The Effect of Safety and Risk Perception on The Public Acceptance of Nuclear Energy

Hyun Gook Kang[1] · Taeyong Sung[1] · Young Sung Choi[2]

[1] Korea Atomic Energy Research Institute
P.O. Box 105, Yusong, Taejon, Korea

[2] Korea Institute of Nuclear Safety
P.O. Box 114, Yusong, Taejon, Korea

Abstract

The public acceptance does not fully depend on the scientific safety. The safety of nuclear power plants in Korea has been improved by several ten times over 20 years. In the 1970s the public acceptance of nuclear power in Korea was very positive because of necessity. Nowadays, however, people consider other environmental factors such as nuclear waste and are looking for the other environmentally sound energy sources. This article shows the progress of nuclear power plants' safety from the viewpoint of science and tries to reveal the structure of publics' attitude toward nuclear power in Korea from the viewpoint of a social study. We will quantitatively show that a significant improvement of the scientific safety has been made over last two decades and the public does not have any discriminative opinion against nuclear power in relation to risk management. However, as a matter of fact, there is considerable criticism toward the utilization of nuclear power. We establish a model in order to explain the relations among several important factors of public acceptance. It explains what the public thinks of the safety of nuclear power, what contributes to the perception of nuclear risk and what factors influence the acceptance of the risk. It is quantitatively found that Korean people regard nuclear power as necessary, but the nearby construction of a plant as another thing. The important factors for explaining such behavior are the judgment of safety and necessity as well as the subjective risk-perception on possible accident, health effect of radiation, and environmental damages. However we should point out that the variance of unexplained factors are high. We miss something important.

I. Introduction

The advance of science and technology was considered as a prerequisite for economic development and associated with a highly positive value. However, the risks created by new technologies have initiated the public concerns, controversies, and social opposition. Therefore, policy analysts and decision-makers have to understand what the public thinks of the safety of nuclear power, what contribute to the perception of nuclear risk and what factors influence the acceptance of the risks. Without the understanding, well-intended policies may be ineffective or even counterproductive [1].

Generally we can classify the studies related to safety or risk into the following two categories: risk analysis based on scientific methodologies such as probabilistic safety assessment (PSA) and risk perception analysis based on social and psychological studies.

The PSA has been widely used in nuclear industry for licensing and identifying vulnerabilities to plant safety since 1975. PSA techniques are used to assess the relative effects of contributing events on system-level safety or reliability and provide a unifying means of assessing physical faults, recovery processes, contributing effects, human actions, and other events that have a high degree of uncertainty. Currently, the nuclear power industry employs the event tree/fault tree methodology for plant-wide PSA. One of the most important roles of the PSA is a demonstration of safety. The PSA demonstrates that a balanced design has been achieved by showing that no particular class of accident of the system makes a disproportionate contribution to the overall risk. The strictness of the safety requirement of Korean authority is also strengthened from 10^{-4}/yr core damage frequency (CDF) to 10^{-5}/yr.

This article also introduces the progress of Korean PSA technology, especially focused on the activities performed by Korea Atomic Energy Research Institute (KAERI). The safety of nuclear power plants in Korea has been improved by several ten times over the past 20 years. Based on the result of this scientific analysis, we could state clearly that nuclear power is one of the safest sources of energy. However, the public does not fully accept this scientific quantitative safety.

Since the 1970s, the Korean people have experienced rapid industrialization. Nuclear power was introduced in this period. Therefore, in the early phase, the public acceptance of nuclear power was very positive in the situation of the rapid growth of energy demand. As the industrialization phase goes by, Koreans are coming to consider environment and safety as more important. Since Korea relies on nuclear power to produce more than 40% of electricity, the public acceptance is essential in national electric power planning. But recent movements of

environmentalism and democratization have made the critical public opinion toward nuclear power plant grow. It is clear that the future expansion of nuclear power depends on the agreement of society. This agreement of society is directly coupled with the safety or risk of nuclear applications.

