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# Effects of Rank-Ordered Feature Perceptions of Energy Sources on the Choice of the Most Acceptable Power Plant for a Neighborhood: An Investigation Using a South Korean Nationwide Sample

**Seungkook Roh [1], Jin Won Lee [2] and Qingchang Li [2,*]**

[1] Nuclear Policy Research Center, Korea Atomic Energy Research Institute (KAERI), 989–111 Daedeok-daero, Yuseong-gu, Daejeon 34057, Korea; skroh@kaeri.re.kr
[2] Marketing Department, School of Business Administration, Jimei University, 185 Yinjiang Road, Jimei District, Xiamen 361021, China; nevermean@empas.com
* Correspondence: alflqc@jmu.edu.cn

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**Abstract:** The present study incorporates a competitive context into an individual's response to the construction of a power plant in his/her neighborhood and the determinants of this response. The study adopts an individual's rank-ordered feature perceptions of competing energy sources to reflect the individual's comparative perceptions of the sources regarding the features, and it investigates the effects of these perceptions on his/her choice of the most acceptable power plant in the area where he/she lives. Our mixed conditional logit analysis of nationwide survey data from South Korea demonstrated the following: among the rank-ordered feature perceptions, the perceptions regarding safety and eco-friendliness significantly predict an individual's choice of the most acceptable power plant for his/her neighborhood, while those regarding affordability, contribution to economic development, and job creation do not. In addition, among those significant features, safety was found to be a stricter criterion than eco-friendliness. The selective significance of the feature perceptions and the differentiated criteria between the significant features provide practical implications for professionals in energy industries, as well as theoretical implications for researchers.

**Keywords:** local acceptance of energy; competitive context; energy source choice; rank-ordered feature perceptions; energy source features; public communications; mixed conditional logit

## 1. Introduction

### 1.1. Research Background: Importance of the Local Response to an Energy Source

For the sustainable supply of electricity for people and organizations, the development of an energy infrastructure is essential. Regarding the development of this infrastructure, the public is an important actor group because their support, or at least tolerance, is a significant requirement for the realization of an energy infrastructure. No matter how brilliant or advanced the energy source is in technological terms, the development of an energy infrastructure can only come to fruition with the public's acceptance of the energy source [1–3].

In particular, local acceptance of an energy source—people's acceptance of the infrastructure for an energy source in their neighborhood—is crucial to the actual implementation of that infrastructure. While general or national acceptance—people's acceptance of the development and use of an energy source in the country—influences national-level policy regarding the energy system, local acceptance is a significant factor for the actual implementation of that system in the local site areas. Not only the implementation of a nuclear power system, which typically has been associated with great concerns regarding safety [4], but also that of alternative energy sources have often been met with public opposition at the site areas [5–7]. This resistance or lack of support from the local community can cause delays or even obstacles to the planning and implementation of the energy infrastructure [8,9]. Thus, for governments and industry professionals, it is important to identify the public's acceptance of energy sources not only at the general/national level, but also at the local level. Such identification not only helps governments and industry professionals devise strategies to convince the public to follow their intended energy policies and implement said policies in the site areas, but also enables them to learn what they need to do to ensure the policies succeed.

### *1.2. Research Purpose: Incorporating the Competitive Context into Local Acceptance*

Due to the importance of this issue, as described above, the local acceptance of an energy source, along with general/national acceptance, has drawn much research attention. For example, studies have examined the differences between the general/national acceptance and local acceptance of an energy source [10–12] and the determinants of the local acceptance of energy sources [13–16]. Within this line of research, there is still much to elucidate. Specifically, there is a need to incorporate the competitive context into the research on local acceptance and its determinants, as we will show in the following paragraphs.

First, a choice variable for the favored energy source needs to be adopted as the dependent variable that represents the local acceptance of an energy source, rather than individual, separate acceptance of different energy sources. Currently, in several countries, the energy industries (e.g., the nuclear power industry and the new renewable energy industry) are desperately competing to win the initiatives and become the country's leading energy suppliers [17,18]. Considering this competitive context, along with the importance of the local acceptance of an energy source, the question of whether the energy source was chosen by the local people as the favorite alternative rather than the energy source having gained local acceptance at the individual/separate level may have implications for the energy industries when trying to win such initiatives. This is because an energy source that the local people relatively prefer over others would have advantages over those others in deploying its energy infrastructure in the area.

Despite this potential significance, people's choices between multiple energy sources have rarely been investigated in association with the explanatory factors. There have been surveys that measured people's favorite future energy source (e.g., Reference [19]). However, while such a choice has usually been used to describe or present the distribution of preferences for energy sources (e.g., choice shares or percentages of energy sources), studies associating this choice with people's perceptions of the features of the energy sources are difficult to find. In contrast, although there has been much research that has investigated the associations between such perceptions and people's acceptance of energy sources, the focus has been on the individual acceptance of energy sources. For example, while several studies have found that people's perceptions of the features of an energy source influence their acceptance of that energy source (e.g., References [20,21]) or acceptance of a rival energy source (e.g., Reference [22]), research on the effects of such perceptions on the choice between competing energy sources is difficult to find.

Second, in terms of individuals' perceptions of the features (or attributes) of energy sources, their comparative perceptions of competing energy sources rather than their separate perceptions of a single energy source need to be analyzed. According to the literature, an individual's perceptions of the features of an energy source (hereafter, feature perceptions of an energy source) predict his/her acceptance of the source [23–26]. For example, the perception that a certain energy source mitigates climate change generally enhances the individual's attitude toward that source, including his/her acceptance of the source. If nuclear power is perceived as mitigating climate change, people's evaluation of nuclear power is more positive [27], and their acceptance of it is higher [28]. However, when an individual is choosing his/her favorite energy source among multiple competing sources, not only his/her feature perception of the focal energy source, but also those of the rival sources are likely to predict his/her choice of the focal source. If people who perceive nuclear power as mitigating climate change also perceive another energy source as better than nuclear power in terms of climate change, then these positive perceptions of nuclear power with regard to their effect on reducing climate change may not necessarily be associated with a higher probability of choosing nuclear power as their favorite energy source. In light of this, a comparative approach to the feature perception of competing energy sources—the degree to which an energy source is perceived to be superior to other sources with regard to the given feature—needs to be adopted to predict the choice of energy source, rather than an approach that looks only at the individual/separate feature perception of a single energy source. However, studies utilizing this comparative approach are difficult to find in the existing literature.

Thus, the present study incorporated the competitive context into the local acceptance of an energy source and its determinants. Regarding local acceptance, we used a discrete choice variable, namely an individual's choice of the most acceptable energy source among competing sources to be built in his/her residential area (neighborhood). As the choice determinants that reflect individuals' comparative feature perceptions of different energy sources, we adopted rank-ordered feature perceptions of energy sources. This was defined as the order of the competing energy sources ranked according to an individual's perceptions of them in terms of given features. For the data analysis, we used a nationwide sample from South Korea, in which several energy sources compete against each other [18]. Our mixed conditional logit analysis demonstrated the following: among an individual's rank-ordered feature perceptions of energy sources, the perceptions regarding safety and eco-friendliness were found to significantly predict his/her choice of the most acceptable power plant for his/her neighborhood. In addition, among these significant features, safety was found to be a stricter criterion than eco-friendliness.

## 2. Analytical Strategy

Consistent with our research purpose—incorporating the competitive context into the local acceptance of an energy source and its determinants—we adopted a discrete choice variable as the dependent variable, namely an individual's choice of the most acceptable energy source if a plant were to be built in his/her neighborhood. Our main independent variables were an individual's rank-ordered feature perceptions of the energy sources. This section describes our analytical strategy for the relationships between these independent and dependent variables.

