity. In doing so, discrete choice models are utilized; specifically, the mixed logit model and the latent class model. Attributes such as the number of transmission towers, the electromagnetic field exposure, the number of blackouts, the duration of each blackout, and the additional electricity costs are considered in the choice experiment to identify residents' varying preference structures. The factors that represent individuals' innate heterogeneity, such as their perceived needs for the project, their attitude with regard to risk, and their city of residence, are also considered to enable further segmentation of consumers.

The results of this paper are expected to contribute in identifying the heterogeneous preferences of subjects for governmental projects, which may eventually help regional governments gain a greater understanding of target consumers' specific needs.

Keywords: Power transmission line, Discrete choice model, Mixed logit model, Latent class model, Heterogeneity, Infrastructure

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Chapter 1. Introduction

Electricity has become one of the most convenient sources of energy because not only that it is relatively easy to transport over large distances, but it can also easily be converted into other types and forms of energy. For these reasons, the electric power business has traditionally been a key national industry. Nevertheless, the demand for electricity has been steadily increasing due to the growth of nations as well as the industrialization of human civilization. There are two primary ways to transmit electricity: by building transmission towers on mountainsides and/or on big fields or by installing high voltage transmission cables and the distribution lines underground. Evidently, the growing demand for electricity combined with the difficulty of developing new electricity sources have augmented the need for transmission capability, which is best achieved by transmission at very high voltages.

Since transmission towers are large and unpleasant, the benefit of grounding the wires is that the surrounding landscape and the city scenery becomes more likable. However, the cost is much higher than it is for tower installation due to the necessity of having to construct and manage concrete tunnels underground for the wires to run through. Consequently, the underground work has primarily been concentrated in large cities with high population density, leaving rural cities, especially those with budget constraints, relatively neglected.

Over time, large 765-kV power transmission towers are naturally being built on mountains and in less-urbanized rural villages like Milyang, threatening the residents' health with greater exposure to electromagnetic waves. According to the KEPCO report in 2013, the nation's power transmission cable grounding rate was merely 10.6% as of February, while the actual transmission tower grounding rate is kept to be significantly different in metropolitan areas like Seoul and in rural areas. The grounding rate of Seoul reaches 88.1%, whereas the grounding rate of Incheon, Busan, Daegu, and Daejeon reaches 61.2%, 41.5%, 30.0%, and 27.9%, respectively. The grounding rate of other rural areas is far less, ranging between 0.8~2.5%, with Kyungbuk having the lowest rate of 0.9% specifically.

Not surprisingly, controversial issues regarding the transmission tower installation have surfaced, sometimes creating serious disputes. A representative case is that of Milyang, where the conflicts of interest between the local residents and KEPCO (Korea Electric Power Corporation) has even led to some extreme deaths of personnel. The basis of claims from both parties are solid, leaving little room for reconciliation. Thus, it is arguable that government projects that may lead to such controversies need to be promoted and implemented in ways that can minimize the imbalance of both the conflicting stakes and the regional conditions.

Since the perceived needs of individuals in varying regions regarding the transmission cable installation differ greatly, their heterogeneity should be fully considered in establishing such regional governmental projects. In this paper, citizens' preference on power transmission cable installation in South Korea is analyzed, focusing on individuals' innate and residential heterogeneity. In doing so, discrete choice models are used; specifically, the *mixed logit model* and the *latent class model*. The mixed logit model is first used to identify the heterogeneity in consumer preference on power transmission cable installation. The latent class model is then used to enable segmentation of consumers. Since the power transmission line installation projects are conducted at a national-level or a regional-level, the need for implications to be as well derived in a group-level is recognized, unlike the case of products that target individual consumers.

Factors such as an individual's perceived need for the project, attitudes towards risk, and the city of residence are considered. The results of this research will help identify the varying preferences of subjects of governmental projects, enabling regional governments to further understand the specific needs of consumers.

Chapter 2. Literature Review

2.1 Electric Power Transmission

2.1.1 Current State

Issues regarding electric power transmission have long raised world-wide interest, for the efficient transfers of energy not only foster economic growths, but also provide a basis of enabling convenient living conditions for its people. Energy is a vital resource and a necessity for a country to operate in a stable manner and to develop various industries that will eventually lead to national growth. Owing to this reality, energy issues have always been at the center of diplomacy. Naturally, conflicting interests regarding energy matters exist among different countries, between varying regions within a country, and even amongst individuals. Coming to an agreement and forming a consensus have always been the most difficult part of the compromising step, raising questions that are most often left unanswered.

Electricity, a commodity that can be produced and be consumed at the same time, cannot be economically stored, which creates the need to secure adequate reserve facilities for a stable power supply. In the case of South Korea, a country that is highly energy dependent on foreign countries (97%) and cannot import nor export electricity with neighboring countries due to its geographically isolated power system, it is a must to secure stable energy sources (KEPCO, 2016). Limitations also exist in the infrastructure of South Korea, for the production of electricity is concentrated in the southern region, whereas the consumption is highest in the metropolitan area. Thus, long-distance transportation is required, and because the demand is not well controlled by the market itself, huge investments in power plant construction are needed to secure the supply capacity (KEPCO, 2016).

Certainly, issues regarding electric power transmission have emerged at the center of disputes in South Korea over the past few years. Electric power transmission is defined as “the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation” (Edison Tech Center, 2015). The interconnected lines that facilitate this movement are known as a transmission network. There are two different ways to transmit electric power: overhead transmission, which incorporates the use of the transmission tower, and underground transmission methods. Although the benefits and drawbacks of each method are clear, there have been disputes about which method to use for the installation of new lines. Four main attributes that are regularly considered in the construction of power transmission lines are 1) efficiency, 2) safety, 3) cost, and 4) robustness (Alonso and Greenwell, 2013).

Although overhead power transmission lines are typically considered more economical, they are more susceptible to outside damages. The damages can cause extended power outages that in extreme cases cannot be restored for days or even weeks, which may cause billions of dollars to repair, and decrease customers’ utility through discomfort, anxiety and helplessness (Alonso and Greenwell, 2013). A benefit of grounding the wires is that the surrounding landscape and scenery becomes more pleasant, because large transmission towers are often unsightly and unnecessary. Health issues are also a concern, as some argue that electromagnetic fields from high-voltage transmission towers may cause harm to the health of nearby residents. Nevertheless, while technical developments have allowed advancements in the reliability of underground power, the costs of construction have not lowered significantly. The high cost of grounding the wires is due to trenching the earth along the line route, maintenance cost, and harder line modifications because it is difficult to access underground wires.

The benefits and drawbacks of the overhead and underground transmission line installation method are summarized in Table 1.

Table 1. Construction Types of Power Transmission Lines

	Overhead Method (Tower + Overhead Line)	Underground Method
Concepts	Construction of transmission towers at regular intervals to connect cables to the ground.	A method of burying the entire transmission line underground. Currently about 10% of the entire transmission lines in Korea are constructed in this method

Benefits	1. Compared to the underground method, the construction / maintenance cost are low. 2. Construction time is short. 3. The faults occurrence probability is low, and it is easy to find the fault points, enabling stable power supply.	1. It is less affected by natural disasters and less restricted in land use. 2. Aesthetics (scenery) of the area can be improved because the unwanted public facilities are not exposed. 3. Several lines can be installed underground, reducing the direct impact on residents.
Drawbacks	1. Land use is limited due to the construction of power transmission towers (about 200 ~ 250 m^2 per transmission tower is required), and the prices of land/ buildings may fall. 2. There is a possibility of infestation of the living environment, destruction of the ecosystem, and diseases caused by electromagnetic field (insomnia due to childhood leukemia / cancer, noise).	1. Construction costs and maintenance costs are higher (around 5 -14 times greater), and it takes a long time to construct the facilities 2. Although the probability of faults is lower than that of the method of geographical augmentation, it is difficult to detect a faulty point in case of a failure, and it takes a long time to recover.

Consequently, with regards to the factor of cost, the underground work has been concentrated on large cities with high population density, leaving rural cities, especially those with budget constraints, relatively neglected. For reference, the construction cost of major 765kV transmission line in South Korea is summarized in Table 2 below. The government plans to construct a new transmission line with a total length of 3,450 km by the year 2027.

Table 2. Construction Cost of Major 765kV Transmission Lines

Business Section	Date of Construction	Duration	Length (km)	Cost (100mil KRW)	Cost/km (100mil KRW/km)	Duration/km (months/km)
Uljin-ShinTaebaek	1996.8~2006.12	10yrs 5mo	47	2,562	54.5	2.7
ShinTaeback-ShinGapyeong	1993.1~2000.7	8yrs 7mo	155	7,435	48.0	0.7
ShinGapyeong-ShinAhnsung	1995.4~2010.3	16yrs 2mo	80	3,382	42.3	2.4
ShinAhnsung-ShinSeosan	1993.1~2000.12	8yrs	137	5,902	43.1	0.7
ShinSeosan-Dangjin	1993.1~1999.9	6yrs 9mo	39	2,201	56.4	2.1
ShinGoree-BukKyungnam	2001.5~	12yrs 9mo	90	5,200	57.8	1.7
Total		50 years	458	21,482	46.9	1.3

Source: KEPCO

Likewise, large 765-kV power transmission towers are being built on mountains and in less-urbanized rural villages. The current state of transmission tower construction in municipal cities in South Korea is summarized in Table 3 below.

Table 3. Transmission Tower Installation State (2013.8.31)

Administrative District	Total	Angle Tower					Pipe Type Tower				
		765kV	345kV	154kV	66kV	Total	765kV	345kV	154kV	66kV	Total
Gyeonggi	6,303	0	2,031	3,868	7	5,906	252	138	7	0	397
Chungbuk	2,605	0	645	1,902	8	2,555	35	15	0	0	50
Chungnam	4,098	0	1,381	2,465	0	3,846	236	16	0	0	252
Gangwon	5,021	9	872	3,566	235	4,682	324	9	5	1	339
Jeonbuk	2,784	0	1,042	1,741	0	2,783	0	0	1	0	1
Jeonnam	4,300	0	1,076	3,074	150	4,300	0	0	0	0	0
Kyungnam	6,035	1	1,875	4,129	0	6,005	16	12	2	0	30
Gyeonggi	4,384	0	1,428	2,930	22	4,380	0	2	2	0	4

Source: KEPCO

The power transmission line grounding rate in cities of South Korea vary dramatically due to such issues. While the nation's power transmission cable grounding rate was merely 10.6% as of year 2013, the rate of Seoul reached 88.1%, whereas the grounding rate of rural areas ranged from 0.8~2.5%, with Kyungbuk having the lowest rate of 0.9% specifically (KEPCO, 2013). The issue of these disparities is not only being remonstrated by the residents of small cities, but also being pointed by the policymakers.

The power transmission cable grounding rate in South Korea is summarized in Table 4 below.

Table 4. Transmission Cable Grounding Rate of South Korea

Administrative District	Transmission Line Length (C-km)			Grounding Rate (%)
	Overhead	Underground	Total	
Seoul	116	857	973	88.1
Incheon	269	425	695	61.2
Busan	473	336	809	41.5
Gwangju	200	120	319	37.4
Jeju	371	208	579	35.9
Daegu	523	181	604	30.0
Daejeon	297	115	412	27.9
Gyeonggi	4,535	620	5,155	12.0
Jeonbuk	2,001	97	2,098	4.6
Ulsan	744	35	779	4.5
Jeonnam	3,036	129	3,164	4.1
Kyungnam	3,208	91	3,299	2.7
Chungbuk	1,881	47	1,928	2.4

Chungnam	3,047	58	3,104	1.9
Kyungbuk	4,215	39	4,254	0.9
Gangwon	3,422	22	3,444	0.6
Sejong	162	0	162	0.0
Total	**28,400**	**3,381**	**31,780**	**10.6**

Source: Committee of Industry and Commerce (2013)

The power transmission cable grounding rate in South Korea shown in Table 4 above can be represented in a bar graph, as in Figure 1.

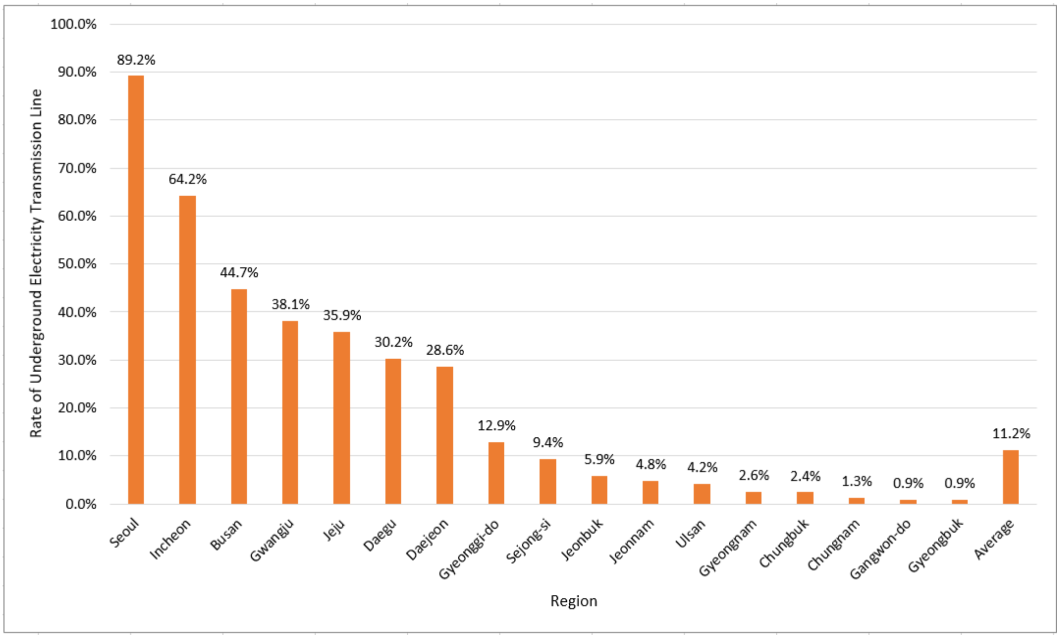

Figure 1. Transmission Cable Grounding Rate of South Korea

2.1.2 Milyang Conflict

The controversy regarding the transmission tower installation has been brought up repeatedly, and these discussions turn into significant disputes. A representative case is that of Milyang, where conflicts of interest between the local residents and KEPCO (Korea Electric Power Corporation) arose. The construction of the transmission line connecting ShinGoree and BukKyungnam (with expected length of 90.5km), which can be seen in Table 1, has halted due to the dissension. The construction has originally been planned to transmit the electric power that is produced from ShinGoree Nuclear Power Plant #3 to the substation located in BukKyungnam of Changnyung-gun. A total of 520 billion KRW was invested, and a total of 162 units of transmission towers were supposed to be built, with 67 (39km) of those in Milyang.

The results of research done by the Korea Electric Power Corporation (KEPCO), the ‘Study on the Exposure to Electric Power Transmission Line’, reports that within the 80m range of 765 kV high-voltage transmission line, the incidence rate of childhood leukemia increased by 3.8 times as the residents were exposed to 3mG strength electromagnetic field throughout the year. Meanwhile, KEPCO claimed that only one household exists in the area, whereas Milyang residents argued that there are dozens of households that operate farm work throughout the year.

Likewise, there are conflicting arguments between KEPCO and the residents of Milyang that are not being resolved. The contradicting arguments regarding this issue of the Milyang case is summarized in Table 5.

Table 5. Conflicts of Interest in Milyang Case

Residents	**Issue**	KEPCO
The transmission cable must be grounded.	**Grounding of the Transmission Cable**	Grounding is impossible because the construction period would be 10 years with a total cost of 2.7 trillion KRW.
Either increase the capacity of the existing transmission line or connect other lines that are under construction.	**Using Already-Installed Transmission Lines**	It may cause power failures due to overload issues when using the existing transmission lines.
Perform the grounding with the money that is available for compensation.	**Compensation Issue**	A total of 13 compensation schemes are proposed including special regional compensation business expenses of 16.5 billion KRW.
An organization is needed for the evaluation of the grounding and alternative method of choice	**Composition of Expert Council**	Due to the tight deadline, let the evaluation occur in parallel with the construction work

Radio waves from high-voltage lines cause a high risk of carcinogenic substances.	**Infringement of Health Rights**	Electromagnetic wave frequency is less than 300Hz, which does not yield enough energy for gene damage.
1,813 residents of 1,484 households in 23 villages signed the protest document against construction. KEPCO is varnishing the press with unrepresentative individuals.	**Stance of Residents**	Approximately half of the residents in the village agree. Citizens and religious groups are intervening to lead opposition.

The dispute has such a serious issue that it has even led to some extreme deaths of personnel demonstrating against the construction. The basis of claims from both parties are solid, leaving little room for reconciliation. Thus, experts argue that governmental projects that may lead to such controversies need to be promoted and implemented in ways that can minimize the imbalance of both the conflicting stakes and the regional conditions.

2.2 Existing Studies on Power Transmission Cable Installation

In this paper, citizens' preference on power transmission cable installation in South Korea is analyzed, focusing on individuals' innate and residential heterogeneity. In doing so, mixed logit and latent class models are used. The mixed logit model is first used to identify the heterogeneity in consumer preference on power transmission cable installation, whereas the latent class model is then used to enable segmentation of consumers. On the basis, we are assuming that heterogeneity exists in the choice of transmission cable installation amongst the respondents, and that various attributes need to be considered to identify their preference structures.

Several research studies have previously been conducted regarding the construction, acceptance, and impact of the electric power transmission cable installation. However, in most cases, the method of discrete choice models has not been utilized; rather, the studies either focused on the environmental and health effects of the construction, or on identifying the attributes that may determine the level of construction acceptance. The discrete choice experiment is designed to grasp consumers' preferences by presenting the ‘virtual’ alternatives, in varying levels, that may realistically exist in the actual market through the questionnaire, which asks the respondents to select the most preferred alternatives. This allows for analysis of the preference structure of the general audience. However, existing studies do not incorporate such concepts, but rather draw on the general issues, which limits their practical implications.

To begin, Furby et al. (1988) reviews literature dealing with the formation and expression of attitudes related to the siting and construction of electric power transmission lines. They develop a conceptual framework that outlines the determinants of those attitudes and public perceptions regarding the issue. The authors conclude that both positive and negative values exist regarding the power transmission line. The negative perspectives are mostly based on the property value effects, aesthetics, environmental concerns (i.e. noise, biological effects), and human health and safety issues (i.e. psychometric analysis). In contrast, it is argued that the economic benefits are clear. Furby et al. (1988) also identified the citizens' main concern regarding the construction process: (1) equity issue, (2) symbolic meaning, (3) information and knowledge, and (4) process characteristics. This study is valuable because it first tries to bring about the issue of electric power transmission cable onto the table and then progresses on with the identification of the potential evaluation factors.

A more recent paper from Cotton and Devine-Wright (2010) explores the perspectives of local citizens affected by the proposed construction of high voltage overhead transmission lines (HVOTLs), which are seen necessary for the connection of a new nuclear power plant at Hinkley Point in Southwest England. Around 8,000 residents in the England region (from Teesside to York) and more than 17,000 residents of Scotland (from Beauly to Denny) were against the specific construction (Grant, 2009). A deliberate focus group methods was used for this study at a two-day public workshop with 38 participants from an affected line-site community. Primarily, perceptions of environmental and social impacts, risks, governance arrangements, and technology choices were identified as concerns. As a result, the residents' oppositions were mostly based not only on the aesthetic issues owing to the building of transmission towers and related infrastructure, but also on the asset value depreciation problem (Priestley and Evans, 1996; Sims and Dent, 2005). Concerns also existed regarding health issues. Draper et al. (2005) pointed out that the chance of children developing leukemia may rise from greater exposure to electromagnetic fields. Accordingly, the concept of NIMBY (Not In My Backyard) is introduced in this paper, stating that although people may conceive the need for the infrastructure installation, they do not want the construction to take place in their area.