This study tries to reveal the structure of the public's attitude toward nuclear power in Korea. The main purpose is to detect how the public acceptance is influenced by judgments such as how safe it is and how much it is necessary. This article explains what the public thinks of the safety of nuclear power, what contributes to the perception of nuclear risk and what factors influence the acceptance of the risk. The data of a national survey conducted in 1995 were analyzed to identify these influences and quantify the relationships among them.

II. PSA Activities in KOREA

In Korea, the first nuclear power plant started its commercial operation in 1978, which was a Pressurized Water Reactor (PWR) supplied by Westinghouse with the capacity of 587 MWe. Since then, over the last 23 years, additional 15 nuclear power plants started their commercial operation and 8 nuclear power plants are under construction. At present, the total electrical capacity of Korean nuclear power is 13,716 MWe and more than 40% of electricity is being supplied by nuclear energy in Korea. In Korea, there are five different reactor types.

The PSA technique has been widely used as a tool to evaluate the safety of nuclear power plants, which are in the design stage as well as in operation. The nuclear industry of United States introduces the PSA as a TMI action. Important milestones of the PSA which are initiated in United States are shown in Table 1. Korean nuclear industry has performed the PSA since middle of the 1980s. For the recently constructed or designed plants, PSAs have been performed to fulfill the requirement from the regulatory body, the Ministry of Science and Technology (MOST), as one of the licensing requirements. Figure 1 shows the PSA schedule of Korean nuclear power plants. Since PSA assesses the overall safety feature of nuclear power plants including the design and operation of major safety systems, maintenance practice and etc., PSA enables us to estimate the overall safety characteristics of plants in several aspects.

As a leading organization in PSA application in Korea, KAERI has developed its own software tools for PSA such as a PSA workstation called KIRAP (KAERI Integrated Reliability Analysis code Package) for the fault tree analysis and accident sequence quantification [2], CONPAS for the event tree analysis [3], and ISSAC for the thermal-hydraulic analysis of CANDU reactors [4]. Most PSAs for Korean nuclear power plants except CANDU reactors are

performed based on the consistent method and data. Until now, all reactor types have shown an acceptable safety level. The results of PSA shows that the safety of nuclear power plants has increased as time went by, i.e., the total CDF is generally decreasing with time as shown in Figure 2.

Table 1. The PSA milestones of United States

Year	Event	Remark
1975	WASH-1400	The first NPP PSA report
1979	TMI Accident	The first core damage accident
1980 - 83	Reactor Safety Study	PSA implementation (model case)
1983	50FR32138	Severe accident statement
1990	Individual Plant Examination	Requirement of PSA for every NPP
1996	Maintenance Rule	Performance monitoring and maintenance of important SSCs (structure, system and component) are required as regulatory actions.
2000	Risk Informed Application	Regulation and operation using PSA information