### 2.1. Data Structure of the Main Independent Variables

Suppose that there are K features for which individual $i$ ranks M different alternatives (energy sources) according to his/her perception. We define $x_{i,j,k}$ as individual $i$'s rank-ordered perception of energy source $j$ regarding feature $k$: for example, $x_{1,2,3} = 4$ means that the first individual in the sample ranks energy source 2 as fourth among the competing energy sources in terms of feature 3. This $x_{i,j,k}$ should not be treated as a metric variable because it is an ordinal variable (i.e., 1st, 2nd, ... , M-th): it should be coded using a set of dummy variables. Thus, instead of a scalar $x_{i,j,k}$, it takes the form of a vector $\mathbf{X_{i,j,k}}$ consisting of dummy variables for the feature perception.

However, we did not adopt ordinary dummy coding for $\mathbf{X_{i,j,k}}$ for the following reason. In ordinary dummy coding, M − 1 dummy variables (whose values are 0 or 1) are used to represent M ranks [29]. For example, regarding feature $k$, if individual $i$ ranks alternative $j$ as the $l$-th, then we can code $\mathbf{X_{i,j,k}} = \left[x_{i,j,k,1st} = 0, \cdots, x_{i,j,k,l\text{-th}} = 1, \cdots, x_{i,j,k,(M-1)\text{-th}} = 0\right]^{\mathrm{T}}$ with the lowest (M-th) rank being the reference category; when alternative $j$ is the M-th, $\mathbf{X_{i,j,k}} = \left[x_{i,j,k,1st} = 0, \cdots, x_{i,j,k,l\text{-th}} = 0, \cdots, x_{i,j,k,(M-1)\text{-th}} = 0\right]^{\mathrm{T}}$. If a regression model includes $\mathbf{X_{i,j,k}}$ as independent variables, then the coefficient of $x_{i,j,k,l\text{-th}}$ indicates the difference in the mean response between the $l$-th rank and the reference category rank (M-th rank). Thus, using ordinary dummy variables, we cannot estimate the incremental difference in the mean response between two adjacent ranks (i.e., $l$-th and ($l$ + 1)-th) unless the lower rank ($l$ + 1)-th = M-th (i.e., the reference category).

Thus, to achieve the objective of this paper, which is to investigate the effects of the rank-order of energy sources regarding features, we adopted cumulatively coded ordinal dummy variables [30–32]. Specifically, the $l$-th rank ($l$ = 1, 2, . . . , M) of the M ranks is represented by M − 1 dummy variables:

$$x_{i,j,k,d} = \begin{cases} 1, \text{ if alternative } j \text{ is ranked } l\text{-th; } l \leq d;\ d = 1,\ 2, \cdots, \mathrm{M}-1 \\ 0, \text{ otherwise} \end{cases} \tag{1}$$

If alternative $j$ is ranked first regarding feature $k$, then $\mathbf{X_{i,j,k}} = \left[x_{i,j,k,1st} = 1,\ x_{i,j,k,2nd} = 1, \cdots,\ x_{i,j,k,(M-1)\text{-th}} = 1\right]^{\mathrm{T}}$; if $j$ is ranked second regarding $k$, then $\mathbf{X_{i,j,k}} = \left[x_{i,j,k,1st} = 0,\ x_{i,j,k,2nd} = 1, \cdots,\ x_{i,j,k,(M-1)\text{-th}} = 1\right]^{\mathrm{T}}$; if $j$ is ranked (M − 1)-th regarding $k$, then $\mathbf{X_{i,j,k}} = \left[x_{i,j,k,1st} = 0,\ x_{i,j,k,2nd} = 0, \cdots,\ x_{i,j,k,(M-1)\text{-th}} = 1\right]^{\mathrm{T}}$. In a regression that uses these cumulatively coded ordinal dummy variables, the coefficient of $x_{i,j,k,d}$ represents the net effect of the $d$-th rank on a dependent variable, y, relative to the effect of the immediately succeeding rank (i.e., the ($d$ + 1)-th rank), after adjustments have been made for the effects of the other variables [32].

### *2.2. Mixed Conditional Logit Model*

Generally, in a choice model, the measured (observable) dependent variable, $Y_{i,j}$, represents whether an individual $i$ chooses alternative $j$, and such a choice is assumed to be determined by the latent (unobservable) dependent variable—$Y^*_{i,j}$:

$$Y^*_{i,j} = V_{i,j} + \varepsilon_{i,j} \tag{2}$$

where $V_{i,j}$ is the systematic component of the latent dependent variable, and $\varepsilon_{i,j}$ is the random (error) component. In a logit model, in which $\varepsilon_{i,j}$ is assumed to follow the Type-I extreme value distribution, the probability that individual $i$ choses alternative $j$, $P_{i,j}$, is determined as follows [33,34]:

$$P_{i,j} = e^{V_{i,j}} / \sum_{m=1}^{M} e^{V_{i,m}} \tag{3}$$

In our research context, we model $V_{i,j}$ such that it is determined by both (a) the set of $\mathbf{X_{i,j,k}}$ (k = 1, 2, 3, . . . , K), where $\mathbf{X_{i,j,k}}$ is the vector of individual $i$'s rank-ordered perception of energy source $j$ regarding feature $k$, and (b) the vector $\mathbf{Z_i}$ of individual $i$'s socio-demographic characteristics:

$$V_{i,j} = Constant_j + \boldsymbol{\beta}_1\mathbf{X_{i,j,1}} + \boldsymbol{\beta}_2\mathbf{X_{i,j,2}} + \cdots + \boldsymbol{\beta}_K\mathbf{X_{i,j,K}} + \boldsymbol{\Gamma}_j\mathbf{Z_i} \tag{4}$$

where the vectors $\boldsymbol{\beta}$s and $\boldsymbol{\Gamma}_j$, respectively, show the effects of their related variables. $\mathbf{X_{i,j,k}}$ is both individual-specific and alternative (source)-specific: the vector varies over individuals ($i$'s) and alternatives ($j$'s) because each individual has his/her own ranks of multiple, different alternatives regarding the given feature. In contrast, $\mathbf{Z_i}$ is individual-specific but not alternative-specific because it represents individual $i$'s socio-demographic characteristics, which do not vary over the alternatives. To simultaneously deal with these alternative-specific and non-alternative-specific data, we adopted the mixed conditional logit analysis [33]. For example, in the case of M kinds of energy sources, one kind of feature regarding which the energy sources would be ranked, and one kind of individual characteristic, $z_{i,1}$, then M systematic components would be given as follows:

$$\begin{gathered} V_{i,1} = Constant_1 + \boldsymbol{\beta}_1\mathbf{X_{i,1,1}} + \gamma_1 z_{i,1} \\ \cdots \\ V_{i,M} = Constant_M + \boldsymbol{\beta}_1\mathbf{X_{i,M,1}} + \gamma_M z_{i,1} \end{gathered} \tag{5}$$

We customized Equation (5) from Nwankwo and Oyeka [25]. In the original equation, a greater value means a greater level (i.e., level $p$ < level ($p$ + 1)) whereas in our context, a greater value means a lower rank (i.e., rank $l$ > rank ($l$ + 1)).