Woo (2010) and Ju and Yoo (2014) specifically performed case studies of South Korea in regards to the overhead power transmission line construction. Woo (2010) focused on the Milyang conflict – 765kV transmission construction and the land value compensation. The paper summarizes the issue of Milyang, why the project is happening and what the problem is, along with a potential solution proposal. Given the nature of 'land' and the social and economic context surrounding the concept of land, the view of public welfare for land is bound to be more constrained than other property rights. Thus, transmission line installation, without doubt, brings about oppositions. The study tried to identify the needs of the residents, opinions of the operators, and possible solutions in terms of real estate policy. The survey was conducted in the Milyang area with 200 resident respondents. The residents answered that they needed compensation for the construction because of (1) the fall in the land value near the transmission towers (70%), (2) stress and pressure from risk-causing infrastructure (22%), and (3) hindrance to the living environment (16.5%). 62.5% of the respondents thought the issue was handled in a one-way system led by KEPCO, while only 1% responded that their voice was being heard properly and fairly.

The study of Ju and Yoo (2014) was the only paper that utilized the discrete choice model: the mixed logit model. The authors used the choice experiment to identify the environmental costs caused by electric power transmission line installation in South Korea. The attributes utilized as explanatory variables were visual disamenity, land use, EMFs (electric and magnetic fields), and cost. Other factors regarding environmental costs such as noise, radio frequency interference, etc. were excluded because their effects were expected to be rather minor (Rowe et al., 1995).

Markholm (2007) studied the electricity transmission cost allocation. The author began by stating that the transmission cables have become an issue similar to that of gas and oil in the United States. The paper briefly summarizes the transmission line installation history of the U.S.; it discusses how the gas and electricity industry first divided in 1935 by determining that each state would produce and consume its own electric power. Then, cross-utility transmission investment began in 1966, and the controllable transmission infrastructure using local-utility was constructed in the 1990's. Lastly, the paper mentions that fair transmission allocation must be just, reasonable, and cost efficient.

A final paper studied community perceptions of wind farm development and the property value impacts of sitting decisions. Bond (2010) argues that the cellular transmission towers and high-voltage transmission lines have similar structures as that of a wind turbine. Likewise, the conflicts that form are often very identical. The study revealed that the disagreement is primarily caused by resident concerns about health threats from electromagnetic fields, destruction of ecosystems, and the value depreciation of land and nearby infrastructure. Studies from Bond and Wang (2005) and Kroll and Priestely (1992) add that the distancing between pylons is a greater stake than the construction itself, since it causes greater depreciation in the values of land and nearby infrastructure.

Chapter 3. Research Model and Methodology

3.1 Research Framework

In this research, two different discrete choice models are used for analysis: (1) the Mixed Logit Model and (2) the Latent Class Model (LCM) methods. Discrete choice models are based on the Random Utility Theory, which is first proposed by McFadden (1974), assuming that consumers' choices are made under the conditions of uncertainty. In the discrete choice experiments designed and used in this study, the respondents are presented with several alternatives, from which the choice of the most preferred option should be made; this disables the use of general regression models. Amongst the discrete choice models, the mixed logit model and the latent class model analysis are both utilized in this study to yield further extended implications.

Mixed logit model is first used to identify heterogeneity in consumer preference on power transmission cable installation. Mixed logit model reflects the heterogeneous preferences that individual consumers have for each attribute by giving attribute coefficients probabilistic distributions (Train, 2009). The heterogeneity is revealed continuously based on the probability distribution. The estimated coefficients of attributes can be utilized to calculate the marginal willingness to pay price, which represents the amount that the consumer would like to pay or receive, when the quantity or the quality of the property changes by one unit, in order to maintain his/her utility as before the change. Sensitivity analysis on adopters' change of choice probability with regards to given change in an attribute can be additionally analyzed to draw implications for the behavioral changes of respondents in situational contexts.

Latent class model is then used to enable segmentation of consumers. Because the power transmission line installation projects are conducted at a national-level or at a regional-level, implications should as well be derived at a group-level, unlike the case of products that target individual consumers. Latent class model reflects the heterogeneity differently from mixed logit model; it assumes that the population can be divided into unobservable number of groups and that consumers in each group have the same preference structure, differing from those of other groups. The heterogeneity is shown discretely through such segmentation. Based on the result, sensitivity analysis can be performed and compared based on respondents' varying group affiliation, which enables researchers to draw upon differing preference structures amongst groups.

Analysis of the mixed logit model and the latent class model being done together is useful in that implications can be elicited both based on the preference structures of South Korea adopters in general as well as based on the segmented adopters in more specified and varying preference structures. This will enable easier aim of consumers and foster future adaptation of the government project.

3.1.1 Mixed Logit Model

Logit model and probit model, which are more generally used in research, make unrealistic assumptions that consumers have identical preference structures for each attribute of the product or service that are being analyzed. On the other hand, the mixed logit model can reflect the heterogeneous preferences that individual consumers have by enabling the researchers to specifically define the probability distribution of each attribute coefficient (Train, 2009). It is also a highly flexible model that can approximate any random utility model (McFadden & Train, 2000).

Based on the Random Utility Theory, a decision maker, labeled n, faces choice among J alternatives, and the decision maker would obtain a certain level of utility from each alternative. The utility that decision maker n obtains from alternative j, where $j = 1, \ldots, J$, can be represented as follows (McFadden, 1973; Train, 2009):

$$U_{nj} = V(x_{nj}, \mathrm{s}_n) + \varepsilon_{nj} = V_{nj} + \varepsilon_{nj} \qquad \text{Eq. (1)}$$

The individual consumer utility U_{nj} can be divided into the deterministic term (aka. representative utility), V_{nj}, and the stochastic term (aka. random term), ε_{nj}. The researcher does not observe the decision maker's utility itself, rather, through some attributes of the alternatives as faced by the decision maker, labeled as $x_{nj} \forall j$, and some attributes of the decision maker, labeled as s_n. A representative utility function that relates these observed factors to the decision maker's utility can be specified accordingly.

The stochastic term captures the other factors that affect utility but of which are not included in the term V_{nj}.

Amongst the given alternatives, the decision maker chooses the alternative that provides the greatest utility. The probability that the decision maker n chooses alternative i is:

$$\begin{aligned} P_{ni} &= \Pr(\mathrm{U}_{ni} > U_{nj} \ \ \forall j \neq i) \\ &= \Pr(\mathrm{V}_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj} \ \ \forall j \neq i) \\ &= \Pr(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \ \ \forall j \neq i) \\ &= \int_{\varepsilon} I(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \ \ \forall j \neq i) f(\varepsilon_n) d\varepsilon_n \end{aligned} \qquad \text{Eq. (2)}$$

Here, $I(\cdot)$ is the indicator function, and the multidimensional integral is made over the density of the unobserved portion of the utility, $f(\varepsilon_n)$. Varying specifications of this density enables the formation of different discrete choice models. Amongst, the multinomial logit model is obtained by assuming that each ε_{nj} is independently and identically distributed extreme value. The distribution is also called as type I extreme value distribution and Gumbel distribution (McFadden, 1973; Train, 2009). The density for each unobserved component of utility and its cumulative distribution is defined as:

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}} \qquad \text{Eq. (3)}$$

$$F(\varepsilon_{nj}) = e^{-e^{-\varepsilon_{nj}}} \qquad \text{Eq. (4)}$$

Therefore, the probability that the decision maker n chooses alternative i from Equation (2) can be re-represented as below (McFadden 1973; Train, 2009):

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{ni}}} \quad \text{Eq. (5)}$$

, where $V_{nj} = \beta' x_{nj}$, and x_{nj} is a vector of observed variables relating to alternative to alternative j . The representative utility is usually specified to be linear in parameters.

While multinomial logit allows the derivation of choice probability in a simple form, it exhibits Independence from Irrelevant Alternatives (IIA) property, which defines that the ratio of the logit probabilities does not depend on any other irrelevant alternatives (say, i and k). That is, the relative odds of choosing i over k are the same no matter what other alternatives are available or what the attributes of other alternatives are (Train, 2009). The limitation of IIA can be overcome by using the mixed logit model, which integrates consumer heterogeneity by giving probabilistic distribution assumptions to the coefficients.

In the mixed logit model, the coefficient vector β_n is on basis assumed to follow normal distribution with the mean value b and the variance of W : $\beta_n \sim N(b, W)$. Nevertheless, when the preference structure is likely to show particular directionality for specific attributes, other distributions (i.e. lognormal distribution) can be assumed (Train, 2009). A typical attribute that is given the lognormal distribution is the cost, for which respondents would naturally prefer products with lower costs. The disturbance term is assumed to follow the i.i.d. type I extreme value distribution, yielding the choice probability in the same form as that of multinomial logit model:

$$P_{ni} = \int \left(\frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{ni}}} \right) f(\beta) d\beta$$

$$= \int \left(\frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{ni}}} \right) \phi(\beta \mid b, \mathrm{W}) d\beta \qquad \text{Eq. (6)}$$

Values of coefficients that are estimated through the mixed logit model represents the marginal contribution of each attribute to the utility with arbitrary units. Thus, unlike the estimates of general models, the estimates of the mixed logit model do not carry comparable meanings between attributes. Therefore, it is necessary to calculate the Marginal Willingness to Pay (MWTP) value for each variable. The marginal willingness to pay represents the amount that the consumer would like to pay or receive, when the quantity or the quality of the property changes by one unit, in order to maintain his/her utility as before the change. MWTP can be represented as of below:

$$MWTP_{x_{jt}} = -\frac{\partial U_{nj} / \partial x_{jt}}{\partial U_{nj} / \partial x_{j,price}} = -\frac{\beta_t}{\beta_{price}} \qquad \text{Eq. (7)}$$

Here, x_{jt} and β_t each represents the alternative and its coefficient excluding the price variable, whereas $x_{j,price}$ and β_{price} each represents the price factor and its coefficient.

Lastly, the relative importance of each attribute to decision-making may be different in respondents' choice of alternatives. The relative importance of each attribute can be obtained from the following equation after calculating the part-worth of each attribute:

$$RI_k = \frac{part - worth_k}{\sum_k part - worth_k} \times 100 \qquad \text{Eq. (8)}$$

The part-worth of attribute k can be found by multiplying the coefficient β_k with the difference of maximum level and the minimum level of attribute k (Choi et al., 2013).

3.1.2 Latent Class Model

Latent class model assumes that consumers' heterogeneity appears continuously, unlike the mixed logit model and the hierarchical Bayesian model where it is assumed that consumers' heterogeneity appears discretely. It is also assumed that such heterogeneity is affected by the unobserved factors. Restated, the population can be divided into Q unobservable number of groups, and consumers in each group have the same preference structure (Greene & Hensher, 2003).

According to the Random Utility Theory, a decision maker, labeled n faces choice among J alternatives, and the decision maker would obtain a certain level of utility from each alternative. The utility that decision maker n, who belongs to group q, obtains from alternative j under condition t, where $j = 1, ..., J$, can be represented as follows (McFadden, 1974; Train, 2009):

$$U_{njt|q} = V_{njt|q} + \varepsilon_{njt|q} = \sum_{k=1}^{K} \beta_{k|q} X_{jkt} + \varepsilon_{njt|q} \qquad \text{Eq. (9)}$$

, where $V_{njt|q}$ is the deterministic term composed of the linear function of K independent variables X_{jkt} and their coefficients $\beta_{k|q}$. The stochastic term $\varepsilon_{njt|q}$ is assumed to follow the type I extreme value distribution.

When the consumer makes a choice that maximizes his/her utility, the choice probability that the decision maker n, who belongs to group q, chooses alternative i under condition t is:

$$\begin{aligned} P_{nt|q}(i) &= P(U_{nit|q} > U_{njt|q} \forall j \neq i) \\ &= (\mathrm{V}_{nit|q} + \varepsilon_{nit|q} > V_{njt|q} + \varepsilon_{njt|q} \forall j \neq i) \\ &= \int I\left(\varepsilon_{njt|q} < V_{nit|q} - V_{njt|q} + \varepsilon_{nit|q} \forall j \neq i\right) f(\varepsilon_{nit|q}) d\varepsilon_{nit|q} \\ &= \frac{\exp(X'_{it}\beta_q)}{\sum_{j=1}^{J} \exp(X'_{jt}\beta_q)} \end{aligned} \quad \text{Eq. (10)}$$

Here, $I(\cdot)$ is the indicator function, and the likelihood function of decision maker n can be expressed as follows (Train, 2009; Green & Hensher, 2003):

$$P_{n|q} = \prod_{t=1}^{T} P_{nt|q} \quad \text{Eq. (11)}$$

In the latent class model, the prior probability of a consumer belonging in each group is set through multinomial logit model. Characteristics of respondents such as demographic variables are used as factors that determine the probability of their being assigned to each group. The probability that the respondent n belongs to group q is:

$$H_{nq} = \frac{\exp(\mathbf{z}'_n \boldsymbol{\theta}_\mathbf{q})}{\sum_{q=1}^{Q} \exp(\mathbf{z}'_n \boldsymbol{\theta}_\mathbf{q})} \quad \text{Eq. (12)}$$

, where $\mathbf{z}_\mathbf{i}$ refers to the observable characteristics that determine group assignment. $\boldsymbol{\theta}_\mathbf{q}$ is set to 0 for intergroup identification (Green & Hensher, 2003). The likelihood function of respondent n can be expressed using the probability that the respondent belongs to each group and the expected value of the conditional probability in the group.

$$P_n = \sum_{q=1}^{Q} H_{nq} P_{n|q} \qquad \text{Eq. (13)}$$

The log likelihood function of the entire sample can be obtained as follows:

$$\begin{aligned} \ln L &= \sum_{n=1}^{N} \ln P_n \\ &= \sum_{n=1}^{N} \ln \left[\sum_{q=1}^{Q} H_{nq} \left(\prod_{t=1}^{T} P_{nt|q} \right) \right] \end{aligned} \qquad \text{Eq. (14)}$$

In this study, the Simulated Maximum Likelihood Estimation method was used to estimate the parameters of $\boldsymbol{\beta}_q$ and $\boldsymbol{\theta}_q$, which utilizes the Expectation-Maximization algorithm. The Expectation-Maximization algorithm enables the estimation even when the number of parameters and the number of assignment groups increase, yielding strength in terms of stability and the maximum value convergence (Pacifico and Yoo, 2013).

After deriving the estimates of the parameters, Bayes' theorem can be used to determine the posterior group assignment probability of respondents. Let us consider the case where the group assignment probabilities of the latent class model are obtained merely based on the demographic variables. The two individuals with the equivalent demographic characteristics are to have the same sensitivities regarding the preference of alternatives. This, however, is a difficult assumption to establish. Such limitation can be relieved by the Bayes' theorem, based on which the posterior probability of an individual n being assigned to group q can be found as of below:

$$\hat{H}_{q|n} = \frac{\hat{P}_{n|q}\hat{H}_{nq}}{\sum_{q=1}^{Q}\hat{P}_{n|q}\hat{H}_{nq}} \quad \text{Eq. (15)}$$

Accordingly, estimates of the respondents' individual parameters can be obtained using the following equation (Green & Hensher, 2003):

$$\hat{\boldsymbol{\beta}}_n = \sum_{q=1}^{Q}\hat{H}_{q|n}\hat{\boldsymbol{\beta}}_q \quad \text{Eq. (16)}$$

As an indicator for evaluating the performance of the latent class model, log-likelihood, Consistent Akaike Information Criterion (CAIC), and Bayesian Information Criterion (BIC) can be considered. However, in the case of log-likelihood, it yields that the model performs better as the number of parameters increase. Therefore, in case of latent class model, it would yield that the performance of the model increases as the number of groups increase. Thus in most cases, CAIC and BIC criteria are used to evaluate the performance of the latent class model (Pacifico and Yoo, 2013). The CAIC can be calculated using the equation below:

$$CAIC = -2\ln L + m(1 + \ln N) \quad \text{Eq. (17)}$$

, where $\ln L$ represents log-likelihood, m represents the number of parameters to be estimated, and N represents the total number of observations.

In case of CAIC, it is seen that the smaller the value, the better the performance of the model. As the number of estimated parameters increase, the value of CAIC increases, controlling for the parameter increase unlike the log-likelihood method. Meanwhile, the value of BIC can be calculated using the equation below:

$$BIC = -2\ln L + m\ln N \qquad \text{Eq. (18)}$$

The difference from CAIC is to what extent the increase in the number of parameters is compensated. In this study both of CAIC and BIC criteria are used to evaluate the performance of the model.

Assuming that the consumers are given free choice in their option of transmission line construction types, additional consumer surplus resulting from such given choice can be derived. First, the choice probability of each attribute of the construction of transmission line is deduced using the consumer preference data in order to observe the preference structure of each group. Posterior estimates of the respondents' individual parameters may be induced using Equation (16). The choice probability of power transmission line construction type is obtained by first deriving the individual choice probability of each group member regarding the composition of attributes and then by taking the mean of those values. Let us say that the total number of members of the given group is represented as N, whereas the attributes of the power transmission line construction type i is represented as y_i. Then, the choice probability of option i is represented as of follows:

$$\Pr(i) = \frac{1}{N}\sum_{n=1}^{N}\frac{\exp(y'_i\beta)}{\sum_j y'_j\beta} \qquad \text{Eq. (19)}$$

For the consumer will make a choice that maximizes his/her utility, consumer surplus of individual n can be found (Train, 2009).

$$CS_n = (1/\alpha_n)\max_j(U_{nj}) \qquad \text{Eq. (20)}$$

, where α_n represents marginal utility on income/cost, ensuing the relationship of $dU_n / dY_n = \alpha_n$. Because the researcher cannot directly observe consumers' utilities, the consumer surplus as well cannot be directly calculated using Equation (20). Thus, based on the Random Utility Theory, consumer utility can be divided into a deterministic and a stochastic part as can be seen in Equation (21). In a logit model, the error term ε_{nj} follows type I extreme value distribution (i.e. Gumbel distribution) and in such case yields linear relationship with income/cost (Williams, 1977).

$$E(CS_n) = \frac{1}{\alpha_n} E\left[\max_j \left(V_{nj} + \varepsilon_{nj}\right)\right] = \frac{1}{\alpha_n} \ln\left(\sum_{j=1}^{J} e^{V_{nj}}\right) + C \qquad \text{Eq. (21)}$$

Value C in Equation (21) corresponds to the unobservable constant that represents the absolute level of utility. In general, researchers are interested not in the absolute level of consumer surplus, rather in the level of change in consumer surplus resulting from changing circumstances. The change in consumer surplus is written as follows:

$$\Delta E(CS_n) = \frac{1}{\alpha_n}\left[\ln\left(\sum_{j=1}^{J^1} e^{V^1{}_{nj}}\right) - \ln\left(\sum_{j=1}^{J^0} e^{V^0{}_{nj}}\right)\right] \qquad \text{Eq. (22)}$$

3.2 Composition of Data

In this paper, stated preference data that are obtained through the choice experiment survey questionnaires are used in order to analyze consumers' heterogeneous preference for power transmission line installation in South Korea.