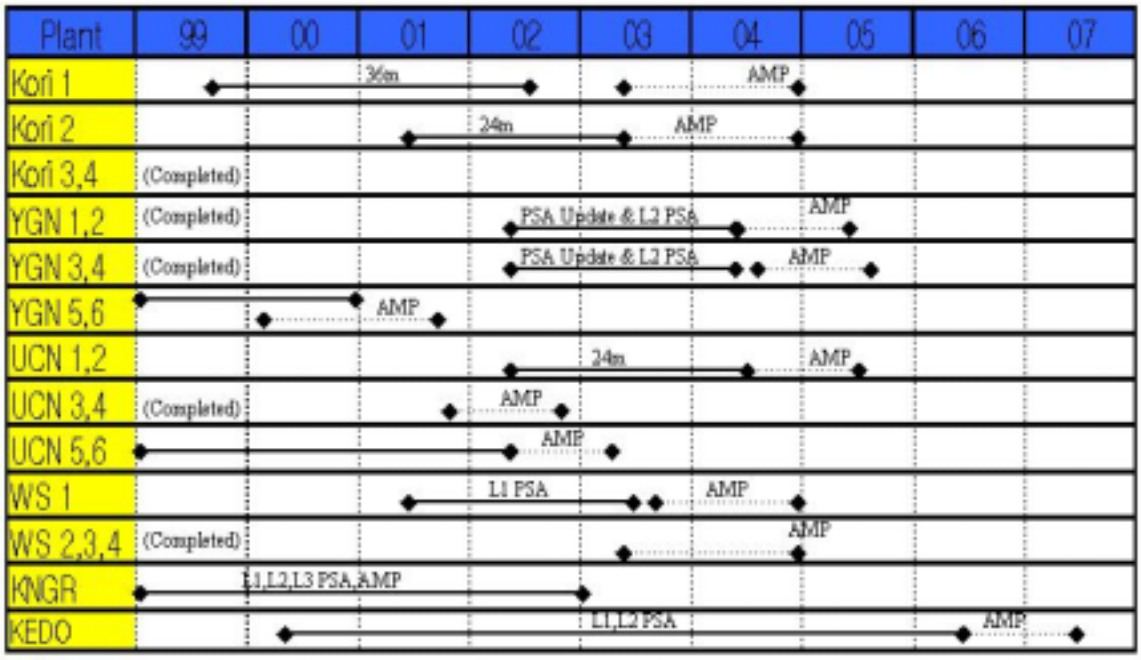


Figure 1. The PSA schedule of Korean nuclear power plants

(L1: level 1, L2: level 2, L3: level 3, and AMP: Accident Management Plan)

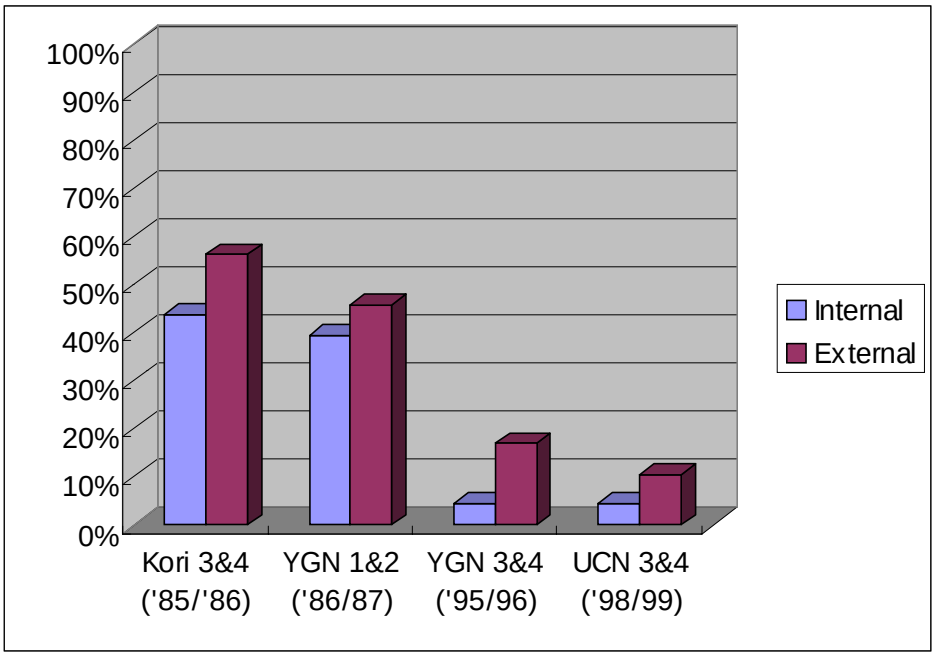


Figure 2. Comparisons between Total CDFs of Korean nuclear power plants (Number in parenthesis is the commercial operating year)

III. Public Expectations of Risk Management

Who is responsible for the risk? Who is the subject of risk management? [5] reports the result of a research performed to answer the question. There are various kinds of risks and their characteristics differ case by case. Poisoning and Traffic accidents can be controlled by an individual. However, the risk from nuclear power plants or from CO_2 emission cannot be controlled by an individual. People expect that the government and utilities will treat this problem.