## 3. Data and Measures

### 3.1. Sample and Data Collection

We used a survey dataset that the Korea Nuclear Energy Agency, a South Korean government-affiliated organization, compiled in 2016. The first author of the present study participated in the survey design. The data collection was conducted through face-to-face interviews by outsourcing to an opinion research firm. The collection adopted a quota sampling method in terms of demographic and geographic features so that the sample could well represent the target population of adult residents aged 19 years and over throughout South Korea. Table 1 summarizes the characteristics of the study sample ($N$ = 1009).

**Table 1.** Sample profile.

| Variables | Description | Values | Proportion |
|---|---|---|---|
| Gender | Respondent's gender | Male | 49.55% |
| | | Female | 50.45% |
| Age | Respondent's age (measured in specific age) | 19–29 | 17.64% |
| | | 30–39 | 19.13% |
| | | 40–49 | 21.70% |
| | | 50–59 | 20.52% |
| | | 60–69 | 19.82% |
| | | 70+ | 1.19% |
| Educational level | Respondent's education degree | Middle school diploma or lower | 8.33% |
| | | High school diploma | 40.44% |
| | | College student or graduate | 50.05% |
| | | Master or higher | 1.19% |
| Income level | Respondent's monthly household income | Below 1.0 million Korean Won | 0.99% |
| | | 1.00–1.99 million Korean Won | 6.74% |
| | | 2.00–2.99 million Korean Won | 12.59% |
| | | 3.00–3.99 million Korean Won | 22.99% |
| | | 4.00–4.99 million Korean Won | 25.17% |
| | | 5.00–5.99 million Korean Won | 20.22% |
| | | 6.00–6.99 million Korean Won | 8.23% |
| | | 7.00–7.99 million Korean Won | 1.59% |
| | | 8.00 million Korean Won and over | 1.49% |

Note: $N$ = 1009.

### 3.2. Measures

#### 3.2.1. Rank-Ordered Perceptions Regarding Energy Source Features ($\mathbf{X}_{\mathbf{i,j,k}}$s)

The first author and the Korea Nuclear Energy Agency team listed features for which the respondent's rank-ordered perceptions of energy sources would be measured. Based on a literature review and hands-on experience, five features were confirmed as essential in an individual's perceptions of energy sources: safety, affordability, eco-friendliness, contribution to economic development, and job creation. (1) In the literature, the safety perception of an energy source has been reported to influence the acceptance of the source: the less safe or more risky an energy source is perceived to be, the less likely that it will be accepted [1,22,25,35]. (2) The affordability of an energy source—the degree to which the source provides electricity at an economical price—is an essential feature of an energy source because it constitutes the very reason to operate a power plant. Thus, the affordability perception of an energy source, which is occasionally measured in the form of the perceived benefit of an energy source in terms of inexpensive electricity prices, has been found to positively influence the acceptance of or attitude toward the source [21,23,24,26]. (3) Eco-friendliness—the degree to which the energy source claims to reduce, minimize, or do no harm to the environment—is also a significant determinant of energy acceptance. A greater perception of eco-friendliness generally leads an individual to perceive the energy source as low in environmental risk and thus renders the source more acceptable [20,35–38]. (4) The contribution to the country's economic development is an economic benefit that an energy source provides at the macro-level. Electricity supplied at economical prices with stability and in sufficient amounts contributes to the efficiency and the competitiveness of the country's industries, which is beneficial to society and its members. Thus, a greater perception of this contribution is associated with greater acceptance or preference for an energy source [23,26]. (5) Job creation is one of the economic impacts of the development and deployment of an energy system. The construction of a plant itself and its operation create employment not only in the focal energy industry itself and but also in its forward industries [39,40]. This job creation can provide direct benefits to an individual (i.e., employment in the relevant industries) or indirect benefits (i.e., fruits of the stimulated economy boosted by job creation). In this light, there is a possibility that the perception of job creation acts as a determinant of energy acceptance. This set of five features is consistent with the feature set that Roh and Kim [41] adopted to identify South Korean people's perceptions of different energy sources, although the detailed measurement methods are not perfectly identical.

In the survey, a respondent was given statements for the five features as follows:

- Safety: "It is an electricity generation source that is safe."
- Affordability: "It is an electricity generation source that is inexpensive and economical."
- Eco-friendliness: "It is an electricity generation source causing less environmental pollution."
- Contribution to economic development: "It is an electricity generation source that contributes to economic development."
- Job creation: "It is an electricity generation source that contributes to job creation."

The respondent was asked to rank the given energy sources based on his/her perception of the sources that more or less correspond with each statement. Four alternative energy sources—hydropower, fossil fuel, nuclear power, and new renewable energy—were provided along with brief explanations of the sources (e.g., "new renewable energy: electricity generation sources that use sun rays, solar heat, wind power, biomass, etc.").

### 3.2.2. Control Variables ($\mathbf{Z_i}$)

Socio-demographic variables including gender, age, educational level, and monthly household income level were measured as control variables. Table 1 includes the measured levels of these variables. For the analysis, age and monthly household income level were standardized. Gender was contrast coded (male = −1, female = 1). Educational level, which was originally measured using four levels, was dichotomized and contrast coded (high school diploma or lower = −1, current college student or higher degree = 1) for parsimony.

### 3.2.3. Choice Variable ($Y_{i,j}$)

The respondent was given a statement: "I will agree with the construction of a power plant in my neighborhood if the plant uses this energy source." Then, the respondent was asked to rank the given energy sources in order of his/her agreement. Consistent with our research purpose, we adopted a respondent's top-ranked energy source as his/her choice of the most acceptable power plant for his/her neighborhood.

## 4. Analysis of the Results

### *4.1. Summary of the Main Independent Variables and the Choice Variable*

Table 2 summarizes the sample's responses regarding the rank-ordered feature perceptions of the energy sources, by the sources' mode ranks (i.e., the rank at which a source is most frequently placed) regarding feature perceptions. Hydropower was generally placed in the middle (second or third), and fossil fuel were generally placed in the low class (fourth). The dominant perceptions of nuclear power varied substantially over the features. Regarding safety and eco-friendliness, nuclear power was ranked low (fourth) and middle-low (third), respectively, whereas it was ranked high or middle-high (first or second) regarding affordability, contribution to economic development, and job creation.

**Table 2.** Mode ranks of energy sources in the respondents' perceptions.

| | Hydropower | Fossil Fuel | Nuclear Power | New Renewable Energy |
|---|---|---|---|---|
| **Safety** | | | | |
| Mode | 2nd | 4th | 4th | 1st |
| Frequency of the mode | 447 (44.30%) | 523 (51.83%) | 385 (38.16%) | 622 (61.65%) |
| **Affordability** | | | | |
| Mode | 2nd | 4th | 1st | 1st |
| Frequency of the mode | 341 (33.80%) | 524 (51.93%) | 403 (39.94%) | 368 (36.47%) |
| **Eco-friendliness** | | | | |
| Mode | 2nd | 4th | 3rd | 1st |
| Frequency of the mode | 422 (41.82%) | 720 (71.36%) | 431 (42.72%) | 611 (60.56%) |
| **Contribution to economic development** | | | | |
| Mode | 3rd | 4th | 1st | 1st |
| Frequency of the mode | 398 (39.44%) | 544 (53.91%) | 412 (40.83%) | 483 (47.87%) |
| **Job creation** | | | | |
| Mode | 3rd | 4th | 2nd | 1st |
| Frequency of the mode | 328 (32.51%) | 470 (46.58%) | 328 (32.51%) | 468 (46.38%) |

Note: $N = 1009$. The mode of an energy source refers to the rank at which the respondents placed that energy source more frequently than at the other ranks. Regarding the perception of a feature, different energy sources can have the same rank as the mode.