The discrete choice experiment is an experiment designed to grasp consumers' preferences by presenting the 'virtual' alternatives, in varying levels, that may realistically exist in the actual market to the respondents through the questionnaire, where amongst, the respondents are then asked to select the most preferred alternatives. This allows the analysis of the preference structure of the general audience.

While it is ideal for the attributes of the choice experiment to not exceed six (Phelps & Shanten, 1978), five different attributes were used in this study asking the respondents' preference regarding the electric power transmission line installation, while assuming that other attributes are set to be identical. Attributes were chosen based on the literature review. As identified in the studies of Cotton and Devine-Wright (2010) and Bond (2010), the aesthetic issues and health problems owing to the transmission towers were among the highest reason of opposition towards the tower construction. Draper et al. (2005) also pointed out that the chance of leukemia occurrence in children may rise from greater exposure to electromagnetic fields. Accordingly, the concept of NIMBY (Not In My Backyard) is introduced, stating that although people may conceive the need for the infrastructure installation, they do not want the construction to take place in their area. In the same vein, attributes regarding the number of transmission towers and the electromagnetic field exposure were included in the choice experiment.

Attribute of cost is included in the experiment because according to the study of Markholm (2007), issue regarding fair transmission allocation that it not only must be just and reasonable, but also cost efficient. The study of Woo (2010) and Ju and Yoo (2014) also identifies the need for construction compensation for the residents. The attribute of 'cost' along with the reliability and quality of service have always been the issue in the power transmission cable installation, for the overhead method and the grounding method comparatively have their strengths and weakness regarding the case. Accordingly, attributes of additional electricity cost, number of blackouts, and the duration of each blackout were included in the experiment.

Using the orthogonality test, total of nine sets of choices were created, which were then grouped into three sets with three choice options assigned to each. In each set, the 'No Choice' option was additionally included.

The summary of attributes is represented in Table 6 below.

Table 6. Summary of Attributes Used for the Choice Experiment

Attribute	Level
Number of Transmission Towers	5% decrease / 10% decrease / 15% decrease (#500 decrease / #1,000 decrease / #1,500 decrease)
Exposure to EMF	10% decrease / 20% decrease / 30% decrease
Number of Blackouts	25% decrease / 50% decrease / 75% decrease
Duration of each blackout	20% increase / 40% increase / 60% increase
Additional Cost	1,000 KRW / 3,000 KRW / 5,000 KRW

The designed choice experiment survey can be seen in the attached Appendix A, where the full survey questionnaires are included.

3.3 Empirical Models

The research framework of this paper utilizes two of the discrete choice models, the mixed logit model and the latent class model, which are based on the Random Utility Theory, in order to analyze the data obtained through choice experiments of the conducted survey. In this section, the research models presented in Section 3.1 are going to be used to drive empirical models that can be used for further empirical analysis. Empirical models are used to identify the residents' preference structure in implementing the power transmission tower and the underground transmission line in South Korea. Specifically, in analyzing the mixed logit model, Bayesian Estimation Method was used since the likelihood function is complex in its structure, making it difficult to use the Maximum Likelihood Estimation method. In estimating the latent class model, the Expectation-Maximization algorithm was used.

3.3.1 Mixed Logit Model

The variables that are used in the mixed logit model are defined and summarized in Table 7 below.

Table 7. Definition of Variables (Mixed Logit Model)

Variable	Definition	Distribution
$x_{i,\text{Tnum}}$	**Number of transmission towers**: The reduction rate in the number of transmission towers when grounding is implemented	Log-normal
$x_{i,\text{EMF}}$	**Exposure to electromagnetic field**: The reduction rate in the exposure of EMF that result from high-voltage transmission lines	Log-normal
$x_{i,\text{Bout}}$	**Number of blackouts**: The reduction rate in the number of blackouts that can happen in 5 years	Log-normal
$x_{i,\text{Btime}}$	**Duration time of blackouts**: The incremental rate in the duration time of each blackout	Log-normal
$x_{i,\text{Cost}}$	**Additional cost of electricity**: Additional charge of electricity when underground method is introduced in the building of power transmission line	Log-normal
$S_{i,\text{Need}}$	**Perceived need/urgency**: Perceived need/urgency in the construction of power transmission lines	Normal
$S_{i,\text{Risk}}$	**Risk averseness**: Attitude towards risk	Normal
$S_{i,\text{Rate}}$	**Grounding rate**: The grounding rate of power transmission line in the city of residence	Normal
$D_{i,\text{noChoice}}$	**No Choice**: Dummy variable. The choice of not choosing any option	Normal

Variables $x_{i,\text{Tnum}}$, $x_{i,\text{EMF}}$, $x_{i,\text{Bout}}$, $x_{i,\text{Btime}}$, and $x_{i,\text{Cost}}$ are core explanatory variables that are used in the empirical model. $x_{i,\text{Tnum}}$ and $x_{i,\text{EMF}}$ each represent the reduction rate in the number of transmission towers and the reduction rate in the exposure of EMF that result from high-voltage transmission lines when grounding is implemented, respectively. Variables of $x_{i,\text{Bout}}$ and $x_{i,\text{Btime}}$ are set regarding blackouts, where they represent the reduction rate in the number of blackouts that can happen in 5 years and the incremental rate in the duration time of each blackout, respectively. Lastly, $x_{i,\text{Cost}}$ variable represents the additional charge of electricity when underground method is introduced in building of power transmission line. This variable is a necessity in the marginal willingness to pay calculation in the later part of this research. $D_{i,\text{noChoice}}$ is implemented as a dummy variable so as to represent the respondents' choice of not choosing any of the given option, in other words, preferring to be left intact.

Three additional explanatory variables were introduced in the empirical model for further analysis. The first is $S_{i,\text{Need}}$, which represents individuals' perceived need/urgency in the construction of power transmission lines. The data is collected on a Likert scale from 1 to 5, where 1 represents 'not at all urgent' and 5 represents 'very urgent'. This variable was implemented to see if one's perceived need and urgency in the construction of transmission line affects his/her choice amongst various options of transmission line installation that are presented.

Variable $S_{i,\text{Risk}}$ represents the individuals' attitude towards risk. This was also collected on a Likert scale from 1 to 5, where 1 represents 'very aversive' and 5 represents 'risk loving'. This variable was additionally implemented to see if one's attitude towards risk affects his/her choice amongst various options of transmission line installation projects. Both the installation of transmission towers and the grounding of power transmission lines raise different risks to the residents, at least in that regarding bringing about some kind of change. Thus, it is expected that an individual's risk averseness would affect his/her preference structure in any way.

Finally, variable $S_{i,\text{Rate}}$ is set to represent the grounding rate of power transmission line in the city of the respondents' residence. The actual grounding rate of eight surveyed cities were implemented to see if the current grounding rate of an individual's city of residence affects his/her choice of transmission line installation projects. The input values ranged from 28.6 (%) to 89.2 (%), where the grounding rate of Daejeon was the lowest and that of Seoul was the highest, respectively. Midst, for $S_{i,\text{Rate}}$ variable symbolizes the concept of 'rate', all values are to be within the range of (0, 100). All of these three proposed variables were implemented as interaction terms in the mixed logit model.

Meanwhile, as mentioned in Section 3.1.1, one of the greatest strengths of the mixed logit model is that the distributions of attributes' coefficients can be assumed. Generally, it is assumed that the coefficients follow the normal distribution; however, for some attributes, problems may arise in doing so. For example, let us consider the variable regarding 'cost'. If a given product is generic and all other conditions are kept identical, coefficients for the attribute 'cost' should be negative for all respondents, for it is trivial that people are always willing to pay less for the same product. However, because normal distribution allows for both positive and negative coefficients, the directivity that realistically does not make sense can be yielded (i.e. that some people prefer more expensive products in the case of above). The assumption of log-normal distribution relieves such limitation, for we can set the directivity of coefficients to be either all positive or all negative. Thus, it is necessary to appropriately assume the distributions of coefficients β_n based on their effects on consumer utility.

In this study specifically, variables $x_{i,\mathrm{Tnum}}$, $x_{i,\mathrm{EMF}}$, $x_{i,\mathrm{Bout}}$, $x_{i,\mathrm{Btime}}$, and $x_{i,\mathrm{Cost}}$ are all assumed to follow the log-normal distribution, where the latter two are to yield negative estimated coefficients. These variables were given the log-normal distribution because their directivities of sensitivity were trivial. All other attributes are assumed to follow the normal distribution as is given. Based on above explanations, the empirical mixed logit model that is studied in this paper can be represented as of below:

Model 1:

$$\begin{aligned} U_{ni} = {} & x_{i,\text{Tnum}}(\beta_{n1} + \beta_{n2}S_{n,\text{Need}} + \beta_{n3}S_{n,\text{Risk}} + \beta_{n4}S_{n,\text{Rate}}) \\ & + x_{i,\text{EMF}}(\beta_{n5} + \beta_{n6}S_{n,\text{Need}} + \beta_{n7}S_{n,\text{Risk}} + \beta_{n8}S_{n,\text{Rate}}) \\ & + x_{i,\text{Bout}}(\beta_{n9} + \beta_{n10}S_{n,\text{Need}} + \beta_{n11}S_{n,\text{Risk}} + \beta_{n12}S_{n,\text{Rate}}) \\ & + x_{i,\text{Btime}}(\beta_{n13} + \beta_{n14}S_{n,\text{Need}} + \beta_{n15}S_{n,\text{Risk}} + \beta_{n16}S_{n,\text{Rate}}) \\ & + x_{i,\text{Cost}}(\beta_{n17} + \beta_{n18}S_{n,\text{Need}} + \beta_{n19}S_{n,\text{Risk}} + \beta_{n20}S_{n,\text{Rate}}) + \beta_{\text{noChoice}}D_{\text{noChoice}} + \varepsilon_{ni} \end{aligned} \qquad \text{Eq. (23)}$$

In estimating the part-worth (β_n) of each attribute in the mixed logit model, two of the estimation methods can be used: (1) the Maximum Likelihood Estimation (MLE) method and (2) the Bayesian Estimation Method. However, there exists limitations in utilizing the MLE method when the likelihood function is complex in its structure, making it difficult to estimate. Whereas, the Bayesian Estimation Method overcomes this problem by giving prior distributions to attribute coefficients and posterior distribution to the likelihood function (Edwards and Allenby, 2003). Thus in this study, the Bayesian Estimation Method that utilizes Gibbs sampling method is used for the analysis. Results are presented in Section 4.2.

3.3.2 Latent Class Model

The variables that are used in the latent class model are defined and summarized in Table 8 below.

Table 8. Definition of Variables (Latent Class Model)

Variable	Definition
$x_{i,\text{Tnum}}$	**Number of transmission towers**: The reduction rate in the number of transmission towers when grounding is implemented
$x_{i,\text{EMF}}$	**Exposure to electromagnetic field**: The reduction rate in the exposure of EMF that result from high-voltage transmission lines
$x_{i,\text{Bout}}$	**Number of blackouts**: The reduction rate in the number of blackouts that can happen in 5 years
$x_{i,\text{Btime}}$	**Duration time of blackouts**: The incremental rate in the duration time of each blackout
$x_{i,\text{Cost}}$	**Additional cost of electricity**: Additional charge of electricity when underground method is introduced in the building of power transmission line
$D_{i,\text{Capital}}$	**Capital area resident**: Dummy variable indicating whether one lives in the capital area '1' or not '0'.
$S_{i,\text{Knowledge}}$	**Average level of knowledge**: Average level of knowledge regarding the power transmission line.
$S_{i,\text{Trust}}$	**Average level of trust in relevant organization**: Average level of trust in the environmental, health, and economic evaluations executed by organizations.
$S_{i,\text{Accept}}$	**Level of acceptance**: Level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood.
$D_{i,\text{noChoice}}$	**No Choice**: Dummy variable. The choice of not choosing any option

Variables $x_{i,\text{Tnum}}$, $x_{i,\text{EMF}}$, $x_{i,\text{Bout}}$, $x_{i,\text{Btime}}$, and $x_{i,\text{Cost}}$ are core explanatory variables that are used in the empirical latent class model, just as in that of the mixed logit model. The utility that consumer n obtains by choosing alternative i is represented as of follows:

$$U_{ni} = \beta_{n1}x_{i,\text{Tnum}} + \beta_{n2}x_{i,\text{EMF}} + \beta_{n3}x_{i,\text{Bout}} + \beta_{n4}x_{i,\text{Btime}} + \beta_{n5}x_{i,\text{Cost}} + \beta_{\text{noChoice}}D_{\text{noChoice}} + \varepsilon_{ni} \quad \text{Eq. (24)}$$

Here, the error term ε_{ni} is assumed to follows type I extreme value distribution (i.e. Gumbel distribution). Equation (24) corresponds to the multinomial logit model that does not incorporate consumer heterogeneity.

In this part of the study, latent class model was used to incorporate consumer heterogeneity in analyzing their preferences regarding the power transmission line installation projects. The empirical latent class model that is studied in this section can be represented as of below:

Model 2:

$$\begin{aligned} U_{ni|q} = {} & \beta_{n1|q}x_{i,\text{Tnum}} + \beta_{n2|q}x_{i,\text{EMF}} + \beta_{n3|q}x_{i,\text{Bout}} + \beta_{n4|q}x_{i,\text{Btime}} \\ & + \beta_{n5|q}x_{i,\text{Cost}} + \beta_{\text{noChoice|q}}D_{\text{noChoice}} + \varepsilon_{ni} \end{aligned} \quad \text{Eq. (25)}$$

In the above Model 2 presented as Equation (25), $U_{ni|q}$ represents the utility that respondent n, who belong in group q, obtains by choosing alternative i. Latent class model assumes heterogeneity between groups and homogeneity within each group. Thus, the same coefficient estimates are obtained for each group.

Variables that are used to segment individuals into groups in the latent class model are $D_{i,\text{Capital}}$, $S_{i,\text{Knowledge}}$, $S_{i,\text{Trust}}$, and $S_{i,\text{Accept}}$ that indicates whether one lives in the capital area or not (dummy), average level of knowledge regarding the power transmission line, average level of trust in the environmental, health, and economic evaluations executed by organizations, and the level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood, respectively.

In representing the dummy variable $D_{i,\text{Capital}}$, the value becomes ‘1’ if the respondent lives in the capital area and ‘0’ if not. Data for the rest of the variables $S_{i,\text{Knowledge}}$, $S_{i,\text{Trust}}$, and $S_{i,\text{Accept}}$ are collected on a Likert scale from 1 to 5, where 1 represents ‘fully against’ and 5 presents ‘fully support’ regarding the level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood, $S_{i,\text{Accept}}$. In order to measure the level of knowledge regarding the power transmission line, two questions regarding the types of the transmission line (i.e. 154, 345, 765 kV) and their effects on health and environment were asked. The mean of the two indicator data was then found for $S_{i,\text{Knowledge}}$, where 1 meant ‘do not know at all’ and 5 meant ‘know very well’. Lastly, in measuring the level of trust on the environmental, health, and economic evaluations executed by organizations, total of four questions were asked based on the type of organizations. Questions indicated 1 as ‘do not trust at all’ and 5 as ‘fully trust’. Results were averaged out to yield the indicator of variable $S_{i,\text{Trust}}$.

Here, the prior probability that the respondent n belongs to group q can be obtained using the equation below:

$$H_{nq} = \frac{\exp(\theta_{q1} Z_{\text{Capital}} + \theta_{q2} Z_{\text{Knowledge}} + \theta_{q3} Z_{\text{Trust}} + \theta_{q4} Z_{\text{Accept}})}{\sum_{q=1}^{Q} \exp(\theta_{q1} Z_{\text{Capital}} + \theta_{q2} Z_{\text{Knowledge}} + \theta_{q3} Z_{\text{Trust}} + \theta_{q4} Z_{\text{Accept}})} \qquad \text{Eq. (26)}$$

Then, values that maximize the log-likelihood function of Equation (14) was yielded and used for the analysis accordingly.

Chapter 4. Empirical Studies

4.1 Descriptive Statistics

This study utilized the obtained data from the survey that was conducted in eight cities of South Korea, specifically the capital city of Seoul, 5 major metropolitan cities (Incheon, Busan, Daegu, Gwangju, and Daejeon), and those in the Gyeonggi area (Ilsan/Bundang). The survey was conducted in order to collect national data regarding consumer acceptance on electric power service, and amongst, questionnaires regarding power transmission line was used in this paper. The survey was executed for 18 days, from July 24th to August 10th of year 2014, addressing 400 residents, men and women, who were of age between 20~59 years-old. Two different versions of questionnaires were used (Type A and B), where the individual interviews were proceeded by Gallup, a specialized survey agency, in order to increase the reliability of the data. Refer to Appendix A for the actual survey questionnaire.

The purpose of this paper is to contribute to the formulation of a reasonable policy that promote public interest, enhance national consensus, and raise regional residents' acceptance by reflecting the preferences of consumers through the estimation of marginal willingness to pay regarding the power transmission line installation. Information such as demographic characteristics and the innate/psychological traits of the respondents were also collected along with their responses to the choice experiments. The sample composition of the survey was carefully constructed as to closely reflect the actual population composition of South Korea in order to effectively yield policy implications from the analysis. The summary of respondents' demographic characteristics is represented in Table 9 below.

Table 9. Demographic Characteristics of Survey Respondents

Classification	Categorization	Number of Respondents (#)	Composition Ratio (%)
Gender	Male	199	49.8
	Female	201	50.2
Age	20s	97	24.3
	30s	103	25.7
	40s	107	26.7
	50s	93	23.3
Education	Secondary Education	161	40.3
	Post-Secondary Education	239	59.7
Monthly Income	~ ₩3,000,000	89	22.3
	₩3,000,000 ~ ₩4,000,000	109	27.2
	₩4,000,000 ~ ₩5,000,000~	96	24.0
	₩5,000,000~	106	26.5

Monthly Expense	~ ₩2,000,000	137	34.2
	₩2,000,000 ~ ₩3,000,000	129	32.3
	₩3,000,000~	134	33.5
Family Composition	Single Household	34	8.5
	2-Member Household	67	16.7
	3-Member Household	91	22.7
	4-Member Household	181	45.3
	5+ Member Household	27	6.8
Type of Residence	Own House	218	54.5
	Lease	182	45.5
City of Residence	Seoul	172	43
	Incheon	46	11.5
	Gyeonggi Area (Ilsan/Bundang)	32	8.0
	Busan	58	14.5
	Daegu	42	10.5
	Gwangju	24	6.0
	Daejeon	26	6.5

Questions that are designed to examine the respondents' perception and usage behavior regarding the electric power service in South Korea were given in the beginning of the questionnaire. A question that is of the most basic concern was asked regarding individuals' interest in the electric power service (i.e. cost, quality, friendliness, etc.) using 5-point Likert scale (1: Not at all interested – 5: Very much interested).