In order to quantify this expectation, we will show some results of research performed in [5]. Figure 3 and 4 shows the role expectation and accomplishment which are estimated by public. Figure 3 shows that people regard the role of government in the nuclear field as especially important and the role of individual as relatively unimportant. As shown in Figure 4, people do not believe that the government and utilities do their role well. In comparison with the other fields, however, the score of government and utilities in the nuclear field is relatively good. Generally speaking, related to risk management, Korean people are not satisfied with the role accomplishment of government and utilities, but the situation in the nuclear field is relatively better.

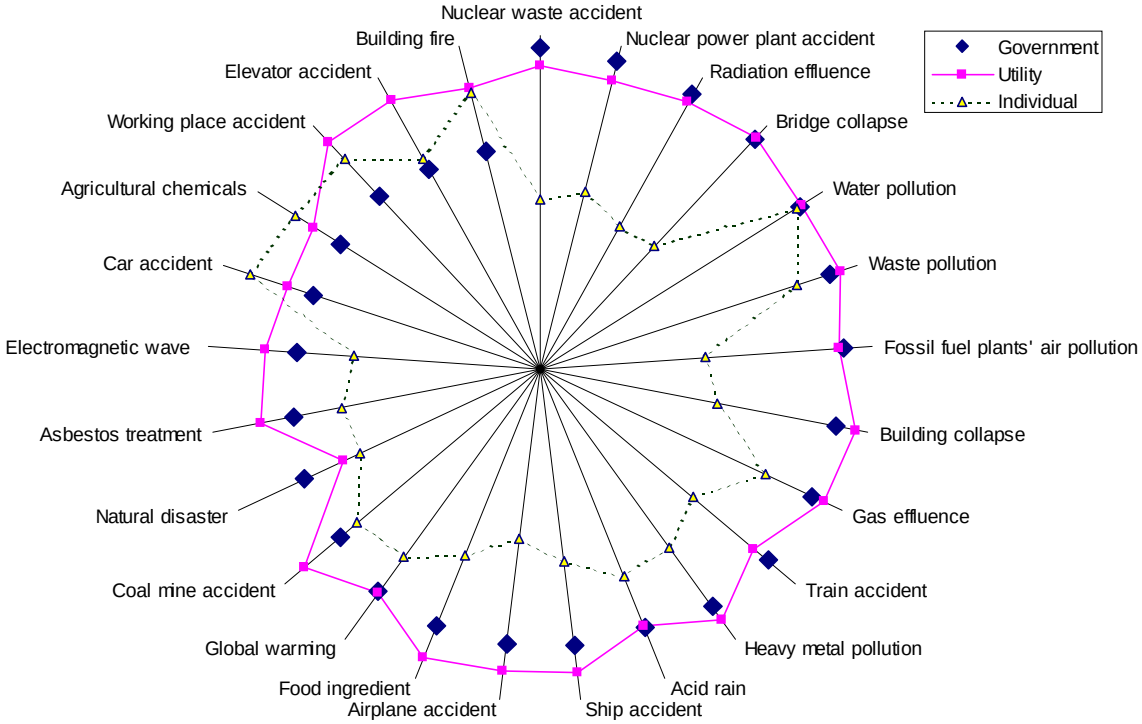


Figure 3. The role expectation of the public

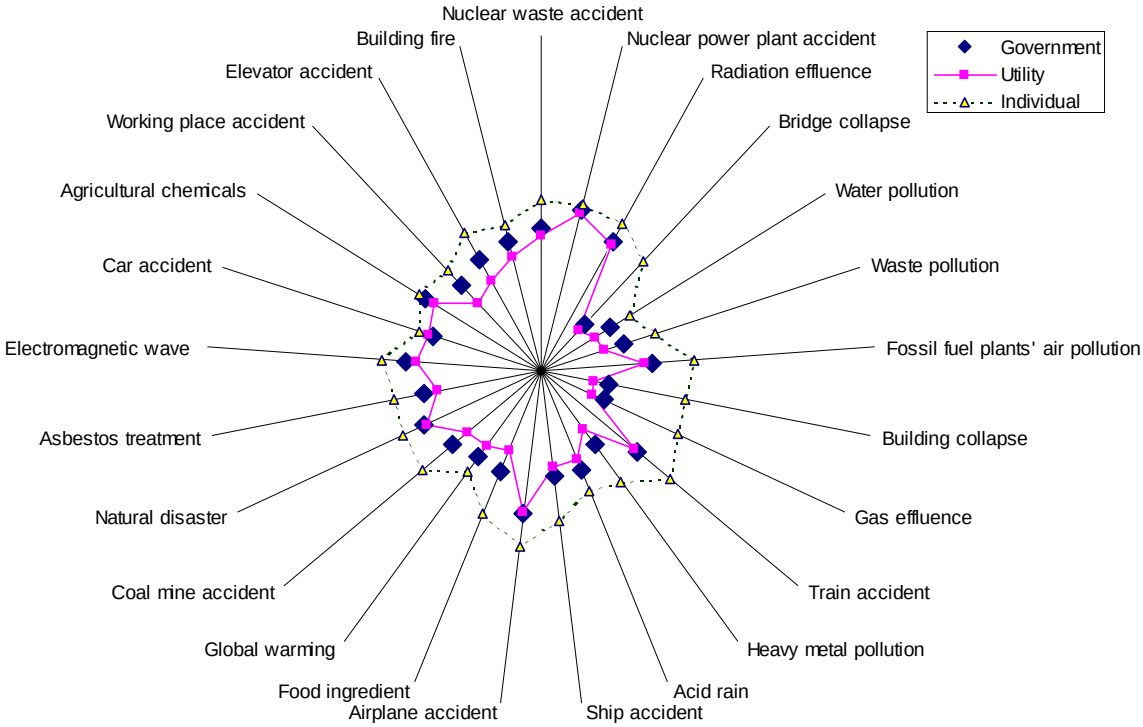


Figure 4. The role accomplishment estimated by the public

IV. A Model of Public Acceptance

A statistical model of public acceptance was developed to detect how the public acceptance is influenced by judgments such as how safe it is and how necessary it is. A nationwide survey data, which was conducted in 1995 to the public by the Gallup Korea was used to estimate the model. Eight questions of the survey were selected for the purpose of the study. The detailed descriptions on this model can be found in [1].

The degree of public acceptance was assumed to be at least partly measured by responses to three questions: the construction of additional nuclear power plants in Korea (National Acceptance), the construction of nuclear power plants nearby his/her community (Local Acceptance), and the nearby construction with the promise of supporting and