The dominant perception of new renewable energy is that it is the best energy source in terms of all of the five features. In fact, the category of new renewable energy does not refer to a single energy source and the survey's explanation for respondents made this point explicit (i.e., the survey informed respondents that new renewable energy encompassed sun ray, solar heat, wind power, biomass, etc.). Despite the substantial differences between these specific sources, they share common characteristics: they utilize natural circulation loops and thus their stocks are replaced with new growth; their technologies are relatively new and thus have much room for further development. These characteristics seem to have led respondents to have more positive perceptions of new renewable energy.

Overall, to summarize, the respondents' dominant perceptions of the energy sources were as follows: hydropower was comparatively fair, fossil fuel was overall inferior, nuclear power was superior only regarding affordability and contribution to economic development, and new renewable energy was overall superior.

Figure 1 shows the choice shares of the energy sources. A total of 721 (71.46%) of 1009 respondents chose new renewable energy as the most acceptable form of energy if a power plant were to be built in the neighborhood. The second most frequent choice was hydropower, with 212 respondents (21.01%). These choice results are consistent with previous findings. The public in many countries generally tends to assess renewable energy—the category of renewable energy includes both traditional hydropower and "new" renewable energy sources—more positively [42] than fossil fuel and nuclear power [1,20–22,27,43].

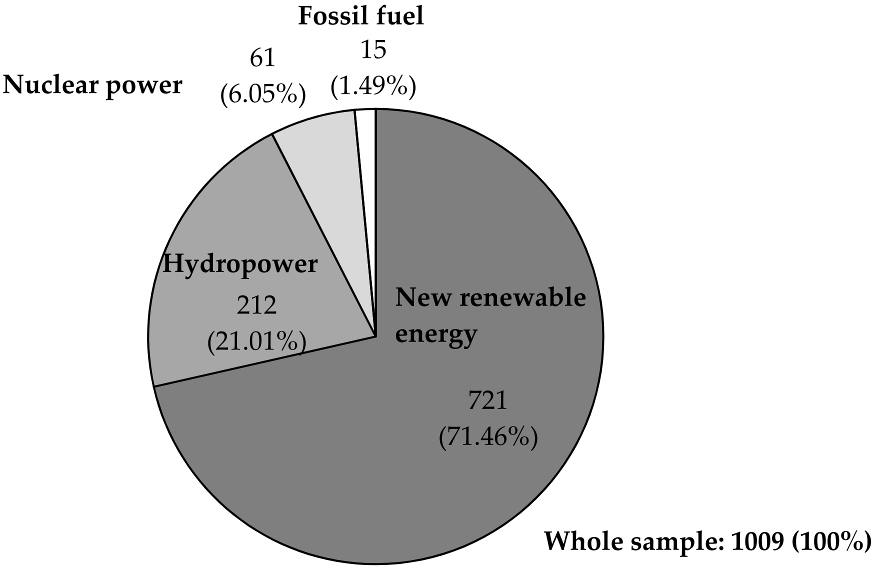

**Figure 1.** Shares of energy sources chosen as the most acceptable power plant for a neighborhood.

### *4.2. Mixed Conditional Logit Results*

Table 3 shows the results from the mixed conditional logit model, which is highly significant (model $p = 0.0000$), and has a considerably high level of explanative power (pseudo $R^2 = 0.51$). The variance inflation factors of the independent and control variables were not greater than 2.53, far below the 10.0 threshold for multicollinearity [44]. The reference option for the choice variable was new renewable energy. The constants were more negative in the order fossil fuel, nuclear power, and hydropower, indicating that the choice probability in ascending order was fossil fuel, nuclear power, hydropower, and new renewable energy, which is consistent with the choice share results from Figure 1. At the 0.05 level, the socio-demographic control variables were found to not be significantly associated with the choice of fossil fuel, nuclear power, and hydropower compared to new renewable energy.

Of the five features of the energy sources, the perception of safety and eco-friendliness were found to be significantly associated with the choice. First, an energy source being perceived as the safest led to a higher probability of the source's power plant being chosen as the most acceptable for the neighborhood compared to being ranked second safest ($\beta = 0.57$, $z = 5.95$, $p = 0.000$), although being perceived as second- and third-safest did not lead to a higher choice probability compared to their succeeding ranks (third- and fourth-safest, respectively). In other words, one step up in the safety ranking from second to first significantly increased the choice probability whereas a similar step from a lower rank did not.

Second, regarding the perception of eco-friendliness, a source being ranked first led to a higher choice probability compared to being ranked second ($\beta = 0.51$, $z = 5.26$, $p = 0.000$); being ranked second also increased the choice probability compared to being ranked third ($\beta = 0.56$, $z = 3.58$, $p = 0.000$). However, improving by one step from fourth to third did not affect the choice probability.

**Table 3.** Mixed conditional logit results.

| **Effect on the choice of the most acceptable power plant for a neighborhood** | | | |
|---|---|---|---|
| **Alternative-specific variables: rank-ordered feature perceptions** | | | |
| Safety: 1st compared to 2nd | 0.57 (0.10) * | | |
| Safety: 2st compared to 3rd | 0.22 (0.15) | | |
| Safety: 3rd compared to 4th | 0.21 (0.22) | | |
| Affordability: 1st compared to 2nd | 0.14 (0.12) | | |
| Affordability: 2st compared to 3rd | −0.21 (0.13) | | |
| Affordability: 3rd compared to 4th | −0.19 (0.15) | | |
| Eco-friendliness: 1st compared to 2nd | 0.51 (0.10) * | | |
| Eco-friendliness: 2st compared to 3rd | 0.56 (0.16) * | | |
| Eco-friendliness: 3rd compared to 4th | −0.10 (0.25) | | |
| Contribution to economic development: 1st compared to 2nd | −0.07 (0.12) | | |
| Contribution to economic development: 2st compared to 3rd | 0.25 (0.14) | | |
| Contribution to economic development: 3rd compared to 4th | −0.21 (0.17) | | |
| Job creation: 1st compared to 2nd | 0.12 (0.12) | | |
| Job creation: 2st compared to 3rd | −0.03 (0.14) | | |
| Job creation: 3rd compared to 4th | −0.03 (0.15) | | |
| | **Reference: New renewable energy** | | |
| | **Hydropower** | **Fossil fuel** | **Nuclear power** |
| Constant | −0.81 (0.10) * | −2.79 (0.33) * | −1.81 (0.16) * |
| **Individual-specific variables: socio-demographic characteristics** | | | |
| Gender [b] | 0.11 (0.09) | −0.30 (0.29) | 0.26 (0.15) |
| Age [c] | 0.06 (0.11) | −0.03 (0.33) | −0.33 (0.18) |
| Educational level [d] | 0.11 (0.12) | 0.24 (0.35) | −0.09 (0.19) |
| Income level [c] | 0.03 (0.10) | −0.24 (0.31) | −0.27 (0.17) |
| Log-likelihood: −685.65; likelihood ratio $\chi^2_{30}$ = 1426.24; $p$ = 0.0000; pseudo $R^2$ = 0.51. | | | |

Note: $N$ = 4036 (i.e., 1009 respondents × 4 kinds of energy sources). The number outside of the parenthesis is the coefficient, the number inside the parenthesis is the coefficient's standard error. [a] Cumulatively coded ordinal dummy variables. [b] Contrast coded: male = −1, female = 1. [c] Standardized. [d] Contrast coded: high school diploma or lower = −1, current college student or higher degree = 1. * $p < 0.01$.