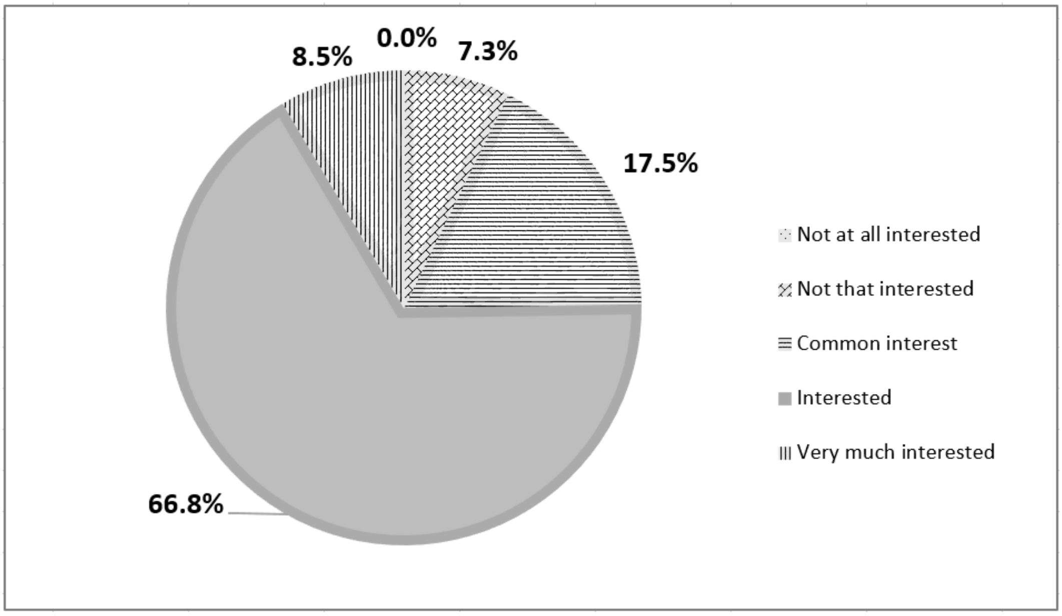

Figure 2. Level of Interest in the Electric Power Service

As can be seen from Figure 2 above, 75.3% of the respondents were either interested or very much interested in the electric power service. In other words, a big portion of the population (or respondents) showed interest in the given service to some extent. On the other hand, only 7.3% of respondents responded that they were not that interested or not at all interested in the electric power service. To be specific, not a single individual responded that he/she was not at all interested. In terms of demographic characteristics, males were more interested than females, and those in their 30s were more interested than those in their 20s.

Then, the study was conducted to identify important factors in using the electric power services. Questions were asked using 5-point Likert scale regarding a total of 12 attributes. The scale ranged from 1, not at all important, to 5, very important. Then, the respondents were asked to rank the one most important factor. The results are summarized in the Table 10 below.

Table 10. Important Factors in the Choice of Electric Power Service

Classification	Average Value	Primary Rank (#)
Level of electricity cost	4.44	137
Reliable supply (i.e. less frequent blackouts)	4.55	84
Securing various types of power plants	4.30	51
Development of alternative energy	4.36	61
Reduction in energy imports and dependence on other countries	4.17	10
Safe operation of power plants	4.40	32
Consistent policy enforcement and regulation	4.16	12

Campaign to promote efficient electricity usage	4.07	2
Customer service (i.e. repairs)	4.19	6
Social contribution activities of corps	3.93	1
Overall impression of the company	4.03	1
Adoption of high technologies	4.17	3

As can be seen, the level of electricity cost and their reliable supply was noted as two most important factors in the electric power service. Factors such as development of alternative energy and securing various power plants are also taken into consideration, indicating that respondents are aware of alternative energy issues and limited source of energy in South Korea. Nevertheless, factors such as social contribution activities of corporations, overall impression of the company, and the campaign promoting efficient electricity usage were chosen to be the least important. Such tendencies were consistent throughout different age levels and gender.

Amongst, let us specifically take a look at six factors that are related to our research interest and can be affected by the power transmission line installation method. The factors considered are the electricity cost, reliable supply (i.e. less frequent number of blackouts), safe operation of power plants, consistent policy and regulation enforcement, customer service, and adoption of high technologies.

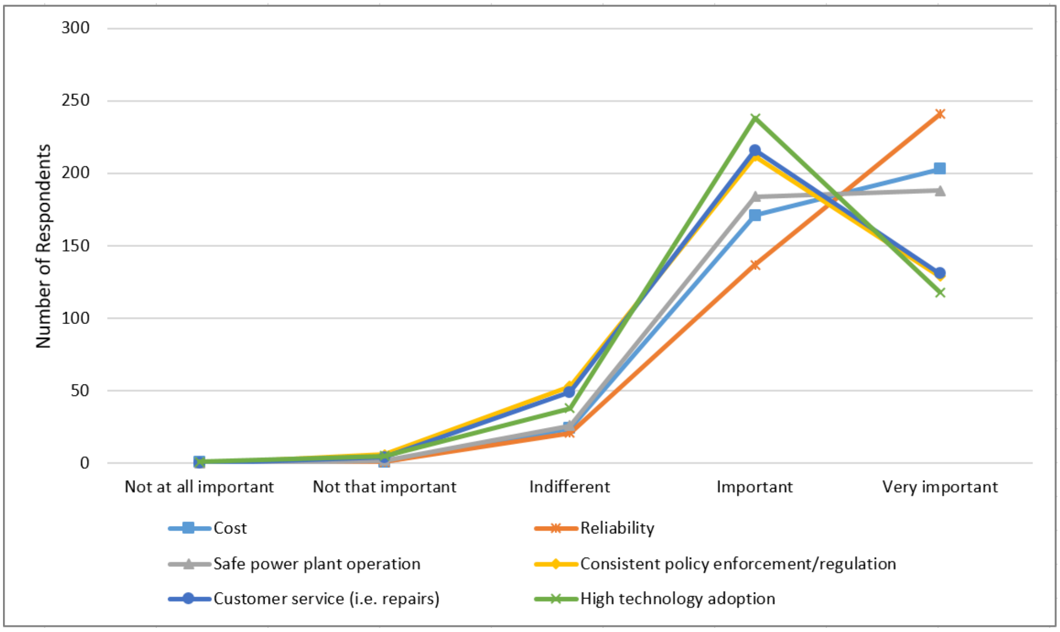

Figure 3. Important Factors in the Choice of Electric Power Service

All of the six factors were mostly considered as either important or very important to the respondents. Amongst, the reliable supply of electric power yielded the greatest ratio of the 'very important' option. Figure 3 graphically reaffirm the data summarized in Table 9 that these factors are considered more important than otherwise by the respondents.

Referring back to Table 10, most people ranked the cost of electricity the highest (132, 33%) among the 12 given factors. Relating to such fact, we then asked through the questionnaire how expensive the electricity bill is considering the usage level. 5-point Likert scale was used, where 1 indicated 'very cheap' and 5 indicated 'very expensive'. This information will be useful in bringing about policy directivity, for example, by considering that power transmission line grounding may increase the electricity cost.

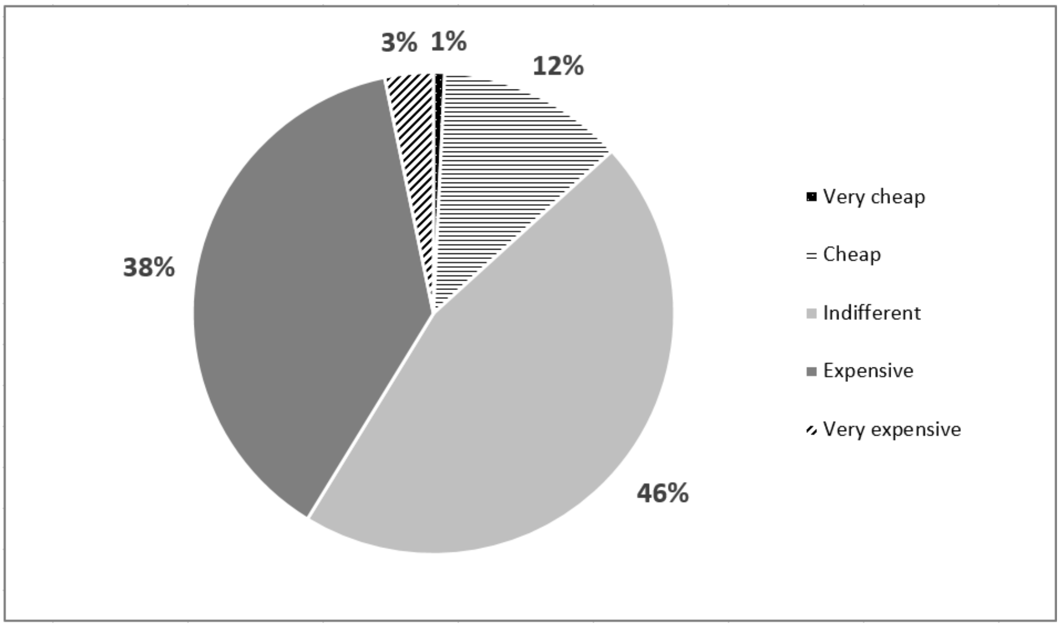

Figure 4. Perceived Level of Electricity Bill

Lastly, we asked the respondents how much they are satisfied with the electric power service provided domestically. The service was divided into 5 components: electricity bill (cost), accurate notice of bill, reliable supply (i.e. less frequent blackouts), blackout notice and prompt restoration, and convenient use of electric meter. 5-point Likert scale was used (1: very dissatisfied, 2: dissatisfied, 3: indifferent, 4: satisfied, 5: very satisfied). Respondents were then asked to rank the first and second component that need to be improved most primarily. The results are presented in Table 11. The average values of responses and the number of people who ranked the component as needed to be improved most primarily are together noted in the table below.

Table 11. Satisfactory Level in Electric Power Service

Classification	Average Value	Primary Rank (#)
Electricity bill (cost)	3.37	61
Accurate notice of bill	3.89	82
Reliable supply (i.e. less frequent blackouts)	3.89	113
Blackout notice and prompt restoration	3.72	88
Convenient use of electric meter	3.66	51
Overall satisfaction level in domestic household electric power service	3.67	

It can be easily seen from Table 11 that the respondents were most satisfied with the reliable supply of electric power. They were also satisfied with the blackout notice and prompt restoration service. This is rather expected because South Korea is well-known for its reliable electric power supply, partly due to the monopolistic structure by KEPCO and also because the size of the country is rather small. The system is organized so that problems and complaints are easily and promptly responded and restored. Contrastingly, respondents were least satisfied with the cost of electricity. This is in line with the result presented in Table 10 and in Figure 4. It is trivial that overall, individuals are most sensitive to the concept of 'cost' in regards to electric power supply service.

4.2 Mixed Logit Model Estimation Results

In order to estimate the mixed logit model using the Bayesian Estimation Method, the estimation code constructed by Train was used (Train & Sonnier, 2005). The program is based on Gauss, a matrix programming language developed by Aptech Systems. Total of 210,000 extractions were made through Gibbs sampling process for Bayesian estimation. Amongst, first 200,000 number of extractions were discarded ('burn-ins') to compensate for the initial value effect. Estimations were performed based on 1,000 values that were extracted every 10 times during the following 10,000 number of extractions. Based on the estimated values of mean (b) and variance (W), total of 2,000 samples were again extracted to obtain the values of marginal willingness to pay (MWTP) and relative importance (RI). The estimation results of the Model 1 presented in Section 3.3.1. Equation (16) is presented in the following section.

4.2.1 Analysis of Preference Structure

The detailed estimation result of Model 1 is presented in Table 12. Specifically, the mean value (b) and the standard deviation ($\sqrt{W}$) of the estimated coefficients are summarized. Whether or not the values are significant was also marked based on the given t-values.

Table 12. Estimation Results of Mixed Logit Model

Attribute	Mean Coefficient (b)	t-value	Standard Deviation ($\sqrt{W}$)	t-value
$x_{i,\text{Tnum}}$	0.9483***	-8.6838	7.7855***	5.7002
$x_{i,\text{Tnum}}s_{i,\text{Need}}$	-0.5924*	-1.7552	4.3712***	6.7748
$x_{i,\text{Tnum}}s_{i,\text{Risk}}$	-1.5115***	-4.8763	4.1146***	5.3450
$x_{i,\text{Tnum}}s_{i,\text{Rate}}$	2.7274***	6.7138	4.1881***	6.1677
$x_{i,\text{EMF}}$	2.0944***	-9.8432	23.0456***	6.3525
$x_{i,\text{EMF}}s_{i,\text{Need}}$	-0.2083	-1.1549	3.5947***	6.8343
$x_{i,\text{EMF}}s_{i,\text{Risk}}$	-0.3556	-1.3158	2.6862***	6.4860
$x_{i,\text{EMF}}s_{i,\text{Rate}}$	0.8383*	1.7154	3.9809***	2.7606
$x_{i,\text{Bout}}$	2.9746***	-12.7811	24.3724***	8.9238
$x_{i,\text{Bout}}s_{i,\text{Need}}$	-1.395*	-1.6712	6.6251***	5.3412
$x_{i,\text{Bout}}s_{i,\text{Risk}}$	0.0887	0.3835	2.4760***	5.4507
$x_{i,\text{Bout}}s_{i,\text{Rate}}$	1.3824***	3.4790	2.7405***	7.5795
$x_{i,\text{Btime}}$	-6.1196***	-13.0026	86.7415***	7.5575
$x_{i,\text{Btime}}s_{i,\text{Need}}$	-3.8219***	-15.7450	2.8170***	4.3966
$x_{i,\text{Btime}}s_{i,\text{Risk}}$	-2.7475***	-7.5574	5.0609***	3.3796
$x_{i,\text{Btime}}s_{i,\text{Rate}}$	-1.1494*	-1.7414	7.7320***	5.1143
$x_{i,\text{Cost}}$	-0.1959***	-20.1189	1.4866***	8.2460

$x_{i,\text{Cost}}S_{i,\text{Need}}$	-0.1087	-0.3970	2.1718***	5.4832
$x_{i,\text{Cost}}S_{i,\text{Risk}}$	0.4814*	1.7325	3.0195***	6.1510
$x_{i,\text{Cost}}S_{i,\text{Rate}}$	1.044**	2.2855	4.6473***	4.9843
$x_{i,\text{noChoice}}$	-0.0105	-0.2395	0.6987***	5.9889
Simulated Log-likelihood		-2636.1680		

***: significant at 99% level, **: at 95% level, *: at 90% level

The mean of coefficients represents the marginal utility of consumers for a unit change in each attribute. It can be seen from above that the mean coefficients of core explanatory variables $x_{i,\text{Tnum}}$, $x_{i,\text{EMF}}$, $x_{i,\text{Bout}}$, $x_{i,\text{Btime}}$, and $x_{i,\text{Cost}}$ are all significant at 99% level. From the result, we can yield the following implication: Consumer's utility increases with (1) a decrease in the number of transmission towers when grounding is implemented, (2) a reduction of exposure of electromagnetic field (EMF) that result from high-voltage transmission lines, (3) a decrease in the number of blackouts that can happen in 5 years, (4) a decrease in the duration time of each blackout, and (5) a decrease in additional charge of electricity when underground method is introduced in the building of power transmission lines.

While, the mean coefficients of other explanatory variables that were used as interaction terms varied greatly in their level of significance. Further implications can be yielded with the interpretations of significant interaction terms. Let us first look at the variable $S_{i,\text{Need}}$, which represents the perceived need/urgency in the construction of power transmission lines. The variable is significant when implemented as an interaction term for $x_{i,\text{Tnum}}$, $x_{i,\text{Bout}}$, and $x_{i,\text{Btime}}$, with coefficients taking negative values. This means that the more an individual perceives the construction of power transmission line as urgent, his/her utility increase with a decrease in the number of transmission towers from grounding, a decrease in the number of blackouts that can happen in 5 years, and a decrease in the duration time of each blackout decreases relatively. When constructing the power transmission lines, the introduction of an underground method increases the cost and time required for the construction, making it more difficult to respond to the perceived urgent need of consumers. Thus the consumers become less sensitive to the revealed benefits that can be earned by building the power transmission underground.

Variable $S_{i,\text{Risk}}$ representing the individuals' attitudes towards risk is significant when implemented as an interaction term for $x_{i,\text{Tnum}}$, $x_{i,\text{Btime}}$, and $x_{i,\text{Cost}}$. The signs for coefficients of $x_{i,\text{Tnum}}S_{i,\text{Risk}}$ and $x_{i,\text{Btime}}S_{i,\text{Risk}}$ are negative, meaning that the more risk-accepting (or risk-loving) an individual is, his/her utility increase with a decrease in the number of transmission towers from grounding and from a decrease in the duration time of each blackout reduces than otherwise. While there are opposing views on whether or not the existence and/or building of high-voltage power transmission towers cause any harm to the residents, those who more are less prone to risks are more likely to better accept uncertainties and to be indifferent to existing inconveniencies. Thus likewise, they would be less sensitive to the reduction of number of high-voltage transmission towers and decrease in blackout duration time.

Nevertheless, the sign for coefficient of $x_{i,\text{Cost}}S_{i,\text{Risk}}$ is positive, meaning that the more risk-accepting (or risk-loving) an individual is, his/her utility increase with a decrease in the additional cost of electricity when then underground method is introduced in building of power transmission line increases. While it is trivial that all individuals prefer cost reduction when other conditions are kept the same, those who are risk-loving are more likely to accept any changes that may need to be made to lower the electricity cost. Such, in this case, may mean installing transmission towers rather than underground power transmission cables, which are much more expensive.

Lastly, refer to the variable $S_{i,\text{Rate}}$ representing the grounding rate of power transmission line in the city of respondent's residence. The coefficients are significant and positive when interacted with $x_{i,\text{Tnum}}$, $x_{i,\text{EMF}}$, $x_{i,\text{Bout}}$, and $x_{i,\text{Cost}}$. This means that the greater the grounding rate of power transmission line in an individual's city of residence, his/her utility increase with a decrease in the number of transmission towers, a decrease in the exposure to electromagnetic field, a decrease in the number of blackouts that can happen in 5 years, and a decrease in the additional cost of electricity when then underground method is introduced in building of power transmission line increases. This can be interpreted as that those living in cities with greater rate of grounding are more sensitive to building ‘non-grounded’ transmission lines. For example, people living in the city of Seoul where the grounding rate reaches 88.1% rarely observe transmission towers in their daily lives, and thus once they do, it will seem very extraneous and alienated. Such tendency in sensitivity can also be viewed as a signal as to how the residents whose utility increases with the rise of the grounding rate would organize the city budgets so that their needs can be better met, yielding faster grounding rate of the electric power transmission line than those of other cities whose residents are relatively less sensitive.

All of the estimates of standard deviation were significant at 99% level, meaning that individual heterogeneity exists in his/her preference structure regarding all attributes of the studied model.

4.2.2 Sensitivity Analysis

Up to now, we’ve observed how different attributes of the electric power transmission line installation affects the consumers’ choice of service. We have also seen how the respondents’ personal characteristics such as their perceived need/urgency in the construction of power transmission lines, their attitudes towards risk, and the grounding rate of power transmission line in the city of the respondents’ residence affect their choice behavior regarding each attribute.

Through the estimation of the mixed logit model, coefficients for each variable were well estimated. Accordingly, the choice probability of a hypothetical project with certain attribute levels when given the other option of ‘no choice’, which in case the respondents choose to stay as is, can be drawn. The change of choice probability with the change in the number of transmission towers, the electromagnetic field exposure, the number of blackouts, and the duration time of each blackout can be figured. Additionally, the change of choice probability with the change in the additional electricity cost was then found. The sensitivity analysis for each case is performed independently and then were integrated into a single graph. In observing changes in the choice probabilities with change in the level of each attribute, the level of any attributes other than that of being observed is kept constant at the average level. The summary of results is presented in the graph of Figure 5 below.