promoting economic development of the community (Compensated Acceptance). The first two types of acceptance are known to be clearly different from the past survey results and explained by the NIMBY (Not In My Back Yard) phenomena and the third one is an interesting question which may give insights for real situations.

Table 2 shows the eight questions and variable notations [1]. Using the variables (CA, NA, LA, NEC, SFTY, RISK), where RISK is the variable constructed from (ACCDNT, RAD ENV), the Public Acceptance model was established using Structural Equations Model (SEM) technique [6]. SEM helped researchers find the relationships among several variables, develop the structure of influence directions and quantify them. The results of modeling are shown in Figure 5. The following could be concluded from Figure 5:

- NA is most influenced by NEC, while LA is most influenced by SFTY, and CA is more influenced by LA than by NA. Considering the NIMBY phenomena, these results are anticipated.
- The additional construction of nuclear power plants is more influenced by necessity than by safety (1.24 times for male and 4 times for female), while the construction nearby his/her community is more influenced by safety than by necessity (2.71 times for male and 1.17 times for female).
- RISK influences NA in the female group but not in male group. This can be explained by examining the standardized correlation coefficient of SFTY and RISK (0.53 for male and 0.23 for female). It seems that while males assimilate the subjectively perceived risk of a nuclear power plant into safety, females consider the two factors as distinct; in other words, the subjectively perceived risk plays a more persistent role in female's judgment than in male's.