## *4.3. Robustness Check*

To check the robustness of our results, we conducted multiple runs of mixed conditional logit analyses using ordinary dummy coding for the rank-ordered feature perceptions (i.e., we coded the rank using three dummy variables, each of which represented a rank other than the base rank, as 0). In these runs, we alternately changed the base rank. As the summarized results presented in Table 4 show, these analyses produced identical findings to those reported in Table 3. In other words, the results of our analyses regarding whether one step up in a feature ranking significantly increased the choice probability (shown in Tables 3 and 4) revealed identical patterns. For example, regarding safety perception, an energy source being perceived as the safest led to a higher choice probability for the source's power plant than for an energy source perceived as second-safest (β for "1st compared to 2nd" = 0.57, $p < 0.001$), although being perceived as the second- and third-safest did not lead to a higher choice probability compared to third- and fourth-safest, respectively. Overall, the different coding schemes confirmed our findings regarding the rank-ordered feature perceptions, supporting the robustness of these results.

**Table 4.** The results using ordinary dummy coding for the rank-ordered feature perceptions.

| **Effect on the choice of the most acceptable power plant for a neighborhood** | |
|---|---|
| **Safety** | |
| When the base rank is the 4th | |
| 1st compared to 4th | 1.01 (0.20) * |
| 2nd compared to 4th | 0.43 (0.21) |
| 3rd compared to 4th | 0.21 (0.22) |
| When the base rank is the 3rd | |
| 1st compared to 3rd | 0.80 (0.14) * |
| 2nd compared to 3rd | 0.22 (0.15) |
| 4th compared to 3rd | −0.21 (0.22) |
| When the base rank is the 2nd | |
| 1st compared to 2nd | 0.57 (0.10) * |
| 3rd compared to 2nd | −0.22 (0.15) |
| 4th compared to 2nd | −0.43 (0.21) |
| **Affordability** | |
| When the base rank is the 4th | |
| 1st compared to 4th | −0.26 (0.15) |
| 2nd compared to 4th | −0.40 (0.15) * |
| 3rd compared to 4th | −0.19 (0.15) |
| When the base rank is the 3rd | |
| 1st compared to 3rd | −0.06 (0.13) |
| 2nd compared to 3rd | −0.21 (0.13) |
| 4th compared to 3rd | 0.19 (0.15) |
| When the base rank is the 2nd | |
| 1st compared to 2nd | 0.14 (0.12) |
| 3rd compared to 2nd | 0.21 (0.13) |
| 4th compared to 2nd | 0.40 (0.15) * |
| **Eco-friendliness** | |
| When the base rank is the 4th | |
| 1st compared to 4th | 0.98 (0.23) * |
| 2nd compared to 4th | 0.47 (0.23) |
| 3rd compared to 4th | −0.10 (0.25) |
| When the base rank is the 3rd | |
| 1st compared to 3rd | 1.07 (0.15) * |
| 2nd compared to 3rd | 0.56 (0.16) * |
| 4th compared to 3rd | 0.10 (0.25) |
| When the base rank is the 2nd | |
| 1st compared to 2nd | 0.51 (0.10) * |
| 3rd compared to 2nd | −0.56 (0.16) * |
| 4th compared to 2nd | −0.47 (0.23) |
| **Contribution to economic development** | |
| When the base rank is the 4th | |
| 1st compared to 4th | −0.03 (0.17) |
| 2nd compared to 4th | 0.04 (0.16) |
| 3rd compared to 4th | −0.21 (0.17) |
| When the base rank is the 3rd | |
| 1st compared to 3rd | 0.18 (0.14) |
| 2nd compared to 3rd | 0.25 (0.14) |
| 4th compared to 4th | 0.21 (0.17) |
| When the base rank is the 2nd | |
| 1st compared to 2nd | −0.07 (0.12) |
| 3rd compared to 2nd | −0.25 (0.14) |
| 4th compared to 2nd | −0.04 (0.16) |

**Table 4.** *Cont.*

| Job creation | |
|---|---|
| When the base rank is the 4th | |
| 1st compared to 4th | 0.07 (0.15) |
| 2nd compared to 4th | −0.06 (0.15) |
| 3rd compared to 4th | −0.03 (0.15) |
| When the base rank is the 3rd | |
| 1st compared to 3rd | 0.09 (0.14) |
| 2nd compared to 3rd | −0.03 (0.14) |
| 4th compared to 3rd | 0.03 (0.15) |
| When the base rank is the 2nd | |
| 1st compared to 2nd | 0.12 (0.12) |
| 3rd compared to 2nd | 0.03 (0.14) |
| 4th compared to 2nd | 0.06 (0.15) |

Note: The results here are excerpted from multiple runs of analyses in which we alternately changed the base rank. The model specifications are the same as that used to generate the results in Table 3, except that we used ordinary dummy coding for the rank-ordered feature perceptions. * $p < 0.01$.

### 4.4. Additional Analysis

We conducted an additional mixed conditional logit analysis whose dependent variable was which power plant respondents chose as the least acceptable option (i.e., the fourth-most acceptable power plant) for their neighborhood. Respondents most frequently chose nuclear power plants (451 respondents: 44.70%) as the least acceptable option and fossil fuel plants came in a close second (448 respondents: 44.40%). Meanwhile, respondents chose hydropower (84 respondents: 8.33%) and new renewable energy (26 respondents: 2.58%) at substantially lower frequencies. Overall, our analysis showed that respondents' least preferred power sources were split between nuclear power and fossil fuel.

As Table 5 shows, we found that the five features of energy sources were significantly associated with respondents' choice of the least acceptable power plant for their neighborhood. We mainly observed that such choices were determined by whether the energy sources respondents chose as the worst (i.e., fourth) or the second-worst (i.e., third) regarding the given features and among the competing energy sources. Regarding the five features, one step up in ranking from fourth to third significantly decreased the probability that respondents would choose the energy source as the least acceptable, whereas one step up among upper ranks (i.e., third and higher) did not necessarily have this effect. Thus, we concluded that respondent perceptions of all five features, —particularly the perceptions of which energy source is the worst regarding these features— determined the power plants they chose as the least-acceptable for their neighborhood. Comparing these findings with the results of our analysis of respondent choice of the most acceptable power plant, reported in Table 3, led to the following conclusions. First, whereas only respondent perceptions of safety and eco-friendliness were associated with their choice of the most acceptable power plant for neighborhood, their perceptions of all five features were associated with their choice of the least acceptable power plant. Second, whereas respondents' perceptions of which energy source was the safest (i.e., first) or eco-friendly (i.e., first or second) drove their choice of the most acceptable power plant, their perceptions of which energy source rank worst in terms of the five features (i.e., fourth) determined their choice of the least acceptable power plant. Overall, different sets of rank-ordered feature perceptions and different ranges of ranks determined respondent choice of the most and least acceptable power plant for a neighborhood. Because this study aimed to integrate competitive contexts into its examination of the determinants of the choice of the most acceptable power plant for a neighborhood, our discussion will focus on this choice.