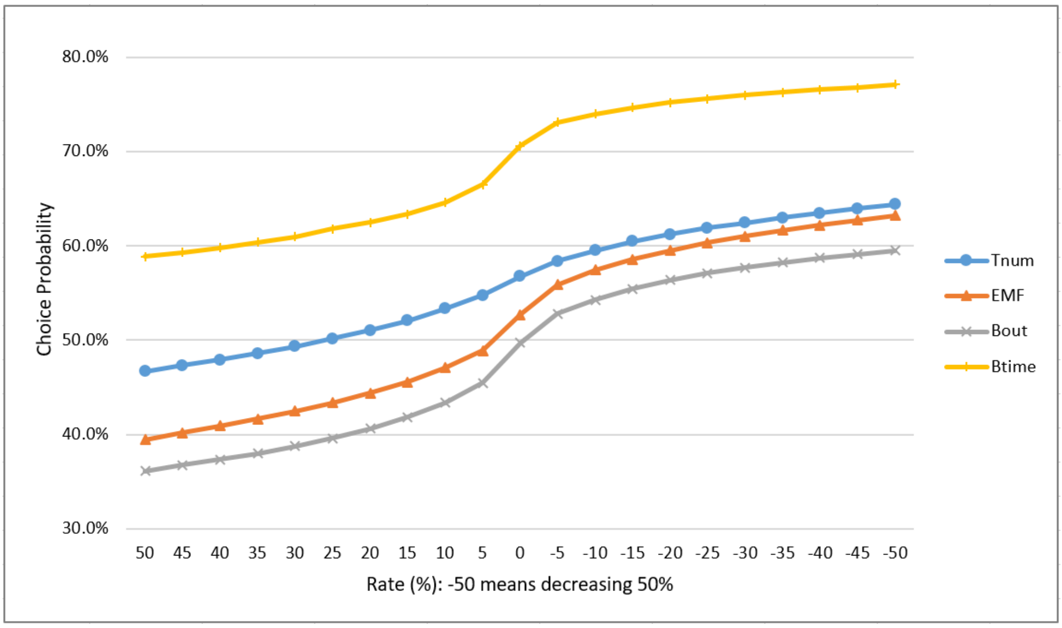

Figure 5. Change of Choice Probability with Change in Attribute Level

As can be seen, the respondents' choice probabilities increase with the decrease of every attribute. The graphs are all represented in the shape of S-curve. Amongst, the change in the choice probability with the decrease in the number of transmission towers rises least steeply, and the choice probability with the decrease in the number of blackouts rises by the highest slope, both near the rate of 0%. Meanwhile, the choice probability difference between rate of -50% and +50% was the greatest for the attribute of electromagnetic field exposure reduction (23.8%). The probability difference for other attributes were greatest in the order of 23.4%, 18.2%, and 17.7%, each representing the number of blackouts, the duration of each blackout, and the number of transmission towers, respectively. Based on such result, we can conclude that the change in the number of transmission towers least affect the choice probability of the respondents amongst these four variables.

Sensitivity analysis regarding the additional electricity cost variable was executed separately, for the change for the cost was measured in the unit of KRW, not in rate (%). The result can be seen in the graph of Figure 6.

Just as the change trends of choice probabilities of other attributes, the change in the choice probability in regards to additional electric cost was revealed to be in a S-shape curve. The difference in the maximum and the minimum choice probability in the above graph was 8.5%, which is the least difference amongst the simulations of all attributes. Moreover, the choice probability with the decrease in the additional electricity rises by the lowest slope near the rate of 0%, even when compared to that of the attribute regarding transmission tower number change.

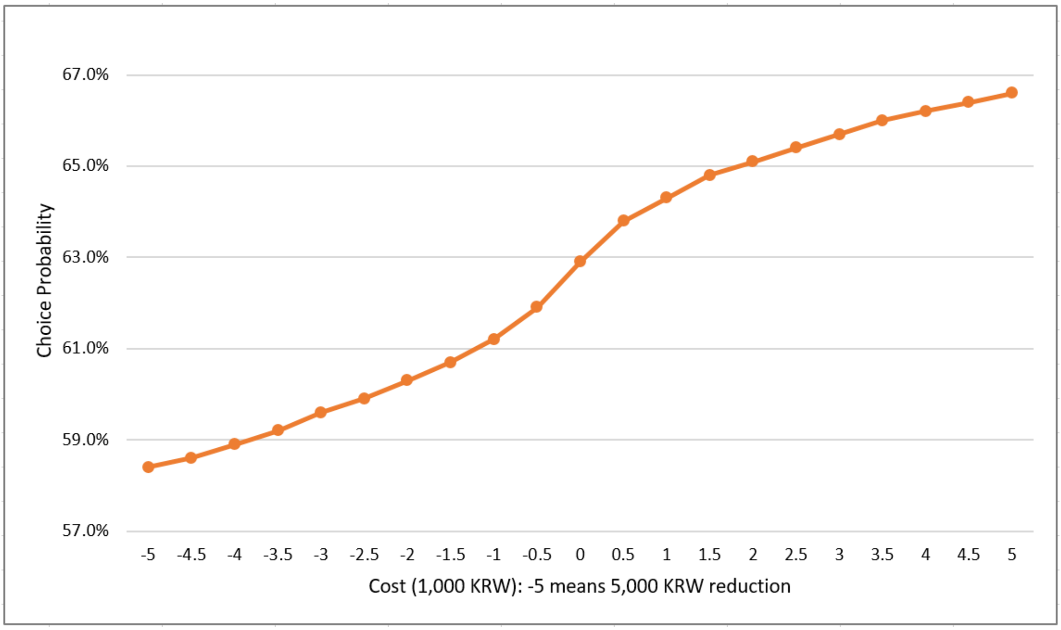

Figure 6. Change of Choice Probability with Change of Additional Cost

Using the estimation results the mixed logit model, we can also observe the change in the choice probability of respondents based on their city of residence regarding a hypothetical project with average attribute levels when given the other option of 'no choice'. The coefficient for the variable $S_{i,\mathrm{Rate}}$, which was set to represent the grounding rate of power transmission line in the city of the respondents' residence was used. The grounding rate was set to vary according to the actual grounding rate of each city, while keeping the coefficients of other variables constant. The sensitivity analysis result is presented in the bar graph of Figure 7 and 8 represented below.

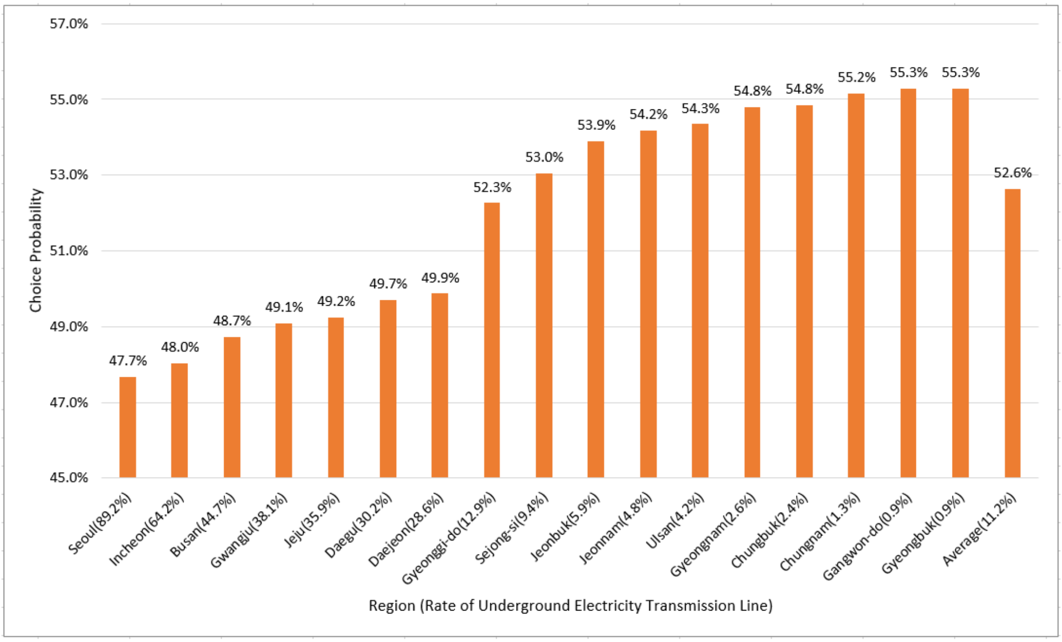

Figure 7. Choice Probability According to the City of Residence

As expected, the choice probability of those living in Gangwon and Gyeongbuk region were the highest with 55.3% probability. The grounding rate of these regions were 0.9%, which is the lowest rate amongst the surveyed. The choice probability of those living in Seoul was the lowest with 47.7% probability, while the grounding rate of Seoul was 89.2%. The average grounding rate of the cities was 11.12%, and the choice probability of the given grounding rate was 52.6%. The difference between the greatest and the lowest choice probability was revealed to be 7.6%, with grounding rate difference of 88.3% (Seoul: 89.2%, Gangwon & Gyungbuk: 0.9%, respectively). It is rather obvious that the choice probability decreases with the increase of the electric power transmission line grounding rate of the respondents' city of residence, implying the greater need of underground construction amongst those who are rather neglected.

Figure 8 is additionally included to visually show the relationship between the rates of underground electricity transmission line of different cities and their choice probabilities. The yielded choice probability is then represented on the regional map of South Korea for further explanation, as shown in Figure 9.

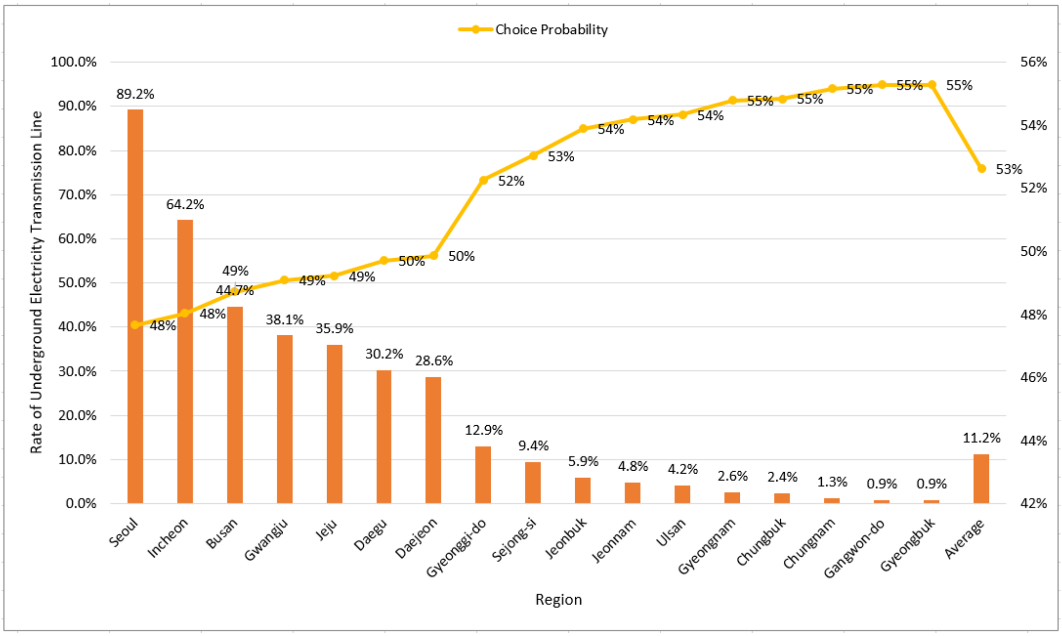

Figure 8. Grounding Rate and the Choice Probability

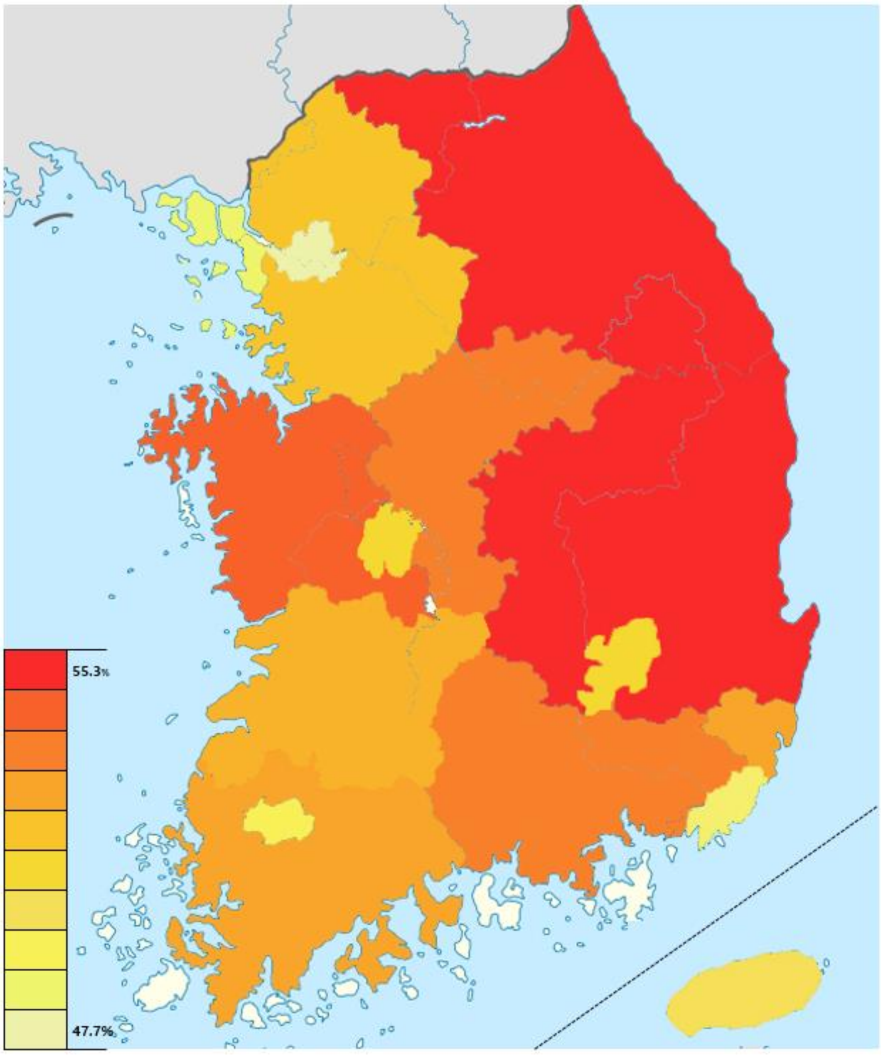

Figure 9. The Choice Probability Map

4.3 Latent Class Model Estimation Results

The analysis of the latent class model was done using the STATA/SE 13.1 program. For parameter estimations, Expectation-Maximization algorithm was used.

4.3.1 Summary of Results

Variables core explanatory variables that were used for the analysis were same as that of the mixed logit model. Four other variables were used to segment individuals into groups in the latent class model: $D_{i,\text{Capital}}$, $S_{i,\text{Knowledge}}$, $S_{i,\text{Trust}}$, and $S_{i,\text{Accept}}$ that indicates whether one lives in the capital area or not (dummy), average level of knowledge regarding the power transmission line, average level of trust in the environmental, health, and economic evaluations executed by organizations, and the level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood, respectively.

5-point Likert scale was specifically used for the measurement of additional variables $S_{i,\text{Knowledge}}$, $S_{i,\text{Trust}}$, and $S_{i,\text{Accept}}$. For variables $S_{i,\text{Knowledge}}$ and $S_{i,\text{Trust}}$, several questions were asked (2-5 questions), where then the collected data was then averaged out to yield indicators for the represented variables. $D_{i,\text{Capital}}$ was used as a dummy variable that collected values of either 0/1. The collected data of these variables are summarized in Table 13 below.

Table 13. Summary of Respondent Characteristics (unit: number (%))

	Lives in capital area			Do not live in capital area	
$D_{i,\text{Capital}}$	250 (62.5)			150 (37.5)	
	Do not know at all	Do not know well	Average	Know pretty well	Know very well
Type of high-power transmission lines	26 (6.5)	176 (44)	151 (37.75)	46 (11.5)	1 (0.25)
Environmental and health effects of high-power transmission lines	14 (3.5)	88 (22)	139 (34.75)	151 (37.75)	8 (2)
$S_{i,\text{Knowledge}}$	20	132	290	197	4.5
	Do not trust at all	Do not trust	Indifferent	Trust	Fully trust
Electricity related government ministries	60 (15)	115 (28.75)	187 (46.75)	87 (21.75)	6 (1.5)
KEPCO	9 (2.25)	118 (29.5)	189 (47.25)	81 (20.25)	3 (0.75)
Environment-related civic groups	4 (1)	55 (13.75)	179 (44.75)	141 (35.25)	21 (5.25)
Experts (i.e. professors)	2 (0.5)	33 (8.25)	181 (45.25)	181 (45.25)	3 (0.75)
$S_{i,\text{Trust}}$	18.75	80.25	184	122.5	8.25
	Fully against	Against	Indifferent	Support	Fully support
$S_{i,\text{Accept}}$	43 (10.75)	241 (60.25)	62 (15.5)	54 (13.5)	0 (0)

In the latent class model, the number of classes should be specified by the researcher. The values of CAIC and BIC, which work as the criteria for determining the optimal number of groups for the potential latent class model, depend on the given number of groups. Information Criteria values were calculated for analysis and the result yielded that the model to be most accurate when the respondents were divided into three different classes. The calculated values are as of follows: (1) Log-likelihood = -1316.321, (2) AIC = 2688.642, (3) CAIC = 2828.403, and (4) BIC = 2800.403. The estimation results of the latent class model based on three-class-division is summarized in Table 14 and 15 below.

Table 14. Estimation Results of Latent Class Model (1)

Class	Attribute	Coefficient	Std. Error	Z-Value
Class 1 (14.6%)	Decrease in the # of transmission towers	0.0745*	0.057	1.31
	Decrease in exposure to electromagnetic field	0.0250	0.0201	1.24
	Decrease in the number of blackouts	-0.0857***	0.0282	-3.04
	Increase in the duration time of each blackout	-0.0234**	0.0126	-1.86
	Increase in the additional electricity cost	-0.0002	0.0002	-1.05
	No Choice	-6.186***	1.7055	-3.63

Class 2 (58.7%)	Decrease in the # of transmission towers	0.1287***	0.0213	6.04
	Decrease in exposure to electromagnetic field	0.0117	0.0102	1.15
	Decrease in the number of blackouts	0.0313***	0.0007	4.79
	Increase in the duration time of each blackout	0.0031	0.0079	0.39
	Increase in the additional electricity cost	-0.0007***	0.0000	-7.99
	No Choice	-0.1566	0.0578	-0.29
Class 3 (26.7%)	Decrease in the # of transmission towers	0.0378	0.0383	0.99
	Decrease in exposure to electromagnetic field	-0.0170	0.0180	-0.94
	Decrease in the number of blackouts	0.0060	0.0084	0.71
	Increase in the duration time of each blackout	-0.0198**	0.0111	-1.78
	Increase in the additional electricity cost	-0.0007***	0.0001	-4.7
	No Choice	-0.1063	0.6208	-0.17

***: significant at 99% level, **: at 95% level, *: at 90% level

Table 14 presents the preference structure of respondents of each group. In case of Class 1, which consists 14.6% of the total respondents, utility changes due to the decrease in the exposure to the electromagnetic field and the decrease in the additional electricity cost was insignificant. On the other hand, their utilities were shown to increase with the decrease in the number of transmission towers, increase in the number of blackouts, and decrease in the duration time of each blackout. They also preferred not to stay in the condition as it is. From such characteristics, we can conclude that respondents in class 1 seeks for change, a change that can for example decrease the number of transmission towers and the decrease in the duration of blackouts. The reason why their utilities increase with the increased number of blackouts can be explained by the argument the transition of electric power service from one type to another (in terms of the construction type) is inevitably accompanied with some risks. For example, in order to ground the overhead transmission line, a construction is a must, which may cause unstable service to some extent. Viewed otherwise, even if the change may cause even more frequent number of blackouts, as long as the duration is short, respondents' utilities would increase. Last but not least, they are also indifferent to the health issues resulting from EMF exposure and electricity cost increase that may follow from such change. Based on the given preference structure, we can define this class as "Change Seekers".

