



Perceptual differences in the factors of local acceptance of spent nuclear fuel repositories



Taehyun Kim*, Hyunjoo Park

Korea Environmental Information Center, Korea Environment Institute, Republic of Korea

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ABSTRACT

In the process of land use planning, massive social costs are incurred as various conflicts arise due to the location of locally unwanted land-use (LULU) such as spent nuclear fuel repositories. The factors affecting local acceptance of such facilities may vary according to individuals' perceptual differences. This study aims to examine the differences in factors affecting local acceptance in regards to residents' risk perception of spent nuclear fuel repositories. To do so, Q methodology was adopted. Three perceptual types—safety concerns-government distrust (type 1), safety trust-government trust (type 2), and safety concerns-conflict avoidance (type 3)—were identified and the differences in local acceptance factors among these types were verified via path analysis. The results showed that risk perception had the highest influence on local acceptance for types 1 and 3, whereas economic feasibility had the greatest influence for type 2. The methodology and results of this study may contribute to developing a policy on siting LULU facilities in consideration of local acceptance and the risk perception of residents.

1. Introduction

As of the end of 2014, approximately 340,000 tons of spent nuclear fuel were produced worldwide—4% of which were produced in South Korea (around 14,000 tons) (Kim, 2016a). As of 2016, the temporary storage for spent nuclear fuel from nuclear power plants is reaching its limit, and thus a discussion on the management of and facility location for spent nuclear fuel is inevitable (Kim et al., 2015). In the process of land use planning, massive social costs are incurred as various conflicts arise due to the location of locally unwanted land-use (LULU), such as basic environmental treatment facilities. Among the cases of LULU, people particularly perceive the danger of spent nuclear fuel—which is categorized as high-level radioactive waste and thus carries a higher potential risk compared to mid- to low-level radioactive waste—more seriously, which results in a conflict of various interests. Despite the continued efforts by the Korean government to resolve this issue, the only systematic methodologies available for gathering opinions and promoting resident participation are basic opinion polls and referendums. However, if the factors affecting local acceptance vary according to individuals' perceptual differences, a policy approach that reflects residents' perceptual differences would be necessary when positioning LULU. In this respect, this study aims to examine the differences in factors affecting local acceptance according to residents' perceptual differences on spent nuclear fuel repositories.

Studies on residents' perceptual differences and local acceptance determinants for radiation facilities, such as spent nuclear fuel repositories, have been continuously conducted to date (Chung et al., 2008; Chung and Kim, 2009; Kim and Kim, 2014; Peters et al., 2004; Seidl et al., 2013).

In such studies, surveys were conducted to examine the process of stigma formation for radiation sources from a risk perception point of view (Peters et al., 2004), and to identify the risk and benefit perceptions (Seidl et al., 2013) and local acceptance determinants (Chung et al., 2008; Chung and Kim, 2009) for radioactive (nuclear) waste disposal facilities. Also, there was a study on spatial politics that was conducted through interviews and by analyzing spatial data from a resident poll on the placement of a low-level radioactive waste disposal facility in Korea (Kim and Kim, 2014). According to that study, it took almost 30 years to determine the facility site due to public oppositions until the city of Gyeongju was selected by local referendums amongst four candidate cities in 2005 and this competitive voting between administrative districts emerged as a factor that could aggravate conflict between and within regions.

Perceptions of high-level radioactive waste disposal facilities were actively studied in the early 1990s in relation to resident conflict, during the process of deciding the placement of the Yucca Mountain Nuclear Waste Repository in Nevada (Slovic et al., 1991; Frey, 1993; Bassett et al., 1996). Later, in the 2000s, several studies on the

* Corresponding author at: Bldg B, 370 Sicheong-daero, Sejong, 30147, Republic of Korea.
E-mail addresses: kimth@kei.re.kr (T. Kim), parkhj@kei.re.kr (H. Park).

perception and placement of radioactive waste disposal facilities were conducted. Yucca Mountain's disposal system for nuclear fuel and high-level radioactive waste was still of concern (Rechard et al., 2014) regarding its site selection and regulatory basis.

Siting nuclear waste facilities has been very difficult in the United States, Europe, Japan, and so on, so these countries have become very interested in the public's perception of these facilities. Some of them showed that their policy stances were related to the perception of high-level radioactive waste and its facilities (Sjöberg, 2004, 2006, 2009; Saling, 2001; Adair, 2015), and others analyzed the factors of perception in various fields, such as time difference (Tsujikawa et al., 2016), facility type (Kruetli et al., 2015; Jenkins-Smith and Kunreuther, 2001), and individual differences (Purvis-Roberts et al., 2007).

Although the subjectivity of cognitive subjects needs to be primarily considered when studying resident perception, such studies mostly include surveys and case studies, and limited research on the perception of spent nuclear fuel has been conducted via a subjectivity analysis methodology. In this context, Kim et al. (2015) examined perception types relating to spent nuclear fuel repository using Q methodology. The authors found that the perception types could be categorized by safety concerns, as follows: government distrust (type 1), safety trust-government trust (type 2), and safety concerns-conflict avoidance (type 3).