**Table 5.** Results regarding the choice of the least acceptable option.

| **Effect on the choice of the lest acceptable power plant for a neighborhood** | | | |
|---|---|---|---|
| **Alternative-specific variables: rank-ordered feature perceptions** | | | |
| Safety: 1st compared to 2nd | | | −0.68 (0.21) * |
| Safety: 2st compared to 3rd | | | −0.18 (0.13) |
| Safety: 3rd compared to 4th | | | −0.64 (0.08) * |
| Affordability: 1st compared to 2nd | | | −0.06 (0.14) |
| Affordability: 2st compared to 3rd | | | 0.07 (0.12) |
| Affordability: 3rd compared to 4th | | | −0.40 (0.11) * |
| Eco-friendliness: 1st compared to 2nd | | | −0.22 (0.20) |
| Eco-friendliness: 2st compared to 3rd | | | −0.64 (0.13) * |
| Eco-friendliness: 3rd compared to 4th | | | −0.25 (0.10) * |
| Contribution to economic development: 1st compared to 2nd | | | 0.18 (0.14) |
| Contribution to economic development: 2st compared to 3rd | | | 0.14 (0.13) |
| Contribution to economic development: 3rd compared to 4th | | | −0.30 (0.11) * |
| Job creation: 1st compared to 2nd | | | 0.05 (0.13) |
| Job creation: 2st compared to 3rd | | | −0.20 (0.12) |
| Job creation: 3rd compared to 4th | | | −0.33 (0.11) * |
| | **Reference: New renewable energy** | | |
| | **Hydropower** | **Fossil fuel** | **Nuclear power** |
| Constant | 0.58 (0.27) | 1.17 (0.25) * | 2.02 (0.24) * |
| **Individual-specific variables: socio-demographic characteristics** | | | |
| Gender | 0.02 (0.25) | −0.10 (0.22) | −0.10 (0.22) |
| Age | 0.43 (0.31) | 0.34 (0.27) | 0.40 (0.27) |
| Educational level | 0.79 (0.33) | 0.44 (0.29) | 0.47 (0.29) |
| Income level | −0.08 (0.28) | 0.30 (0.25) | 0.25 (0.25) |
| Log-likelihood: −841.68; likelihood ratio $\chi^2_{30}$ = 1114.18; $p$ = 0.0000; pseudo $R^2$ = 0.40. | | | |

Note: The model specification is the same as that used to generate the results in Table 3, except that the dependent variable was the choice of the least acceptable power plant for a neighborhood. * $p < 0.01$.

## 5. Discussion

### *5.1. Theoretical Implications and Future Research Directions*

#### 5.1.1. Contextualization of the Study

The present study investigated the effects of individuals' rank-ordered feature perceptions of competing energy sources (instead of separate perceptions of a single energy source) on their choice of the most acceptable power plant for a neighborhood (instead of their separate willingness to accept an energy source). Our incorporation of competitive contexts into the analysis marks a step forward in understanding local acceptance of energy sources and its determinants. However, drawing conclusions from the findings requires cautious consideration of the other contexts in which we conducted the investigation.

First, the five features (i.e., safety, affordability, eco-friendliness, contribution to economic development, and job creation) for which we incorporated competitive contexts were mainly based on the benefit-risk framework, a widely-used approach for modeling people's evaluations of technologies (e.g., References [45–47]), including energy technologies (e.g., References [1,48–51]). Previous studies applying this framework to energy acceptance have found that the benefits and risks individuals perceive from an energy source are positive and negative predictors, respectively, of their acceptance of that energy source. The five features are sub-categories of either these benefits or risks, or both. Safety is the conceptual opposite of risk; eco-friendliness can be regarded as either the conceptual opposite of environmental risk or a synonym for environmental benefit, or both. Affordability, contribution to economic development, and job creation are economic benefits.

However, benefit and risk perceptions related to energy sources are not the only important determinants of energy source acceptance; existing studies have shown that several factors influence benefit and risk perceptions. For example, the degree of trust that individuals have in energy source-related institutions (e.g., governments and companies) exerts a significant influence on how they perceive the benefits and risks of the energy sources [23]. Other antecedent variables such as affective feelings, values, beliefs, and ideological and political orientations have been shown to influence both benefit/risk perceptions and trust. For example, an individual's affect can influence his/her acceptance of wind, solar, nuclear, and natural gas power, by influencing his/her benefit and risk perceptions from those energy sources [21]. Research has also shown that an individual's environmental values (e.g., pro-environmental ideological orientation) also influence his/her acceptance of specific energy sources (e.g., References [21,52]). In light of these findings, our incorporation of a competitive context into the analysis of determinants of local energy source acceptance, conducted mainly within the boundaries of the benefit-risk framework, did not encompass all possible determinants.

Second, our findings provide insights regarding the determinants of individuals' general power plant-related preferences (i.e., the power plant they would ideally accept or tolerate for their neighborhood) rather than their preferences for specific site plans or power plant offerings. Although our survey item for the most acceptable neighborhood power plant prompted respondents to imagine a situation in which their local areas would serve as sites of power plants, it did not provide specific site plans or offerings for residents (e.g., safety or environmental measures for the construction and operation of the power plants, or economic incentive or compensation for the sites). As a result, the respondents' energy choices were likely based on their general, memory-based attitudes rather than specific, stimulus-based attitudes in real contexts. In hypothetical choices of alternatives, people may generally prefer certain alternatives they regard as ideal, but in actual-choice situations, many may choose less-ideal alternatives offered with incentives to compensate for their less-ideal features. Of course, general preferences are significant predictors of actual choice behaviors even if the former and the latter may not perfectly coincide [53]. Considering both the weakness and importance of general preferences in predicting actual behavior, the determinants of energy choice in the present study should be understood as determining individuals' general preferences about power plants in their neighborhood, which are significant determinants of actual behaviors regarding the construction of such power plants (e.g., voting or advocating for or against such construction) but not the actual behaviors themselves.

Third, our survey did not reflect social, historical, political, economic, and other factors that may vary across regions. For example, whether and how a power plant has been operating in a respondent's region may affect his/her perceptions of the corresponding energy source and local acceptance of a power plant adopting that energy source. Since the present study did not consider region-specific contexts, the possibility that its findings vary regionally remains.

Overall, for the reasons mentioned above, drawing implications of our findings requires cautious consideration as follows. For the first reason mentioned above, the benefit–risk framework and existing findings on risk perceptions will serve as important tools in interpreting findings regarding the influences of the rank-ordered feature perceptions of competing energy sources, although we will also utilize other views and logics. For the second and third reasons, the influences of the rank-ordered feature perceptions that we identified are their influences on general preferences regarding neighborhood power plants rather than direct influences on actual behaviors, which occur in response to specific site plans or offerings in real, regional contexts.

#### 5.1.2. The Selective Significance of the Rank-Ordered Feature Perceptions

Our results found that only some of the rank-ordered feature perceptions (i.e., those regarding safety and eco-friendliness) were significantly associated with the choice of the most acceptable power plant for a neighborhood. This selective significance of the feature perceptions raises the need to consider the distinctive characteristics of the features. The significant features—safety and eco-friendliness—both relate to concerns about life/health. The insignificant features—affordability, contribution to economic development, and job creation—relate to economic consequences. Thus, one may interpret this selective significance as implying that the life/health-related features of energy sources rather than their economic features are people's primary consideration in their choice of the most acceptable power plant for their neighborhood.

Another distinction can be made using the benefit–risk framework. Risk in general refers to the "possibility of loss or injury" [54]. In this sense, the life/health-related features in our study relate to risks, because if safety or eco-friendliness is not fulfilled, it leads to negative consequences such as loss of lives or health. Thus, we can term these features as life/health-related "risk" features. On the other hand, the economy features relate to benefits, as they concern positive economic outcomes that a power plant can bring (i.e., affordable electricity, economic development, or job creation). From this perspective, we can term these features economic "benefit" features. Applying this distinction, the selective significance of the features can be interpreted as implying that people are sensitive to risks but less so to benefits in their choice of the most acceptable power plant for their neighborhood. This interpretation is consistent with Tanaka's findings [48], namely that when selecting the site of a plant, perceived risk is extremely important and perceived benefit is not so important in predicting the public acceptance of a nuclear facility.