Class 2 consists of 58.7% of the respondents, which can be considered as the greatest group composition. The members of the group had the following preference structure: their utilities increase with the decrease in the number of transmission towers, the decrease in the number of blackouts, and the decrease in the additional electricity cost. Such characteristics can be seen as rather practical, for these are the factors that can directly affect your daily lives and those that can for sure increase your quality of life. Whereas, the decrease in the exposure to electromagnetic field cannot directly be observed nor is clearly proven to cause harm to one's health. The duration of blackouts also would not matter if the number of blackouts itself is significantly reduced. We can accordingly define this class as "Pragmatic Adopters".

Lastly, Class 3 represents 26.7% of the respondent population. The preference structure of those belonging to this group was rather simple. Their utilities increased with the decrease in the duration of blackouts and with the decrease in the additional electricity cost. Amongst, the cost variable was the only variable with 99% significance level. The rest of the explanatory variables were yielded to be insignificant. This implies that the factor 'cost' is the utmost important factor in the decision makings of the group members. This group can thus be named as "Frugal Adopters".

Table 15 presents the characteristics of respondents belonging in each group compared to those in the reference class, which in this case is set as Class 3. Variables of $D_{i,\text{Capital}}$, $S_{i,\text{Knowledge}}$, $S_{i,\text{Trust}}$, and $S_{i,\text{Accept}}$ that indicates whether one lives in the capital area or not (dummy), average level of knowledge regarding the power transmission line, average level of trust in the environmental, health, and economic evaluations executed by organizations, and the level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood, respectively, were used for segmentation.

Table 15. Estimation Results of Latent Class Model (2)

Class	Attribute	Coefficient	Std. Error	Z-Value
Class 1	Residing in capital area	-0.1603	0.6704	0.24
	Average knowledge level	1.1069***	0.3279	3.38
	Average trust level	-1.8275***	0.5994	-3.05
	Average acceptance level	1.0025***	0.2868	3.5
	Constant	-0.4004	1.6077	-0.25
Class 2	Residing in capital area	-0.6604**	0.3560	-1.86
	Average knowledge level	0.7678***	0.2416	3.18
	Average trust level	-0.6862**	0.3235	-2.12
	Average acceptance level	0.2629*	0.1957	1.34
	Constant	0.6997	1.0712	0.65
Class 3	Reference			

***: significant at 99% level, **: at 95% level, *: at 90% level

As can be seen in the table, respondents belonging in Class 1 had greater level of knowledge in the construction of power transmission line than those in Class 3. Meanwhile, they had a lower average trust level in the organizations that perform environmental, health, and economic evaluations. This may be so because whereas the related organizations have usual tendencies of announcing their study results and evaluations leaned towards their interest, those with greater knowledge level will be better aware that they may need to be careful in fully accepting the given information verbatim as they are, for they themselves will have knowledge basis on which they can build independent stances regarding the issue. Nevertheless, members of Class 1 had a higher level of acceptance in building high-voltage transmission infrastructure in the nearby neighborhood was higher than those in Class 3. These results are in line with the preference structure represented in Table 15. With high knowledge level regarding the issue and clear judgement basis, they can more willingly accept changes, including that of transmission infrastructure installation as “Change Seekers”.

Contrastingly, those belonging in Class 2 could not well be described as to have a high average acceptance level (90% significance level). While all other characteristics were revealed to be the same as those in Class 1 (have a higher average knowledge level and a lower trust level), respondents in Class 2 had a lower chance of residing in the capital area than those belonging in Class 3. Such character is in line with the grouping of “Pragmatic Adopters”, in order to be practical and economic requires some level of knowledge. Moreover, those residing outside the capital area have a higher chance to be limited in budget, as can also be seen through the regional budget constraint leading to lower adoption of underground transmission line. Although they are aware of the benefits, they prefer to adopt technology that does not harm them financially and can yield realistic and hands-on effect on their daily lives.

Lastly, contrastingly to members of Classes 1 and 2, those belonging in Class 3 were revealed to have a lower average knowledge level regarding the construction of power transmission line and a lower level of trust in the organizations that perform environmental, health, and economic evaluations. Being rather uninformed, a single attribute that they can consider precisely without having to worry about making ignorant choices is the 'cost'. Thus as named "Frugal Adopters", their preference structure is rather simple and straight forward.

Meanwhile, pragmatic adopters and frugal adopters can be categorized on the same line considering that their utilities increase with the decrease in the additional electricity cost, as so-called "Cost-Sensitive Adopters", whereas those who are change-seekers do not consider the attribute of cost. Thus we can state that the heterogeneous structure is rather hierarchical. The segmentation result can be summarized in Figure 10 below.

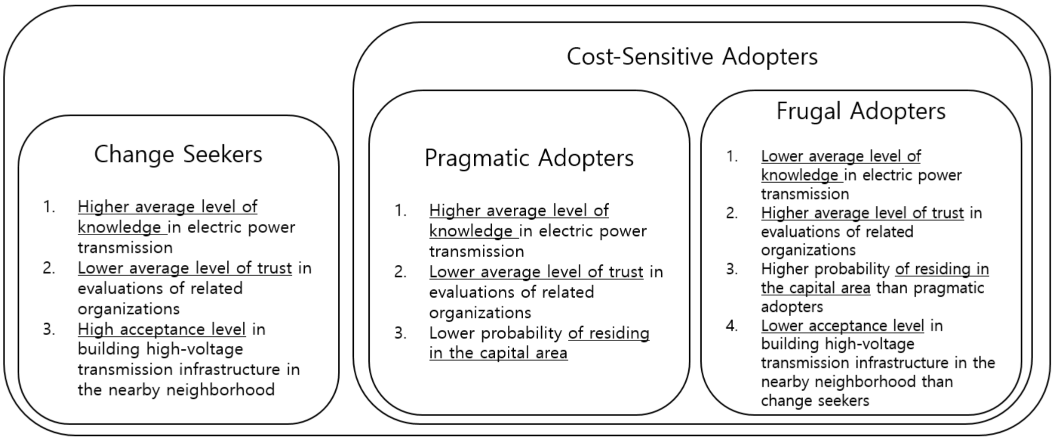

Figure 10. Segmentation of Latent Class Model Results

4.3.2 Sensitivity Analysis

Through the estimation of the latent class model, we were able to segment the consumers into three groups according to their adoption characteristics. Coefficients for different attributes of the electric power transmission line installation for each group were as well estimated. Accordingly, the choice probability of a hypothetical project with certain attribute levels when given the other option of 'no choice', which in case the respondents choose to stay as is, can be drawn. In other words, the change of choice probability with the change in the level of each attribute of the project can be figured. The sensitivity analysis for the change in the number of transmission towers, number of blackouts, and the additional electricity cost were performed independently for every group to observe varying changes. In analyzing changes in the choice probabilities with change in the level of each attribute, the level of any attributes other than that of being observed is kept constant at the average level.

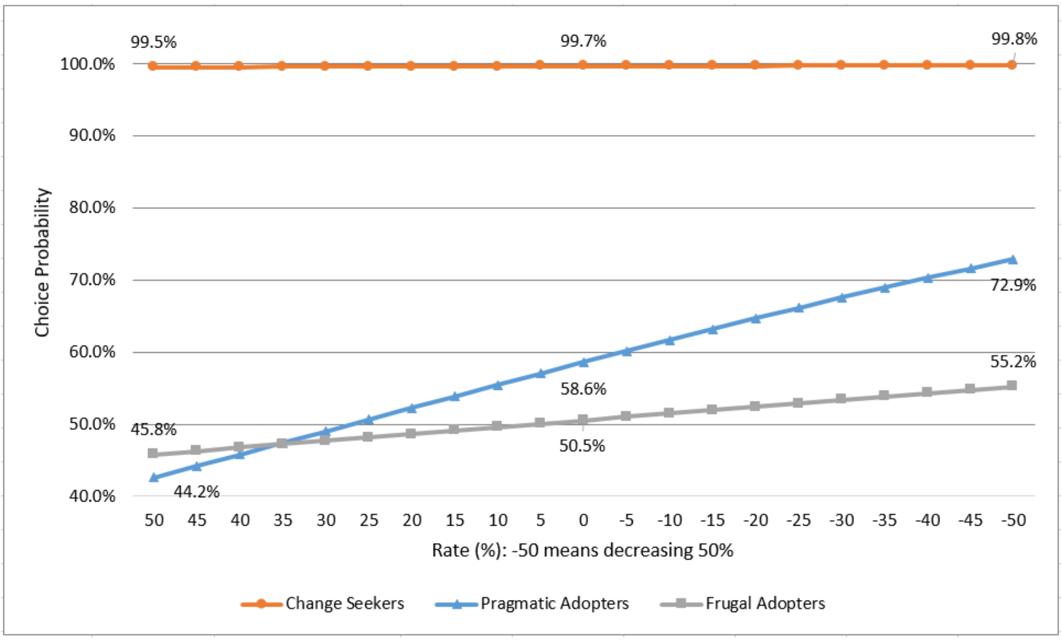

Figure 11. Change of Choice Probability with Change of Transmission Towers

The summary of results is presented in the graph of Figure 11, 12, and 13. As can be seen in Figure 11, the respondents' choice probability increase with the decrease in the number of transmission towers, and such tendency is in a linear form. The rise of the probability is most steep with the pragmatic adopters with the probability difference of 28.7% and least steep for change seekers with the probability difference of 0.3%. The attribute of the number of transmission tower was significant at 99% level for the pragmatic adopters, so the graph is on the same line as our latent class analysis result.

Nonetheless, the respondents' choice probability increase with the decrease in the number of blackouts, and such tendency is also in a linear form as in Figure 12. The rise of the probability is again most steep with the pragmatic adopters with the probability difference of 7.6% and least steep for frugal adopters with the 1.5% probability difference.

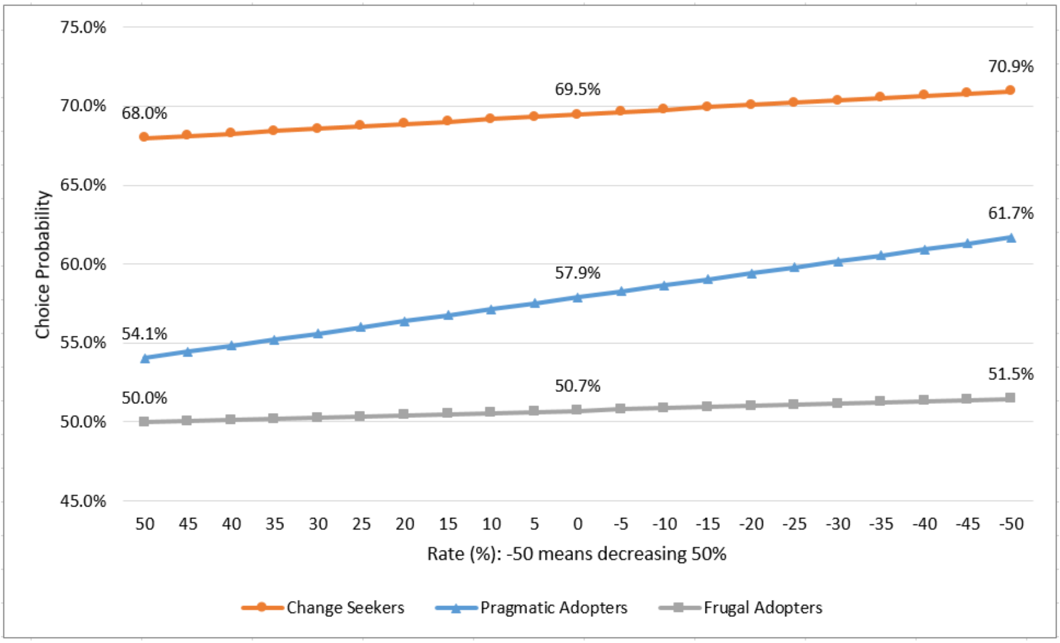

Figure 12. Change of Choice Probability with Change of Number of Blackouts

The directivity of the graph in Figure 12 is in parallel as that of the results presented in Table 15. This is because the attribute of the decrease in the number of blackouts was significant for change seekers and pragmatic adopters only, each at 95% and 99% level, respectively. In other words, frugal adopters are to be least sensitive to the given attribute. Sensitivity analysis regarding the additional electricity cost variable was executed separately as shown in Figure 13 below, for the change for the cost was measured in the unit of KRW, not in rate (%).

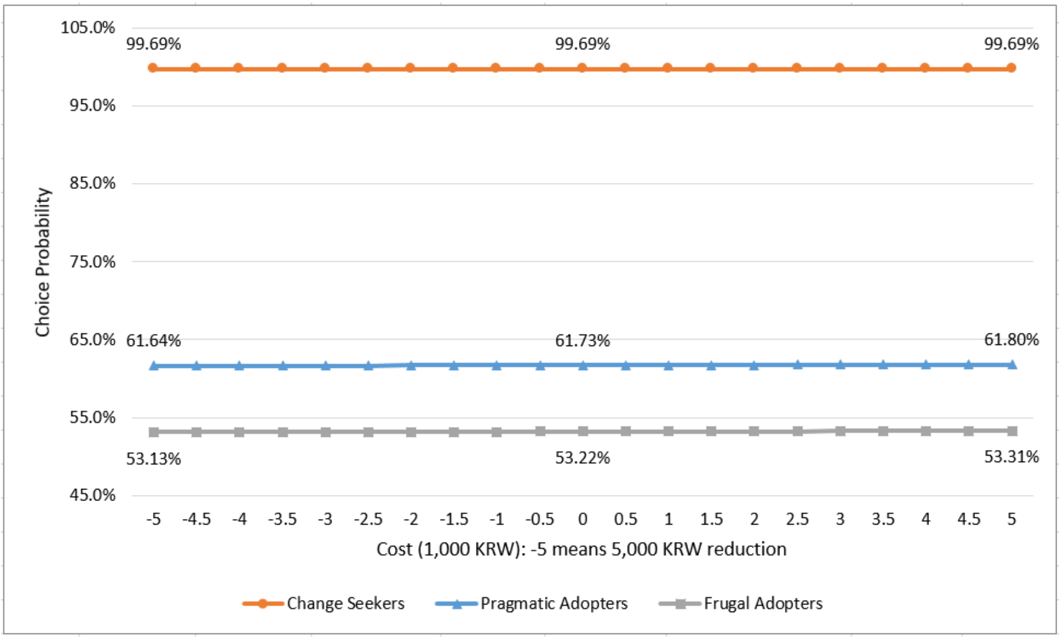

Figure 13. Change of Choice Probability with Change of Additional Cost

The change in additional electricity cost rarely affected the change in the choice probability of change seekers. Contrastingly, the decrease in the additional electricity cost yielded increase in the choice probabilities for pragmatic adopters and frugal adopters, who were categorized as cost-sensitive adopters. The rise of the probability in pragmatic adopters is 0.16%, whereas the rise is 0.18 for frugal adopters. Frugal adopters are those who only care about the attribute regarding costs, so they would be more sensitive to additional electricity costs than pragmatic adopters, who do care about costs, but also consider other factors in their choice behaviors.

Chapter 5. Discussion and Conclusion

It has long been argued that when pursuing governmental projects that may lead to controversies due to varying interests, they need to be promoted and implemented in ways that can minimize the imbalance of both the conflicting stakes and the situational conditions. This is especially true with the case of electric power transmission line installation in South Korea, where the conflicting interests of KEPCO and the residents of Milyang has even led to the halt of the construction, with stakeholders unable to reach a means of consensus regarding the issue.

In this paper, citizens' preference on power transmission cable installation in South Korea was analyzed, focusing on individuals' heterogeneity. In doing so, discrete choice models are used. The mixed logit model was used to identify the general preference structure of the respondents (individual heterogeneity), whereas the latent class model was used to enable group segmentation (group heterogeneity). Attributes such as the number of transmission tower, electromagnetic field exposure, number of blackouts, duration of each blackout, and additional electricity cost were primarily considered for the choice experiment. Factors that represent respondents' psychological characteristics, such as individual's perceived need for the project, attitude towards risk, and the city of residence were additionally considered for analysis. The stated preference data was gathered using survey questionnaires, which were executed for 18 days, from July 24^{th} to

August 10th of 2014, addressing 400 residents, men and women, who were between ages 20-59 years old.

The mixed logit model was first used to identify the heterogeneity in consumer preference structure on power transmission cable installation. The results showed that the consumer's utility increased with (1) a decrease in the number of transmission towers when grounding is implemented, (2) a reduction of exposure of electromagnetic field (EMF) that result from high-voltage transmission lines, (3) a decrease in the number of blackouts that can happen in 5 years, (4) a decrease in the duration time of each blackout, and (5) a decrease in additional charge of electricity when the underground method is introduced in the building of power transmission lines.

With regard to the psychological factors, the more an individual perceives the construction of power transmission line as urgent, his/her utility will increase with a decrease in the number of transmission towers from grounding, a decrease in the number of blackouts that can happen in five years, and a decrease in the duration time of each blackout. Moreover, it was discovered that if an individual is risk-accepting (or risk-loving), his/her utility will increase with a decrease in the number of transmission towers from grounding and from a decrease in the duration time of each blackout, than otherwise. Lastly, the respondents' utility increased with a decrease in the additional cost of electricity when the underground method was introduced. The variable that represented the grounding rate was positive and significant for all attributes other than the duration of blackouts, suggesting that the environment of residence significantly affects the choice of the respondents.

Through sensitivity analysis, changes in the choice probabilities along with changes in the level of each attribute was observed, while the level of any attributes other than the one being observed is kept constant at the average level. The increase in respondents' choice probabilities with the decrease of every attribute was represented in an S-shaped curve. The changes in the choice probability with the decrease in the number of transmission towers rises least steeply, and the choice probability with the decrease in the number of blackouts rises by the highest slope, both near the rate of 0%. Meanwhile, the choice probability difference between the rate of -50% and +50% was the greatest for the attribute of electromagnetic field exposure reduction (23.8%). Based on this result, we can conclude that the change in the number of transmission towers affects the choice probability the least amongst the four variables, excluding cost. We can also conclude that the choice probability with the decrease in the additional electricity rises by the lowest slope, near the rate of 0%, even when compared to that of the attribute regarding transmission tower number change. Lastly, a rather obvious result that the choice probability decreases with the increase of the electric power transmission line grounding rate of the respondents' city of residence was figured, implying that underground construction amongst is necessary the cities that are often overlooked.

