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The Text-Mining Approach Towards Risk Communication in Environmental Science

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1. Introduction

As the failure of waste management had endangered the public safety, public concerns and awareness regarding waste disposal facilities which may bring dioxin pollution risk, PCB risk and other toxic threat have grown so much. A long-life radioactive waste disposal facility also becomes one of the public concerns. As the high level radioactive waste is not so familiar with the public, it brings the sense of fear of unidentified materials among local. Therefore, the site selection of high level radioactive waste (HLW) final disposal facility faces much difficulty in the world except in Finland and Sweden.

If concerns of environmental topics of the daily life could be properly connected with nuclear power issues, people would certainly be easy to participate in the discussion about the necessity of such facilities.

Therefore, the author investigated the relationship between the nuclear power issues and environmental topics such as household waste management or the precautionary principle analyzed by text-mining method. In this method, the author conducted the investigation cooperated with university students as subjects. The elements of this experiment consist of lectures on environmental topics, keywords of each lecture submitted by the students, and questionnaire survey result on nuclear power generation answered by the students.

Many researches on the risk communication regarding nuclear power issues have been implemented. For example, Kugo analyzed the public comments and discussion by using a text mining method (Kugo, 2005, 2008). Yoshikawa also introduced the researches on the human interface of the computer-aided discussion board (Yoshikawa, 2007). These researches aimed to grasp the representativeness of the public opinion by analyzing majority of the subjects.

However, the problem that the research data were not necessary reliable in term of the representativeness of the public because of the fluctuations of subjects' opinion existed. For example, a person has the tendency to make a decision in a heuristic way in case of requiring a prompt answer. Therefore, the new point of the method of this analysis was that the author did not include the information of the majority of the subjects but the minority based on the assumption that the reliance of the information of minority subjects was higher than those of the majority since the minority submitted the keywords without heuristic decision making.

2. Method and result of analysis

First, the author gave lectures on the risk perception and desirable autonomous ideas in the area of various environmental sciences including nuclear power generation issues at a university class. Students submitted a keyword that they considered as the best representative for each lecture. The keywords submitted were classified into two groups by cluster analysis and correspondence analysis on the keywords-subjects cross table. These analyses result to calculate the eigenvalue of the cross tabulation.

On this calculation process, every small part of the keywords-subjects cross table called a cluster. A relative relation of a cluster could be grasped, plotting two compounds of the eigenvalue of clusters on the x-y axis position. Chi-square distance could easily be calculated by using these x-y data. By chi-square distance from the centre, it could be majored of the representativeness of the students.

This result of the analyses indicated that the keywords of frequent occurrence locate near the centre of the chart and the keywords of less frequent occurrence locate at a circumference part. Based on the keyword cluster deployment on the chart and its characterization, the arrangement of the keyword cluster can be interpreted along with the assumed mental model.

Students whose consciousness level was low would choose keywords that were easy to find through the lectures (lecture titles, word appeared on the delivered documents, etc.). In that case, the frequency of chosen keywords would be high because those keywords were limited to in the documents. On the other hand, students whose consciousness level was a little higher would choose keywords that were emotional or used in the discussion during the lectures. If these keywords depended on the students internal idea, not limited to in the documents, the frequency of these keywords occurrence would be less than that of keywords chosen by low-consciousness level students. Thus, the author paid more attention to the less frequency keywords and students who submitted these keywords.

Second, the author conducted the questionnaire research pertaining nuclear power generation and high level radioactive waste (HLW) disposal management at the end of all lectures. The concepts of the questionnaire consisted of necessity, approval for facility installation, and acceptance of adjoining facility. The students selected number of answer from “yes” to “no” by seven grades. Consequently, two groups of the students above described were characterized by ANOVA (Analysis of Variance) respectively. One was passive, and the other was active toward the attitude of acceptance of a nuclear facility.