The life/health versus economy distinction and the risk versus benefit distinction both provide rationales for the selective significance of the features. Nevertheless, it cannot be ruled out that such selective significance arises from another distinction that lies between the features, namely the differentiated degrees of distributional/distributive justice. This refers to the issue of how the consequences of a development, which can be either public "benefits" or "burdens," are shared [55,56]. The consequences of high levels of economic benefits, that is, realized economic benefits, are likely to be largely enjoyed by all members of the country. In our research setting of South Korea, regional electricity pricing has not been introduced as of 2018 [57]. Thus, the benefit of affordable electricity from a power plant is not limited to the local people near the plant. When an energy source contributes to economic development, the benefits are also enjoyed by all individuals and organizations in the country. Jobs that are created in the areas near the power plant might not directly benefit the local people who may not work in the relevant industries.

In contrast, the negative outcomes from high levels of life/health-related risk features are borne directly and preferentially by those who reside near the power plant [9]. When the safety of a plant is not secured (e.g., dam failure flood, fossil fuel tank explosion, nuclear reactor explosion, or biomass plant explosion), those in the areas proximal to the plant are more directly exposed to the dangers that affect their lives and health. Additionally, the damage from the poor eco-friendliness of an energy source are primarily borne by the close residents. For example, when plant construction is inevitably accompanied by the destruction of a forest, wildlife habitat, agricultural land, or scenic lands; or when the operation of a plant consistently emits pollutants, the damages preferentially and intensively affect the nearby areas, although greenhouse gas emission can have more global influences. As such, the local residents near a power plant primarily and directly bear the life/health risks of the plant, whereas they are just one of the common beneficiaries of the economic benefits. From this perspective, the selective significance of the features might be because people preferentially focus on minimizing their potential burden from a plant, which is in agreement with the NIMBY phenomenon ("not in my backyard") [15,58].

As such, there exist multiple dimensions for the distinction between the significant and insignificant features that we found: (1) life/health versus economy, (2) risks versus benefits, and (3) burdens primarily taken by the local residents versus benefits enjoyed by all national citizens. These distinction dimensions are confounded, as safety and eco-friendliness correspond to life/health-related risks that are primarily taken by the local people, and the features of affordability, contribution to economic development, and job creation correspond to economic benefit features that are shared by all citizens of a country. Thus, disentangling these dimensions and determining which dimension(s) are relevant for the selective significance of the features may be a future research topic. It is worth considering extending the research setting so that it includes not only local choice but also national choice of an energy source. If the significance of a feature for choice varies between the local and national choice, then such a difference might be thought of as due to the mismatch between those bearing the burden and the beneficiaries of a plant.

#### 5.1.3. Difference between the Two Significant Features

A difference in the effect was found even between the two significant features. Regarding safety, only the net effect of the first rank versus (i.e., relative to) the second rank was significantly positive, whereas net effect of the second versus the third and the third versus the fourth rank were not (see Table 3). That is, only being perceived as the best in terms of safety was associated with a higher probability of being chosen as the most acceptable power plant for a neighborhood than the immediately lower, succeeding rank. This implies that the respondents tended to use a strict cut-off for safety.

On the other hand, the respondents were found to apply a less strict cut-off for eco-friendliness. The net effect of being ranked first versus second, and of being ranked second versus third, was significantly positive. That is, not only being ranked first in terms of eco-friendliness, but also being ranked second led to a higher choice probability than the immediately lower, succeeding rank. In other words, with regard to eco-friendliness, if an energy source is perceived as being within the top two, this increases the choice probability for that source. Overall, while respondents used both safety and eco-friendliness as significant criteria, they used the former as a stricter criterion.

The difference between these two features is unlikely to be based on the aforementioned distinctions of (1) life/health versus economy, (2) risks versus benefits, and (3) local burdens versus national benefits, because the features share a similarity in these distinctions. One possibility is that the difference may have arisen from the features' differentiated time horizons for the actualization of the risks. If safety is not achieved (e.g., a safety hazard such as a flood or explosion), its damage to lives and health is immediate. Compared to this, the consequences of a lack of eco-friendliness are relatively long-term. For example, even if the plant construction causes the destruction of natural environments or lands, or the operation of the plant emits pollutants or greenhouse gases, the resultant damage to human lives and health are realized relatively slowly compared to the damage from accidents. From this perspective, a lack of safety is a state of immediate risk, while a lack of eco-friendliness corresponds to relatively long-term risks. The literature states that immediate risks are generally perceived as more salient and of greater urgency than long-term risks; as a result, people may prefer to avoid immediate risks, whereas they are unduly tolerant of long-term risks [59]. Thus, our finding—that the respondents use a stricter criterion for safety (i.e., related to immediate risks) than for eco-friendliness (i.e., related to long-term risks)—can be thought of as reflecting people's differentiated tolerance for immediate risks and long-term risks.

This finding calls for research attention to the public's differentiated thresholds for safety and eco-friendliness in their acceptance or choice of an energy source. For example, the existence of thresholds (i.e., minimum levels required) for safety and eco-friendliness needs to be investigated. If such thresholds are found, they need to be compared between the features. This identification and comparison will contribute to knowledge of the differentiated importance of determinants of acceptance or choice of an energy source.

### *5.2. Practical Implications for Energy Industries*

The selective significance of the rank-ordered feature perceptions provides implications to the energy industries competing in South Korea. As noted in the previous sub-section, safety and eco-friendliness are energy source risk features. Thus, the significant effects limited to safety and eco-friendliness perceptions imply that risk governance—the institutional and social processes used to guide and regulate a society's collective decision-making and activities regarding risky objects [60,61]—is a core basis for the establishment and implementation of energy policy. In risk governance, the public plays an important role in conjunction with various other actors, including governments, municipalities, economic players, and scientific experts, to initiate collectively binding policies regarding risky objects [60–62]. Recognizing the role of the public in such contexts, the significant effects limited to perceptions of safety and eco-friendliness imply that to effectively and efficiently increase local acceptance of power plants, the energy industry needs to undertake communication efforts focused on improving how the public perceives the life/health features—safety and eco-friendliness—of their offerings relative to their competitors. Furthermore, members of the public are not merely targets of one-sided edification in risk governance and their perceptions of certain features of objects form based on the actual presence of such features [63]. Thus, the fact that our findings highlighted the exceptional significance of safety and eco-friendliness perceptions implies that parties related to energy sources (e.g., governments, municipalities, industry professionals, scientific experts, or civil organizations devoted to promoting the energy source) need to promote the investment of resources and efforts to improve the actual levels of these energy source features.

However, several additional points warrant mention. First, as noted in Section 5.1.1, the respondents' preferences for energy sources corresponded to their general preferences, which stem from their general, memory-based attitudes rather than specific, stimulus-based attitudes in real contexts. Second, the insignificant effects of the economy features in our results—affordability, contribution to economic development, and job creation—do not necessarily reject the importance of the other forms of economic benefits, such as incentive or compensation, that are provided to the local people in reward for the siting of a plant. As we described in Section 5.1.2, in the present research context, the economic features are related to the economic benefits that are shared by all members in the country; they are not about economic incentive or compensation to persuade the local people into accepting the construction of a power plant in their neighborhood. For these reasons, our suggestions, focusing on perceptions of life/health features, serve as guidelines for energy industry positioning strategies aimed at improving people's general preferences for energy sources, rather than for the composition of incentive offers in negotiation with local people. On this premise, we present energy positioning guidelines that reflect their characteristics as well as our analysis results.