- The variance of unexplained factors (ζ_1, ζ_2, and ζ_3) are somewhat high, which warns that the predictive powers of dependent variables are so low and indicates more explanatory variables are needed.

Table 2. Eight Questions and Their Notations

(NA) What do you think about additional construction of NPP (nuclear power plant)?
1. should increase actively
2. Should increase steadily
3. should maintain current level
4. should decrease
5. should shut down all of them

(LA) If a NPP would be constructed nearby your community, will you approve it or not?
1. approve strongly
2. approve somewhat
3. decide after seeing the extent of supporting community
4. disapprove somewhat
5. disapprove strongly

(CA) If a NPP would be constructed with the promise of supporting and promoting the economic development of your community, will you approve it or not?
1. approve strongly
2. approve somewhat
3. disapprove somewhat
4. disapprove strongly

(SFTY) What do you think about the safety of NPP of our country?
... I think it to be
1. very safe
2. somewhat safe
3. little safe
4. not safe at all

(NEC) What do you think about the necessity of NPP of our country?
... I think it to be
1. very necessary
2. somewhat necessary
3. little necessary
4. not necessary at all

Which of the two arguments (A) and (B) do you agree with, and how much?

(ACCDNT)
(A) There will be no accident like Chernobyl in our nation
(B) NPP is like a explosive bomb

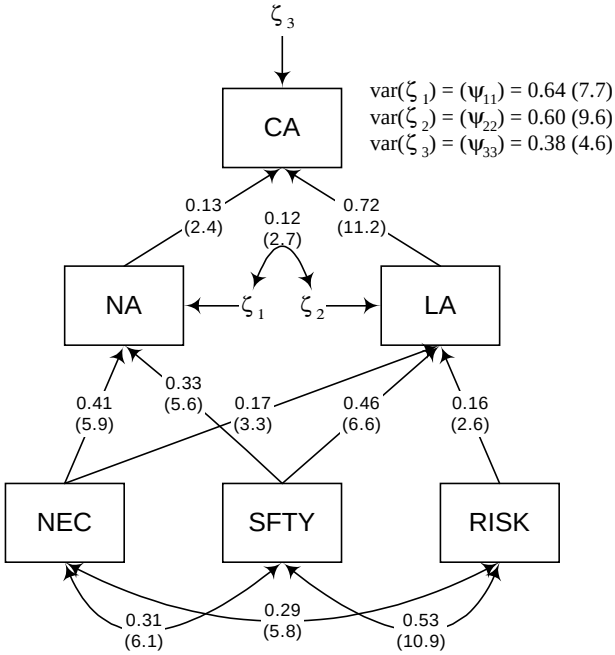
1. complete agreement with (A)
2. somewhat agreement with (A)
3. neutral to (A) and (B)
4. somewhat agreement with (B)
5. complete agreement with (B)

(RAD)
(A) There is no risk by radiation release near NPP
(B) There are possible health damages like a deformed child

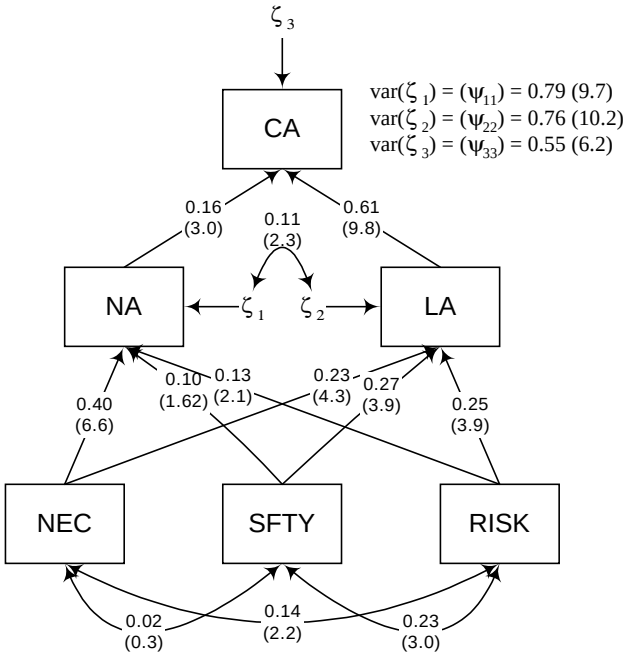
1. complete agreement with (A)
2. somewhat agreement with (A)
3. neutral to (A) and (B)
4. somewhat agreement with (B)
5. complete agreement with (B)