As a method of “objectifying subjectivity,” the Q methodology possesses numerous merits as well as limitations. According to a study by Kim and Kim (2014), while many studies have used quantitative research methodologies including local acceptance questionnaires, geographical information system data, and statistical models, there are a limited number of integrated studies that apply qualitative or mixed methodologies (Kim et al., 2015). To fill this methodological gap in researches of local acceptance on LULU, we utilized a methodology that combined Q analysis with the traditional survey method. As the purpose of this study is to analyze differences between determinants of local acceptance in relation to resident perceptions of spent nuclear fuel repositories, we adopted a mixed methods approach, combining qualitative (Q analysis) and quantitative (survey) approaches.

2. Materials and method

There is a research gap one must consider to grasp the types of subjective perceptions of individual residents in the inside of the standpoint. In Korea, public opinions on draft environmental impact assessment reports and the necessity of holding a public hearing are collected only in open question form. Open questions have the advantage to close ones that may miss essential factors important to the public. However, it could be difficult for the general public, not experts, to understand the technical report and present their opinions on it. Therefore, it is necessary to develop a systematic method of collecting opinion of residents to reflect various individual viewpoints about LULU (Kim et al., 2015) by combining bottom-up (Q analysis) and top-down methods (survey).

Contrary to a simple questionnaire or case study, this study examined the perspective (subjectivity) of residents regarding high-level radiation facilities, and identified the difference in acceptance determinants between subjective perspective types via Q analysis and structural equation model analysis. We choose Q analysis among several subjective research methods as a qualitative component because it provides robust understandings for grouping survey respondents based on their perspective by categorizing the types of controversial point of views via factor analysis (Danielson, 2009; Franz et al., 2013).

First, Q analysis was conducted to determine people's perceptions of spent nuclear fuel and its repositories. Q methodology allows the identification of an individual's thoughts, as it scientifically measures an individual's personal perspective and opinions with the minority as a variable. A Q analysis is conducted in 5 steps: 1) 45 Q statements are prepared, 2) 54 subjects are selected for the P sample, 3) Q

classification is conducted, 4) Q factor analysis is conducted on the selected subjects, and 5) the results are interpreted.

The Q statements were prepared in a non-structural but systematic manner (refer to report), and a total of 239 statements were selected from reports, news articles, interviews, papers, and books. The statements covered all topics on nuclear energy and spent nuclear fuel. A literature review and expert consultations were conducted from June 1 to June 24, 2015, to select 69 statements from the total 239 statements based on the main evaluation criteria of the Korean Nuclear Society, Korean Radioactive Waste Society, and the Green Korea 21 Forum (2011). The selected statements were divided into the following categories: environmental impact, economic feasibility, risk perception, social acceptability, and management and operation. A total of 45 statements were ultimately prepared after simplifying them by deleting and merging duplicate items.

The 54 research subjects (P sample) included both professionals and non-professionals, and were a mix of genders, ages, educations, and occupations. They were selected from among the residents of the Ulsan and Gyeongju regions, which are near a nuclear power plant.

Subsequently, the respondents were asked to copy and categorize 45 index cards, each listing a Q statement, onto a Q sheet for Q classification. Q classification is a process in which respondents are asked to forcefully categorize Q statements based on a nine-point scale, with three most-agreed statements (nine points), four agreed statements (eight points), three most-disagreed statements (one point), and four disagreed statements (two points). The data obtained through Q classification were subjected to factor analysis using the PQ Method software (Kim et al., 2015).

The PQ Method software has a centroid method (Qcent) and a principal component analysis (PCA) method for extracting factors. One of the most commonly used analyzes is to extract only those factors with eigenvalues which is the sum of squares of the variables greater than 1.00. Since the eigenvalue is affected by the number of variables, it is necessary to observe the explained variance (%) of each factor. In this study, factor analysis was performed by selecting factors with eigenvalue of 1.00 or more, total variance of each factor of 5% or more, and number of P samples of 3–4 or more.

From Q classification, resident perceptions of spent nuclear fuel repositories were classified into the following three types: confidence in government, confidence in safety, and focus on environment or people.

When the types were classified using the collective intelligence of the investigators, the common opinion was adopted and reflected in representative statements through discussion regarding inconsistency, and the words that could best be used to distinguish each type from the others were presented.

Accordingly, the types were determined to be “Safety concerns-government distrust (type 1),” which was characterized by low confidence in the government and safety; “Safety trust-government trust (type 2),” which was characterized by high confidence in the government and safety; and “Safety concerns-conflict avoidance (type 3),” characterized by high confidence in the government but a “not in my backyard” (NIMBY) attitude toward facility placement due to safety concerns.

The respondents' subjective perceptions were classified into three types based on the Q analysis. It was apparent that the factors affecting acceptance varied for each perception type, and that resident perception of facilities was not simply divided into agree or disagree. Furthermore, different approaches to opinion gathering and policy-making are required for each perception type. Based on the analysis of 45 residents' perceptions of locally unwanted land-use, three types of recognition were derived. A total of 16 items of the agreed question and 20 items of the disagreed question were the items with had a z-score of ± 1 or more. A total of 33 indicators were selected, leaving only one representative item except for duplicate items (Table 1). The z-score is the value obtained by dividing the deviation by the standard deviation, and is the conversion score in which the average of the origin is zero

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