The latent class model was then used to enable segmentation of consumers. Because the power transmission line installation projects are conducted at a national level or at a regional level, implications in a group level need to be derived as well, unlike the products that target individual consumers. Four other variables were used to segment individuals into groups in the latent class model: indications of living in the capital area, average level of knowledge regarding the power transmission line, average level of trust in the environmental, health, and economic evaluations executed by organizations, and the level of acceptance for high-voltage transmission infrastructure in the nearby neighborhood, respectively.

Based on the CAIC and BIC values, it was determined that the respondents are best modeled when divided into three classes. Accordingly, the respondents were classified into “Change Seekers”, “Pragmatic Adopters”, and “Frugal Adopters”. Here, the Pragmatic Adopters and Frugal Adopters could be together classified as cost-sensitive adopters. Meanwhile, Change Seekers had a higher average level of knowledge in electric power transmission, a lower level of trust in evaluations of related organizations, and a higher acceptance level in building high-voltage transmission infrastructure in the nearby neighborhood than frugal adopters. Pragmatic Adopters also had a higher average level of knowledge in electric power transmission and lower level of trust in evaluations of related organizations, along with a lower probability of residing in the capital area. The preference structure of each group was figured, yielding choices that were on the same line as revealed by their names.

The following implications can also be yielded: the more an individual perceives the construction of the power transmission line as urgently needed, the more they will want the transmission line installation method that can promptly respond to their needs. The introduction of an underground method increases the cost and time required for the construction, making consumers less sensitive to the revealed benefits of building the power transmission line underground. Thus, the government should well emphasize the importance, the need and/or the urgency of its project to the residents of the city in which overhead transmission lines are being planned for easier adoption.

Moreover, while there are opposing views on if the existence and/or building of high-voltage power transmission towers causes any harm to the residents, those who are less prone to risks are more likely to better accept uncertainties and be indifferent to existing inconveniencies. Lastly, those living in cities with a greater rate of grounding are more sensitive to building overhead transmission lines. Such tendencies in sensitivity can also be viewed as a signal as to how these residents would organize the city budgets so that their needs can be better met, yielding faster grounding rate of the electric power transmission line than those of other cities whose residents are relatively less sensitive. Thus likewise, they would be less sensitive to a reduction in the number of high-voltage transmission towers and a decrease in blackout duration time.

The results of this paper are expected to contribute in identifying the varying preferences of subjects for governmental projects, which can help regional governments have a greater understanding of the specific needs of consumers.

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Appendix 1: Survey Questionnaire

Questionnaires regarding power transmission line was used in this paper. The survey was executed for 18 days, from July 24th to August 10th of year 2014, addressing 400 residents, men and women, who were of age between 20~59 years-old. Two different versions of questionnaires were used (Type A and B), where the individual interviews were proceeded by Gallup, a specialized survey agency, in order to increase the reliability of the data. In this part of the appendix, Type A of the survey questionnaire is appended for reference.

208 SAJIK-DONG JONGRO-GU SEOUL, KOREA, 110-054 TEL(02)3702-2100 / FAX(02)3702-2121/E-mail info @gallup.co.kr / internetwww.gallup.co.kr
affiliated with GALLUPINTERNATIONAL

GMR 2014-141-009 전력서비스에 대한 소비자 수용도 조사 (TYPE A) | | | | 1 |

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

한국갤럽조사연구소에서는 **기초전력연구원의 의뢰로** 일반국민 여러분의 **전력서비스에 대한 태도와 선호도를** 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(제13조, 제14조)에 따라 통계목적으로만 사용되며, 귀하의 의견은 철저히 보호됨을 약속드립니다. 바쁘시겠지만, 조사에 협조해 주시면 대단히 감사드리겠습니다.

2014년 7월
한국갤럽조사연구소
박 무 익

먼저, 응답자 선정 질문입니다.

SQ1. 응답자 성별 : 1. 남성 2. 여성

SQ2. 귀하께서는 올해 만으로 나이(=2013-출생년도)가 얼마나 되십니까?

만 [ ][ ] 세 → **만20세-59세 사이만 조사 진행**

SQ3. 귀하께서는 귀댁의 세대주 또는 세대주 배우자 되십니까?

1. 세대주
2. 세대주 배우자
3. 세대주나 세대주 배우자 아님 → **조사종료**

SQ4. 귀댁에서는 매월 소득이 있으십니까?

1. 예 (소득 있음) 2. 아니오 (소득 없음) → **조사종료**

SQ5. 귀하가 현재 살고 계시는 지역은 어디입니까?

1. 서울 2. 인천 3. 신도시(경기도 일산)
4. 신도시(경기도 분당) 5. 부산 6. 대구
7. 광주 8. 대전 9. 그 외 지역

→ **보기 9. 응답은 조사종료**

SQ6. 다음 중 귀하 본인이나 함께 살고 계시는 가족 분이 근무하시는 업종에 해당하는 보기를 모두 선택해 주십시오.

1. 광고 대행사 및 시장조사 관련 업종
2. 방송국/신문/잡지 등 언론계
3. 한국전력이나 발전사 등 에너지 관련 회사
4. 음료/주류/ 제과 등 식품 관련 회사
5. 은행/보험 등 금융 관련 회사
6. 제약/의료 관련 회사
7. 기타 회사 / 모두 해당 없음

→ **보기 1.~3. 응답은 조사종료**

다음 페이지부터 응답자 자기기입식으로 진행해 주십시오.

질문 작성 시 유의사항

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

A. 전력서비스에 대한 인식 및 사용행동

먼저, 전력서비스에 대한 귀하의 일반적인 의견을 묻는 질문입니다.

문1. 귀하께서는 평소 전력서비스(전기요금, 품질, 친절도 등)에 대해 어느 정도 관심을 갖고 있으십니까?

전혀 관심없다	관심없는 편이다	보통이다	관심있는 편이다	매우 관심있다
1	2	3	4	5

문2. 귀하께서는 다음 제시한 각 요인이 전력서비스 이용에 어느 정도 중요하다고 생각하십니까?

	전혀 중요하지 않다	중요하지 않은 편이다	보통이다	중요한 편이다	매우 중요하다
	1	2	3	4	5
1. 전기요금 수준	1	2	3	4	5
2. 안정적인 전기 공급(낮은 정전 빈도 등)	1	2	3	4	5
3. 다양한 발전원(화력, 원자력, 신재생 에너지 등) 확보	1	2	3	4	5
4. 태양열/태양광, 풍력, 지열 등 대체 에너지 개발	1	2	3	4	5
5. 에너지 수입 및 해외 의존도 감소	1	2	3	4	5
6. 안전한 발전소 운영(원자력 발전소 등)	1	2	3	4	5
7. 정부의 일관적인 전력서비스 정책 집행 및 규제	1	2	3	4	5
8. 효율적인 전력 소비를 위한 캠페인	1	2	3	4	5
9. 고장수리나 각종 민원처리 등 전력회사의 고객 서비스 수준	1	2	3	4	5
10. 전력회사의 사회공헌 활동(각종 기부, 지원/자원봉사 활동 등)	1	2	3	4	5
11. 전력회사의 전반적인 이미지	1	2	3	4	5
12. 전력공급 관련 첨단기술 적용 여부	1	2	3	4	5

문2-1. 그럼, 전력서비스에서 중요한 요인은 무엇이라고 생각하십니까? 중요한 순서대로 다음 답란에 2개까지 응답해 주십시오.

1위		2위	

1. 전기요금 수준
2. 안정적인 전기 공급(낮은 정전 빈도 등)
3. 다양한 발전원(화력, 원자력, 신재생 에너지 등) 확보
4. 태양열/태양광, 풍력, 지열 등 대체 에너지 개발
5. 에너지 수입 및 해외 의존도 감소
6. 안전한 발전소 운영(원자력 발전소 등)
7. 정부의 일관적인 전력서비스 정책 집행 및 규제
8. 효율적인 전력 소비를 위한 캠페인
9. 고장수리, 민원처리 등 전력회사의 고객 서비스 수준
10. 전력회사의 사회공헌 활동(기부, 지원/자원봉사 활동 등)
11. 전력회사의 전반적인 이미지
12. 전력공급 관련 첨단기술 적용 여부

문3. 귀하께서는 전력서비스에 대해 어느 정도 만족하십니까? 다음 각 항목별로 만족도 수준을 응답해 주십시오.

	매우 불만족한다	불만족하는 편이다	보통이다	만족하는 편이다	매우 만족한다
	1	2	3	4	5
1. 전기 사용요금 수준	1	2	3	4	5
2. 정확한 전기 사용요금 통지	1	2	3	4	5
3. 전기 공급의 안정성(낮은 정전 빈도 등)	1	2	3	4	5
4. 정전지역 안내 및 신속한 복구	1	2	3	4	5
5. 전기 계량기(미터기) 사용 편리성	1	2	3	4	5
◉ 앞서 평가한 모든 점을 고려해 보았을 때, 현재 국내 가정용 전력서비스에 대한 전반적 만족도	1	2	3	4	5

문3-1. 그럼, 전반적인 전력서비스 만족도 향상을 위해 가장 우선적으로 개선되어야 할 항목은 무엇이라고 생각하십니까? 중요한 순서대로 다음 답란에 2개까지 응답해 주십시오.

1위		2위	

1. 전기 사용요금 수준
2. 정확한 전기 사용요금 통지
3. 전기 공급의 안정성(낮은 정전 빈도 등)
4. 정전지역 안내 및 신속한 복구
5. 전기 계량기(미터기) 사용 편리성
6. 기타(구체적으로 응답해 주십시오 : ______________________)

문4. 귀하께서는 우리나라 국민이나 귀 댁에서 전기를 아끼기 위해 어느 정도 노력한다고 생각하십니까? 우리나라 국민과 귀 댁의 전기절약을 위한 노력 수준에 대해 각각 응답해 주십시오.

	전혀 그렇지 않다	그렇지 않은 편이다	보통이다	그런 편이다	매우 그렇다
	1	2	3	4	5
1. 우리나라 국민들은 전기를 절약하기 위해 노력한다	1	2	3	4	5
2. 우리집은 전기를 절약하기 위해 노력한다	1	2	3	4	5

문5. 그럼, 귀하께서는 사용량 대비 국내 전기요금 수준은 어느 정도라고 생각하십니까?

매우 싸다	싼 편이다	보통이다	비싼 편이다	매우 비싸다
1	2	3	4	5

문5-1. (문5.에서 1.매우 비싸다 또는 2.비싼 편이다에 응답한 경우만 응답해 주십시오.)
월 평균 전기요금 수준이 비싸다고 응답한 이유는 무엇입니까? 중요한 순서대로 다음 답란에 2개까지 응답해 주십시오.

1위		2위	

1. 전기 사용요금이 계속 인상되어서
2. 전기 사용요금 체계가 불명확해서
3. 낮은 전력서비스 품질 때문에(불시 정전 등)
4. 누진세가 적용되어서 (※ 누진제 : 전기 사용량에 따라 전기요금 단가를 높이는 제도)
5. 산업용 전기 요금 대비 비싸서
6. 기타(구체적으로 응답해 주십시오 : ______________________)

문6. 귀하께서는 귀 댁의 월 평균 전기요금 지출 수준에 대해 어느 정도 잘 알고 계십니까?

전혀 모른다	모르는 편이다	보통이다	잘 아는 편이다	매우 잘 안다
1	2	3	4	5

문7. (문6.에서 2.~5.에 응답한 경우만 응답해 주십시오. 1. 전혀 모른다에 응답한 경우, 문8.로 가십시오.)
그럼, 귀 댁의 월 평균 전기요금 지출 수준은 구체적으로 얼마나 됩니까? 앞에서 응답하신 지출 수준을 구체적인 금액으로 응답해 주십시오. (일반적으로 4인 가족 월 전기요금은 평균 4~5만원 수준입니다.)
※ 본 질문은 귀 댁의 전기요금 지출 수준에 따른 전력 서비스 정책별 지출의향에 대해 분석하기 위한 질문으로, 다른 용도로는 절대 사용되지 않으니, 잘 모르시더라도 대략적으로라도 응답 부탁드립니다.

월 평균 전기요금 지출수준 : [ ] 십 [ ] 만 [ ] 천 원 정도

문8. 귀하께서는 국내 전력회사인 한국전력(KEPCO)에 대해 전반적으로 어떻게 생각하고 계십니까?

매우 부정적으로 생각한다	부정적으로 생각하는 편이다	보통이다	긍정적으로 생각하는 편이다	매우 긍정적으로 생각한다
1	2	3	4	5

0. 관심없음/ 잘 모름

문8-1. (문8.에서 1.~2. 부정적으로 생각한다에 응답한 경우만 응답해 주십시오.)
그럼, 한국전력(KEPCO)에 대해 전반적으로 부정적으로 생각하고 계시는 가장 큰 이유는 무엇입니까? (단답)

1. 원전비리 의혹
2. 여름철 전력난 심화
3. 비싼 전기 사용요금
4. 낮은 전력서비스 품질(잦은 불시정전 발생 등)
5. 방만경영 공기업
6. 기타(구체적으로 응답해 주십시오 : ______)

→ **문9-1. 위 가정용 전기요금 체계 및 누진제 설명문으로 가십시오.**

문8-2. (문8.에서 4.~5. 긍정적으로 생각한다에 응답한 경우만 응답해 주십시오.)
그럼, 한국전력(KEPCO)에 대해 전반적으로 긍정적으로 생각하고 계시는 가장 큰 이유는 무엇입니까? (단답)

1. 저렴한 전기 사용요금
2. 우수한 전력서비스 품질
3. 국가 기간산업 기업으로 안정적인 전기공급
4. 각종 사회공헌 활동 수행
5. 기타(구체적으로 응답해 주십시오 : ______)

▣ 가정용 전기요금 체계 및 누진제 설명문

가정용 전기요금은 기본요금 6단계와 전력량 요금 6단계로 나눠져 있으며, 기본요금과 전력량 요금 모두 누진제가 적용되고 있음.
(전기요금 누진제는 전기 사용량에 따라 전기요금 단가를 높이는 제도로, 일정량 이상 사용하면 단위당 부과되는 금액이 가중됨.)
예 : 전기요금 6단계(월 사용량 500kWh 초과)는 전기요금 1단계(월 사용량 100kWh 이하) 보다 요금단가가 10배 이상 더 높음.

문9-1. 귀하께서는 이러한 전기요금 체계 및 누진제에 대해 오늘 이전에 알고 계셨습니까?

1. 예(알았음)
2. 아니오(몰랐음)

문9-2. 그럼, 귀하께서는 가정용 전기요금에 적용되는 누진제에 대해 어떻게 생각하십니까?

부정적이다	부정적인 편이다	보통이다	긍정적인 편이다	긍정적이다
1	2	3	4	5

문10. 귀하께서는 최근 1년 이내에 정전을 경험한 적이 있으십니까?

1. 예(있음)
2. 아니오(없음) → **다음 페이지 B. 전력서비스 유형별 선호도로 가십시오.**

문10-1. (문10.에서 1. 예(있음)에 응답한 경우만 응답해 주십시오.)
그럼, 최근 1년 이내에 정전을 몇 번이나 경험하셨습니까?

최근 1년 내 정전 경험 횟수 : [ ][ ] 회

C. 송전선로 유형별 선호도

다음은 송전선로에 대한 귀하의 일반적인 의견을 묻는 질문입니다. 다음 설명문을 잘 읽고 질문에 응답해 주십시오.

▣ 송전선로에 대한 설명문

1. 우리나라는 전력 사용량이 꾸준히 증가하고 있는 상황이므로 안정적인 전력공급을 위해 발전소 건설 계획 및 시공이 계속해서 진행되고 있습니다. 한편, 우리나라 전력 생산은 남부지방에, 전력 소비는 수도권 지역에 편중되어 있어 생산된 전력의 수송을 위해서는 송전선로의 건설이 필수적입니다. 이에 따라 정부는 2027년까지 총 거리 3,450km의 송전선로를 새로 건설할 계획을 세우고 있습니다.
2. 그러나, 최근 밀양 송전탑 관련 분쟁 사례와 같이 송전선로 건설 시 토지이용 제한, 자산 가치 하락, 거주환경 침해 및 토지훼손, 전자기장으로 인한 질병 발생 등을 우려한 주민들의 반대로 송전선로 건설계획에 차질을 빚는 경우가 발생하고 있습니다. 특히, 위와 같은 피해를 우려한 주민들은 송전선로를 땅 속에 매설하는 지중화 방식을 채택할 것을 요구하지만, 한전 측은 비용과 현실적 어려움을 이유로 송전탑을 건설하는 지상화 방식을 주장하고 있어 갈등이 심화되고 있습니다.

송전선로 건설 방식에는 지상화 방식과 지중화 방식이 있으며 각각의 특징은 다음과 같음.

	지상화(송전탑 + 가공선로) 방식	지중화 방식
개념	송전탑을 일정 간격으로 건설해 케이블을 지상으로 연결하는 방식	송전 케이블을 지하에 매설하는 방식으로, 우리나라 전체 송전선로의 약 10%가 지중화 방식으로 건설되어 있음
장점	지중화 방식에 비해 건설비용 및 유지보수 비용이 저렴하며 건설시간도 짧음. 또한, 고장 발생확률이 낮고 고장 지점의 발견이 용이해 안정적인 전력공급이 가능	자연재해 영향과 토지이용 제한이 적으며, 기피시설이 외부에 노출되지 않아 미관이 개선됨. 또한, 지하에 여러 선로를 시설할 수 있으며 인체 영향이 적음.
단점	송전탑 건설로 토지 이용이 제한되며(송전탑 하나당 약 200~250㎡부지 필요), 주변 토지/건물 매매가격이 하락함 생활환경 침해, 생태계 파괴 및 전자기장으로 인한 질병(소아 백혈병/암, 소음으로 인한 불면증)발생 가능성 있음	지상화 방식에 비해 건설비용과 유지보수 비용이 높으며(5~14배로 추산), 설비 건설에 오랜 시간이 소요됨 또한, 지상화 방식에 비해 고장 발생확률이 적으나, 고장 시 고장지점의 발견이 어려우며 복구에 장시간이 소요됨

문1-1. 귀하께서는 평소 송전선로 관련 이슈(밀양 송전탑 문제 등)에 대해 어느 정도 관심을 갖고 있으십니까?

전혀 관심없다	관심없는 편이다	보통이다	관심있는 편이다	매우 관심있다
1	2	3	4	5

문1-2. 그럼, 귀하께서는 송전선로 건설이 어느 정도 시급하다고 생각하십니까?

전혀 시급하지않다	시급 않은 편이다	보통이다	시급한 편이다	매우 시급하다
1	2	3	4	5

문2. 귀하께서는 송전선로 관련 다음 두 가지 사항에 대해 어느 정도 알고 계십니까?

	전혀 모른다	모르는 편이다	보통이다	아는 편이다	매우 잘 안다
	1	2	3	4	5
1. 초고압 송전선로의 종류 (154, 345, 765 kV 등) ························	1	2	3	4	5
2. 초고압 송전선로의 환경 및 인체에 대한 영향 ························	1	2	3	4	5

문3. 귀하께서는 초고압 송전선로 관련 다음 두 항목에 대해 어느 정도 위험하다고 생각하십니까?
※ 송전선로 건설 방식은 ① 송전탑을 일정 간격으로 건설해 지상으로 케이블을 연결하는 방식인 지상화 방식과 ② 송전 케이블을 지하에 매설하는 방식인 지중화 방식 등 2가지 방식이 있습니다.