#### 5.2.1. Hydropower

As presented in Table 2, the dominant ranking of hydropower regarding the five features was in the middle (second or third). In other words, people's dominant perception is that hydropower is neither the best nor the worst with regard to the studied features. Despite these perceptions, which are not outstanding, the choice share of hydropower is fairly good, at 21.01%, after new renewable energy (71.46%). This relatively good choice result despite the overall non-outstanding feature perceptions seems to be due to the fact that the dominant ranking of hydropower in terms of eco-friendliness (second) was within the threshold rank for that feature (i.e., within the second rank).

To maintain and leverage this fair rank regarding eco-friendliness, hydropower must address both positive and negative factors. The positive aspect is that, once constructed, the operation of the plant is free from the emission of pollutants or greenhouse gases. However, its construction is inevitably accompanied by destruction of the area, which would otherwise remain as forests, wildlife habitat, or agricultural land [64]. The current perception of hydropower in terms of eco-friendliness is, naturally, a reflection of these two conflicting factors. In other words, unless the negative environmental impacts caused by plant construction are mitigated, efforts to leverage the perception of the eco-friendliness of hydropower higher are likely to face difficulties.

From this perspective, the hydropower industry needs to consider a more forward-looking transfer of its main generation platforms, from conventional large-scale hydropower to small-scale hydropower. Small-scale hydropower (or low-head hydropower), using tidal flows or rivers, does not need a dam to retain water and thus, does not cause the submerging of areas. Therefore, compared to conventional large-scale hydropower, small-scale hydropower reduces the environmental impact from construction [65,66], which is advantageous to the public's perception of this source of power in terms of its eco-friendliness [67]. On the other hand, small-scale hydropower is criticized for being less economically attractive than conventional large-scale hydropower because of its lack of economy of scale [68]. Regarding this trade-off, our results can provide guidelines for decision-making. Our results imply that eco-friendliness is a significant feature in people's choice of the most acceptable power plant for their neighborhood, while the economic features are questionable influencers. Thus, at least in terms of local people's preference, transferring to small-scale hydropower may provide more opportunities for plant construction. In addition, small-scale hydropower is likely to be more advantageous in achieving actual safety and a perception of safety by the people. As it does not require a dam [69], small-scale hydropower may dramatically reduce the risks that stem from having a dam (e.g., a flash flood caused by a breached dam).

### 5.2.2. Fossil Fuel

The situation for fossil fuel can be described as being "beleaguered." The dominant perceptions regarding the significant features are the worst (i.e., ranked fourth for safety and eco-friendliness), and its choice share (1.49%) is the worst (see Table 2 and Figure 1). It seems that the fossil fuel industry needs to concentrate more on people's perception regarding fossil fuel's safety. That fossil fuel is one of the major sources of air pollution and climate change is close to an undeniable scientific truth [70,71]. This fact also appears to be well known to the South Korean public, judging from the fuel's dominant rank for eco-friendliness, where 71.36% of the respondents in our sample ranked it fourth, which was the lowest. From this perspective, leveraging people's perception of fossil fuel in terms of eco-friendliness appears to be highly infeasible. Thus, focusing efforts on people's perception of the safety of fossil fuel will at least be a relatively implementable strategy.

### 5.2.3. Nuclear Power

The dominant perception of nuclear power substantially varied depending on the feature, as described in Section 4.1. The problem for nuclear power is that its outstanding or fair dominant perceptions were all related to the insignificant features (i.e., ranked first or second for affordability, contribution to economic development, and job creation), while the low dominant perceptions were concentrated on the significant features (i.e., ranked fourth for safety and third for eco-friendliness) (see Table 2). This seems to be the reason why nuclear power had a considerably low choice share (6.05%) (see Figure 1). For the following reasons, we recommend that the nuclear power industry exerts more efforts to address people's perception of the eco-friendliness of nuclear power by emphasizing the power's fundamental strength with regard to environmental protection.

First, leveraging people's perception regarding safety has a systematic obstacle due to nuclear power's fundamental weakness, which is that an accident at a nuclear facility can lead to critical, widespread, and long-lasting damage to lives and the environment from the released radioactivity and the resultant radioactive contamination [72]. Thus, the safety issue has always been a critical concern for nuclear power [73]. Moreover, in the aftermath of the Fukushima accident in 2011, the safety concerns about nuclear power have been reinforced [74]. In contrast, nuclear power has strong advantages regarding eco-friendliness, as it minimizes the emission of air pollutants and greenhouse gases.

Second, as we previously presented, the cut-off rank was less strict for eco-friendliness (second) than for safety (first). Nuclear power's dominant rank for eco-friendliness (third) was one step lower than the cut-off rank, while that for safety (fourth) was three steps lower. Because the rank was not an interval variable but an ordinal variable, a three-step difference may not be necessarily greater than a one-step difference. However, considering the competitors' possible reactions (i.e., exerting communication efforts to defend their current positions against any communication efforts by the nuclear power industry), focusing efforts on outdoing three more competitors would be a less-recommendable approach than seeking to outdo only one competitor. Moreover, as we stated in the preceding paragraph, it is likely to be less feasible for nuclear power to outdo its competitors in terms of safety. Thus, if the nuclear industry chooses to focus on safety rather than eco-friendliness, it is choosing to try to outdo a greater number of competitors regarding a feature for which it will be particularly difficult to improve.

#### 5.2.4. New Renewable Energy

The dominant perception regarding new renewable energy is that it is the best energy source for all five given features (see Table 2). Particularly, the energy's being dominantly perceived top rank regarding the significant features—safety and eco-friendliness—seems to be the main driver of it having the greatest choice share (61.65%) (see Figure 1). Thus, for the new renewable energy industry, the general recommendation would be to maintain and reinforce people's current perceptions of new renewable energy by focusing communication efforts on reminding people about the energy's superiority regarding safety and eco-friendliness.

However, this general guideline may vary for different types of new renewable energy. Particularly, the actual reality and the public perception of biomass—an energy source from burning wood and other organic matter—is substantially different to the general category of new renewable energy. Biomass is classified as a renewable energy source according to the European Union (EU) policy framework [75] because plant stocks can be replaced with new growth; it is classified as a "new" renewable energy source by the South Korean government [18]. However, unlike other traditional (i.e., hydropower) or new (e.g., wind power or solar energy) renewable energy sources, the ability of biomasses to lower pollution and reduce greenhouse gas emissions is disputed [76]. In particular, concerns about possible air pollution from biomass combustion caused a recent plan to construct a biomass power plant in Pohang, South Korea, to be met with opposition from local residents [77]. Prior to this, in 2017, a government-authorized plan for the construction of a biomass plant in Namwon was switched to a plan for a solar energy plant in response to local protests stemming from anxiety over a biomass plant's direct and indirect effects on fine dust generation [78]. As such, the generally favorable perceptions of the general category of new renewable energy may not be true for biomass. Thus, compared to other sub-categories of new renewable energy (i.e., wind power and solar energy), the biomass industry will need intensive investment to improve its actual ability to reduce air pollution, as well as improving its perceived ability to do so. If this is not achieved, according to our analysis results, which emphasize the significance of eco-friendliness and the insignificance of the economic features, the biomass industry is expected to suffer consistent opposition from local people despite its economic attractiveness.

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