(ENV)
(A) Nuclear Power is clean energy not discharging global warming gas
(B) Nuclear Power has the possibility of disrupting environment

1. complete agreement with (A)
2. somewhat agreement with (A)
3. neutral to (A) and (B)
4. somewhat agreement with (B)
5. complete agreement with (B)



(a) Male
(N=553, chi-square=8.19, d.f.=4, p-value=0.08, TLI(NNFI)=0.98, CFI=0.99



(b) Female
(N=467, chi-square=2.94, d.f.=3, p-value=0.4 TLI(NNFI)=1.0, CFI=1.0)

Figure 5. Standardized parameter estimates and z-values in parenthesis for (a) male and (b) female group and the number of observation (N), the chi-square value, the degree of freedom (d.f.), the probability value (p-value) exceeding the chi-square value, Tucker-Lewis index (TLI, also called non-normed fit index (NNFI)), and comparative fit index (CFI)

V. Discussion and Summary

In this article, we quantitatively show that a significant improvement of a scientific safety has been made over last two decades and the public does not have any discriminative opinion against nuclear power in relation to risk management. However, public acceptance on nuclear power plants does not fully depend on these scientific safety and objective opinions.

The following three results are quantitatively investigated from the viewpoint of the public and scientists.

- Nuclear power plants in Korea have been operated safely in last two decades and PSA results show that their scientific safety has improved as time has gone by.
- About risk management, Korean people regard the role of government as momentous but they are not fully satisfied with the role accomplishment of government or utilities. However, the situation in the nuclear field is relatively better.
- It was quantitatively found that Korean people regard nuclear power plants as necessary, but the nearby construction of a plant as another thing. The major factors to explain such behavior are the judgment of its safety and the subjective risk-perception on possible accident, the health effect of radiation, and environmental damages. The result confirms that nuclear safety is an essential prerequisite for the acceptance of nuclear power. However, this model explains just 21%-62% of decisions and this result indicates that more explanatory variables are required.

Now, we have question. What is the missing variable in the models shown in Figure 5? In the authors' opinion, the answer might be related to culture and economy. Over the last two decades, the Korean people have experienced a boom in the value of real estate. A nuclear power plant in their backyard implies that it is impossible to expect the rapid escalation of real estate value. And traditionally, the Korean people are strongly attached to their land (real estate). Of course, the authors cannot state that it is the true answer. We, the young generation, should try to find out the answer for the further development of nuclear power.

Further studies which aim to investigate the differences between young and old persons, the effects of public relations programs, the relationships between nuclear safety regulation and the public perception of nuclear safety, and how to strengthen the public trust on nuclear safety and safety regulation are also needed.

References

1. Young Sung Choi, Dong Keuk Park, In Jin Song, and Jong Seok Kim, “The Effects of Nuclear Safety and Risk Perception on the Acceptance of Nuclear Power,” Proceedings of the Korean Nuclear Society Spring Meeting, Cheju, Korea, May 2001.
2. S. H. Han, et. al., “KAERI Integrated Reliability Analysis Code Package (KIRAP) Release 2.0 User's Manual,” KAERI/TR-361/93, KAERI, 1993.
3. Ahn, K.I. et al, “CONPAS 1.0 User’s Manual,” KAERI/TR-651/96, 1996
4. Development of Computer Code for Level 2 PSA of CANDU Plant, KAERI, 1995
5. A Systematic Research for Nuclear Risk and Other Technological Risk Management in Korea, KAERI/CM-055/94, 1995.
6. K.A. Bollen, Structural Equations with Latent Variables, John Wiley & Sons, 1989.