	전혀 위험하지 않다	위험하지 않은 편이다	보통이다	위험한 편이다	매우 위험하다
1. 초고압 송전탑/송전선로 지상 건설시 인근 지역 거주자의 건강	1	2	3	4	5
2. 초고압 송전선로 지중화 시 지역 거주자의 건강	1	2	3	4	5

문4. 귀하께서는 다음의 기관에서 수행하는 초고압 송전시설 환경/인체 위해성 및 경제성 평가에 대해 어느 정도 신뢰하십니까?

	전혀 신뢰하지 않는다	신뢰하지 않는 편이다	보통이다	신뢰하는 편이다	매우 신뢰한다
1. 전력 관련 정부 부처	1	2	3	4	5
2. 전력 관련 사업 주체 (한국전력)	1	2	3	4	5
3. 환경 관련 시민단체	1	2	3	4	5
4. 대학 교수 등 전문가	1	2	3	4	5

문5. 귀하께서는 다음 제시한 각 요인이 초고압 송전시설 관련 정책에 어느 정도 중요하다고 생각하십니까?

	전혀 중요하지 않다	중요하지 않은 편이다	보통이다	중요한 편이다	매우 중요하다
1. 초고압 송전선로의 환경/인체 위해성 대한 과학적인 평가	1	2	3	4	5
2. 관련 자료의 투명한 공개	1	2	3	4	5
3. 의사결정 과정에 다양한 이해관계자의 참여 (민주성)	1	2	3	4	5
4. 의사결정의 투명하고 공정한 집행	1	2	3	4	5
5. 초고압 송전탑, 송전선로 인근 지역에 대한 적절한 보상	1	2	3	4	5
6. 송전선로 운영 기관(한전)의 신뢰성	1	2	3	4	5

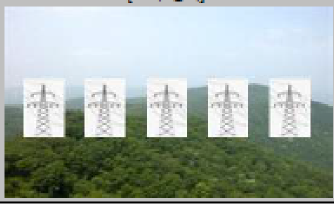
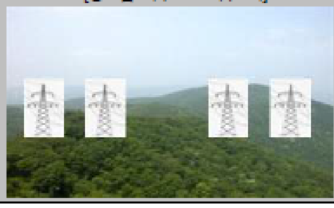
문6. 귀하께서는 초고압 송전시설을 귀하의 거주지 인근 지역에 건설하는 것에 대해 어느 정도 찬성 또는 반대하십니까?

매우 반대한다	반대하는 편이다	보통이다	찬성하는 편이다	매우 찬성한다
1	2	3	4	5

송전선로 건설에 대한 유형별 선호도

1. 지금부터는 송전선로 건설 시 일부 구간을 지중화 방식으로 건설함에 따라 발생할 수 있는 상황을 조합한 송전선로 건설 유형별 선호도를 묻는 질문입니다.
2. 응답하실 유형별 선호도 질문은
   ① 송전선로 건설 유형에 대한 설명문(송전선로 건설 후 발생가능 상황의 여러 속성과 속성별 수준에 대한 설명)과
   ② 송전선로 건설 유형별 선호도(유형별 선호 순위 및 1위 선호 유형)를 묻는 질문 3개가 제시됩니다.
3. 귀하께서는 ① 우선, 송전선로 건설 유형 설명문을 숙지하시고, ② 송전선로 건설 유형별 선호도(유형별 선호 순위 및 1위 선호 유형)에 응답해 주시면 됩니다.

▣ 송전선로 건설 유형의 속성 및 수준 설명문

속성		속성 설명 및 수준
1. 송전탑 개수	설명	송전선로 지중화 방식을 도입시 줄어드는 송전탑의 비율 ① 2027년까지 건설 예정인 송전선로가 모두 지상에 건설될 경우 필요한 송전탑은 약 10,000개로 추산됨 ② 지중화 방식이 도입될 경우 송전탑을 건설할 필요가 없어지므로 시야가 개선될 것으로 예상됨 ▣ 지중화 방식 도입으로, 송전탑 개수가 20% 감소해 시야가 개선된 경우 예시 [현재 상태]  → [송전탑 개수 20% 감소시] 
	수준(3개)	① 5% 감소 (약 500개 감소) ② 10% 감소 (약 1,000개 감소) ③ 15% 감소 (약 1,500개 감소)
2. 전자기장 노출	설명	송전선로 지중화로, 초고압 송전선로에서 발생하는 전자기장에 대한 노출이 감소하는 정도 ① 전자기장에 지속적으로 노출되는 경우 소아 백혈병 등 암질병 발병확률이 높아진다는 연구결과가 있음 ② 그러나, 일정 거리 이상 떨어진 경우 그 영향이 미미하다는 연구결과도 있어, 송전선로 전자기장의 인체건강에 대한 영향은 여전히 논란의 여지가 있음
	수준(3개)	① 10% ② 20% ③ 30%
3. 정전사고 횟수	설명	5년 내에 발생할 수 있는 정전의 횟수 (지난 5년 기준 정전 사고 약 5회 발생) ※ 송전선로 지중화 방식이 도입될 경우 정전사고 횟수가 줄어들 것으로 예상됨
	수준(3개)	① 25% 감소 (5년간 총 4회 발생) ② 50% 감소 (5년간 총 2~3회 발생) ③ 75% 감소 (5년간 총 1회 발생)
4. 정전사고 당 정전시간	설명	1회 정전시 정전상태가 지속되는 시간 (국내 평균 정전시간은 1회의 정전사고 당 약 15분임) ※ 지중화 방식이 도입될 경우 보수에 걸리는 시간이 늘어날 것으로 예상됨
	수준(3개)	① 20% 증가 (사고 1회당 약 19분) ② 40% 증가 (사고 1회당 약 22분) ③ 60% 증가 (사고 1회당 약 25분)
5. 추가 전기요금 부담	설명	송전선로 건설 시 지중화 방식을 도입할 경우 추가적으로 부담해야 하는 전기요금
	수준(3개)	① 월 전기료 2% 상승 (월 전기료 5만원 기준 1,000원 추가 부담) ② 월 전기료 6% 상승 (월 전기료 5만원 기준 3,000원 추가 부담) ③ 월 전기료 10% 상승 (월 전기료 5만원 기준 5,000원 추가 부담)

다음은 송전선로 건설 유형별 선호도를 묻는 질문입니다.

지금부터 설명 드린 속성 5개를 조합하여 구성한 송전선로 건설 유형 선호도 질문이 3개가 제시됩니다.
① 귀하께서는 동시에 제시한 3개의 송전선로 건설 유형별 선호 순위를 1위부터 3위까지 응답해 주시고,
② 현재 상태 유지가 포함된 4개의 유형 중, 가장 선호하는 유형 하나에 O표해 주시면 됩니다.
※ 제시한 5개의 송전선로 건설 유형 관련 속성 이외의 다른 모든 속성은 서로 동일한 것으로 가정하고 응답해 주십시오.

문1. ① 다음 제시한 3개의 송전선로 건설 유형 중, 선호 순위를 1위부터 3위까지 응답해 주시고,
② 선호하는 유형 없음이 포함된 4개의 유형 중, 가장 선호하는 유형 하나에 O표해 주십시오.

◉ 송전선로 건설 관련 선호유형 질문 1

	유형 A	유형 B	유형 C	비선택
1. 송전탑 개수	10% 감소 (약 1,000개 감소)	10% 감소 (약 1,000개 감소)	5% 감소 (약 500개 감소)	선호하는 송전선로 건설 유형 없음 (현재 상태 유지)
2. 전자기장 노출	20% 감소	10% 감소	20% 감소	
3. 정전사고 횟수	50% 감소 (5년간 총 2~3회 발생)	25% 감소 (5년간 총 4회 발생)	75% 감소 (5년간 총 1회 발생)	
4. 정전사고 당 정전시간	40% 증가 (사고 1회당 약 22분)	60% 증가 (사고 1회당 약 25분)	20% 증가 (사고 1회당 약 19분)	
5. 추가 전기요금	월 전기료 2% 상승 (월 전기료 5만원 기준 1,000원 추가 부담)	월 전기료 6% 상승 (월 전기료 5만원 기준 3,000원 추가 부담)	월 전기료 6% 상승 (월 전기료 5만원 기준 3,000원 추가 부담)	
① 선호 순위 응답란 → (1위부터 3위까지 응답)				
② 가장 선호하는 유형 응답란 (4개 중 하나에 ○표 →)	유형 A	유형 B	유형 C	비선택

◉ 송전선로 건설 관련 선호유형 질문 2

	유형 A	유형 B	유형 C	비선택
1. 송전탑 개수	15% 감소 (약 1,500개 감소)	5% 감소 (약 500개 감소)	5% 감소 (약 500개 감소)	선호하는 송전선로 건설 유형 없음 (현재 상태 유지)
2. 전자기장 노출	30% 감소	30% 감소	10% 감소	
3. 정전사고 횟수	75% 감소 (5년간 총 1회 발생)	50% 감소 (5년간 총 2~3회 발생)	50% 감소 (5년간 총 2~3회 발생)	
4. 정전사고 당 정전시간	60% 증가 (사고 1회당 약 25분)	20% 증가 (사고 1회당 약 19분)	60% 증가 (사고 1회당 약 25분)	
5. 추가 전기요금	월 전기료 2% 상승 (월 전기료 5만원 기준 1,000원 추가 부담)	월 전기료 6% 상승 (월 전기료 5만원 기준 3,000원 추가 부담)	월 전기료 2% 상승 (월 전기료 5만원 기준 1,000원 추가 부담)	
① 선호 순위 응답란 → (1위부터 3위까지 응답)				
② 가장 선호하는 유형 응답란 (4개 중 하나에 ○표 →)	유형 A	유형 B	유형 C	비선택

문1. ① 다음 제시한 3개의 송전선로 건설 유형 중, 선호 순위를 1위부터 3위까지 응답해 주시고,
② 선호하는 유형 없음이 포함된 4개의 유형 중, 가장 선호하는 유형 하나에 O표해 주십시오.

◉ 송전선로 건설 관련 선호유형 질문 3

	유형 A	유형 B	유형 C	비선택
1. 송전탑 개수	10% 감소 (약 1,000개 감소)	15% 감소 (약 1,500개 감소)	10% 감소 (약 1,000개 감소)	선호하는 송전선로 건설 유형 없음 (현재 상태 유지)
2. 전자기장 노출	30% 감소	10% 감소	10% 감소	
3. 정전사고 횟수	25% 감소 (5년간 총 4회 발생)	25% 감소 (5년간 총 4회 발생)	75% 감소 (5년간 총 1회 발생)	
4. 정전사고 당 정전시간	20% 증가 (사고 1회당 약 19분)	40% 증가 (사고 1회당 약 22분)	20% 증가 (사고 1회당 약 19분)	
5. 추가 전기요금	월 전기료 2% 상승 (월 전기료 5만원 기준 1,000원 추가 부담)	월 전기료 6% 상승 (월 전기료 5만원 기준 3,000원 추가 부담)	월 전기료 10% 상승 (월 전기료 5만원 기준 5,000원 추가 부담)	
① 선호 순위 응답란 → (1위부터 3위까지 응답)				
② 가장 선호하는 유형 응답란 (4개 중 하나에 ○표 →)	유형 A	유형 B	유형 C	비선택

문5. 귀하께서는 다음의 기관에서 수행하는 사용후핵연료 시설의 환경/인체 위해성 평가에 대해 어느정도 신뢰할 수 있습니까?

	전혀 신뢰하지 않는다	신뢰하지 않는 편이다	보통이다	신뢰하는 편이다	매우 신뢰한다
	1	2	3	4	5
1. 사용후핵연료 관련 정부 부처	1	2	3	4	5
2. 원자력 관련 공공기관	1	2	3	4	5
3. 환경 관련 시민단체	1	2	3	4	5
4. 대학 교수 등 전문가	1	2	3	4	5

문6. 귀하께서는 다음 제시한 각 요인이 사용후핵연료 정책에 어느 정도 중요하다고 생각하십니까?

	전혀 중요하지 않다	중요하지 않은 편이다	보통이다	중요한 편이다	매우 중요하다
	1	2	3	4	5
1. 사용후핵연료 보관기술에 대한 과학적, 객관적 평가	1	2	3	4	5
2. 관련 자료의 투명한 공개	1	2	3	4	5
3. 의사결정 과정에 대양한 이해관계자의 참여 (민주성)	1	2	3	4	5
4. 의사결정의 투명하고 공정한 집행	1	2	3	4	5
5. 사용후핵연료 보관시설 지역에 대한 적절한 보상	1	2	3	4	5
6. 사용후핵연료 보관시설 운영 기관의 신뢰성	1	2	3	4	5
7. 사용후핵연료 관련 지속적 기술개발	1	2	3	4	5

문7. 귀하께서는 사용후핵연료 보관시설을 본인의 거주지 인근 지역에 건설하는 것에 대해 어느 정도 찬성 또는 반대하십니까?

매우 반대한다	반대하는 편이다	보통이다	찬성하는 편이다	매우 찬성한다
1	2	3	4	5

문8. 평소 귀하의 리스크(위험 또는 불확실성)에 대한 태도는 어떻다고 생각하십니까?

매우 회피한다	회피하는 편이다	보통이다	수용하는 편이다	매우 잘 수용한다
1	2	3	4	5

G. 응답자 특성

마지막으로, 자료분류를 위한 응답자 특성 질문입니다.

D1. 귀하의 평소 신제품 구입행동은 어느 쪽에 가깝다고 생각하십니까?

다른 사람보다 신제품(신상품)을 빨리 산다 ◀──		보통이다		──▶ 다른 사람들이 많이 사용하여 검증된 제품을 산다
1	2	3	4	5

D2. 실례지만, 귀하의 직업은 무엇입니까?

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 (구체적으로 응답해 주십시오 : ________________________________)

D3. 실례지만, 귀하께서는 학교를 어디까지 마치셨습니까?

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

D4. 귀하가 살고 계신 주택의 보유 형태는 다음 중 어디에 해당됩니까?

1. 자가
2. 전/월세
3. 기타 (구체적으로 응답해 주십시오.)

D5. ① 현재 귀하와 함께 살고 계신 가족은 모두 몇 명입니까? 응답자 본인을 포함한 가족 수를 응답해 주십시오.
② 그럼, 귀하와 함께 살고 계신 가족 중, 만 60세 이상, 초중고생, 미취학아동과 그 외 가족은 각각 몇 명이나 됩니까?

구분		응답란
① 같이 살고 있는 가족 수 (응답자 본인 포함)		☐ 명
② 같이 살고 있는 가족구성 (합계가 ①과 같음)	- 응답자 본인	1 명
	- 만 60세 이상 가족 수	☐ 명
	- 초중고생 가족 수	☐ 명
	- 미취학 아동 가족 수	☐ 명
	- 그 외 가족 수	☐ 명

다음 D6.~D8.은 귀 댁의 소득과 지출수준 및 지출구조에 따른 전력서비스 정책별 지출의향을 분석하기 위한 질문입니다.
다른 용도로는 절대 사용되지 않으니, 잘 모르시더라도 대략적으로라도 응답 부탁드립니다.

D6. 현재 귀 댁의 **월평균 소득 수준**은 얼마나 됩니까? 세금은 제외한 **보너스, 이자수입 등 모든 수입**을 합해서 응답해 주십시오.

1. 99만원 이하
2. 100만원~149만원 이하
3. 150만원~199만원 이하
4. 200만원~249만원 이하
5. 250만원~299만원 이하
6. 300만원~399만원 이하
7. 400만원~499만원 이하
8. 500만원~699만원 이하
9. 700만원~999만원 이하
10. 1,000만원 이상

D6-1. 그럼, 귀 댁의 월평균 소득 수준은 **구체적으로** 얼마나 됩니까? 앞에서 응답하신 소득 수준을 **구체적인 금액으로** 응답해 주십시오.

월 평균 소득수준 : [ ] 천 [ ] 백 [ ] 십 만원 정도

D7. 현재 귀 댁의 **월평균 지출 수준**은 얼마나 됩니까? 보너스, 저축(투자 포함)과 부채상환 등을 제외한 **순수한 생활비 지출 수준**을 기준으로 응답해 주십시오.

1. 49만원 이하
2. 50만원~99만원 이하
3. 100만원~149만원 이하
4. 150만원~199만원 이하
5. 200만원~249만원 이하
6. 250만원~299만원 이하
7. 300만원~349만원 이하
8. 350만원~399만원 이하
9. 400만원~449만원 이하
10. 450만원~499만원 이하
11. 500만원 이상

D7-1. 그럼, 귀 댁의 월평균 지출 수준은 **구체적으로** 얼마나 됩니까? 앞에서 응답하신 지출 수준을 **구체적인 금액으로** 응답해 주십시오.

월 평균 지출수준 : [ ] 천 [ ] 백 [ ] 십 만원 정도

★ 끝까지 응답해 주셔서 대단히 감사합니다 ★

면 접 후 기 록			
응답자 성명		응답자 연락처	
조 사 일 시	___월 ___일 ___시	면접원 성명	(ID: _______)
실사 검증원	(ID: _______)	실사 연구원	(ID: _______)

Abstract (Korean)

전기 수요의 지속적인 증가와 새로운 전력 공급원 개발의 어려움으로 인해, 고압의 전기를 더욱 효과적으로 전달하기 위한 방안이 요구된다. 이에 따라, 전력 수송 능력(transmission capability)을 극대화하는 송전시스템의 필요성이 대두되고 있다. 전기를 전송하는 방법에는 지상에 송전탑을 건설하는 방법과 고전압 송전케이블(high voltage transmission cable)과 배전선(distribution line)을 지하에 설치하는 방법이 존재한다. 지하에 송전선로를 설치하는 방식은 지상 송전탑이 필요하지 않기 때문에, 주변 경관과 도시 경관을 해치지 않는다는 장점이 있다. 또한, 송전탑으로 인한 전자기장 문제 역시 해결이 가능하다. 그러나, 송전선로를 설치하기 위한 지하 공간을 건설하고 관리하는 데에는 거대한 비용이 수반된다. 결과적으로, 인구 밀도가 낮은 농촌에서는 예산의 제약으로 인해 기존 방식의 지상 송전탑이, 충분한 예산 확보가 가능한 대도시에서는 지하 송전선로가 주로 활용되고 있다. 이러한 지역적 불균형으로 인한 송전시스템에 대한 거주민들의 선호도 차이는 정부가 송전시스템 설치 과제를 추진하는데 있어 논쟁의 주요한 원인이 된다.

본 논문에서는 한국에서의 송전선로 설치에 대한 거주민들의 선호도 조사를 수행하고자 한다. 거주민들의 선호도는 개인의 특성과 거주지의 이질성에 의해 영향을 받는다고 가정하였으며, 이에 대한 분석을 위해 이산선택모형(혼합로짓모형 및 잠재계층모형)이 활용되었다. 선택모형에서는

송전탑의 개수, 전자기장 노출 정도, 정전 횟수, 정전 지속 시간 및 추가적인 전기사용료의 속성 외에 송전선로 설치에 대한 개인의 인지된 필요성(perceived need)과 위험에 대한 태도(attitude towards risk), 거주지의 이질성이 고려되었다.

본 연구의 결과는 정부 과제를 수립하는데 있어, 개인의 특성과 지역에 따른 선호도 차이를 반영함으로써 과제의 효율성을 제고 가능하도록 한다.

주요어 : 송전선로, 이산선택모형, 혼합로짓모형, 잠재계층모형, 선호분석, 이질성, 사회기반시설
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