Third, by using keyword cross table, the author analyzed the correlation between the keyword groups of the lecture at each theme. Thus, the communication points could be extracted by paying attention to the correspondence of the pair of keywords chosen at two themes of lectures. In this paper, the author shows the results of two cases such as keywords group of the theme of nuclear power generation and household waste management, and the theme of nuclear power generation and the precautionary principle as examples. The concept of this correlation analysis shows in Figure 1.

2.1 Lectures on environmental science and keywords and assumed mental model

The students received the series of fifteen lectures (ninety minutes per a lecture) on environmental science. In these lectures, they discussed various themes such as global warming, waste problem, ozone hole, dioxin poison, radioactivity, precautionary principle,

and some other themes. The basic concept of these discussions was that we should have objective viewpoint not to avert the risk but to face it. After every lecture, students submitted the most impressive keyword in the theme with a message of the reason. The number of keywords was one hundred and sixty seven in total. The effective number of students who attended the whole lecture was fifty.

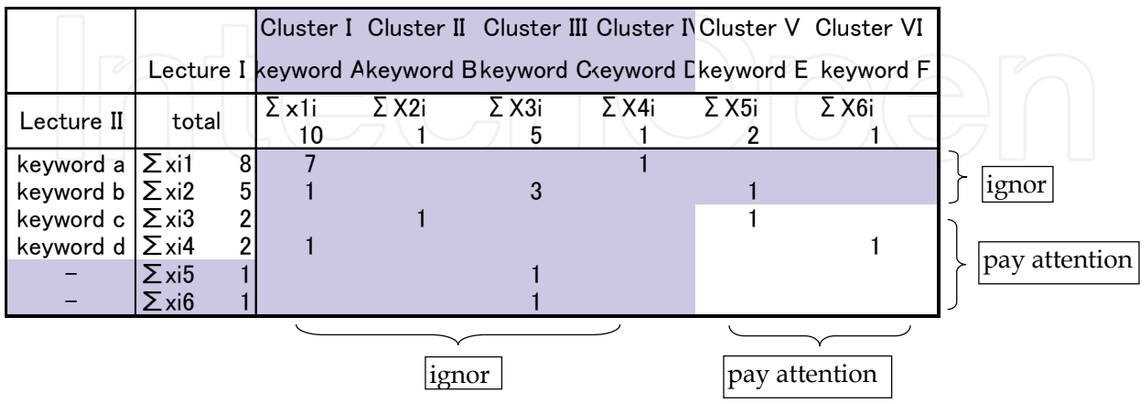

Fig. 1. Concept of the keyword cross table analysis by the keywords of two lectures

Table 1 gives the themes of fifteen lectures and the number of the submitted keywords at every lecture. In this research of the relationship between the theme of "nuclear power generation" and "household waste management" and the relationship between the theme of "nuclear power generation" and "the precautionary principle", the author tried to find the students' common value in their internal mind. Table 2 shows the submitted keywords at above designated three lectures.

	Theme of Lecture	**Number of submitted keyword**	
# 1	System of global environment	21	/ 54 students
# 2	Global warming	18	/ 55
# 3	Precautionary principle	13	/ 57
# 4	Dioxin	17	/ 55
# 5	Household Waste management	13	/ 55
# 6	Ecological footprint	10	/ 56
# 7	Ozone hole	9	/ 53
# 8	Energy	17	/ 53
# 9	Radioactivity	10	/ 53
# 10	Nuclear power generation	9	/ 50
# 11	Earthquake	9	/ 49
# 12	Environmental Sociology	11	/ 46
# 13	Safety and Relief	10	/ 49
# 14	Others	-	-
# 15	Questionnaires survey	-	-
		167	total

Table 1. Theme of lectures and the number of submitted keywords at every lecture

lecture on Nuclear Power generation	**lecture on Household Waste management**	**lecture on the Precautionary principle**
Friburg（the name of city)	*3R(Reduce,Reuse,Recycle)*	*Zero risk*
MOX Fuel utilization in LWRs	*Quantity of disposal waste*	*Dioxin*
Nuclear fuel cycle	*Incentive*	*Dioxin news report*
Nuclear Power generation	*Globalization*	*Risk*
Nuclear energy revolution	*Discharge of the waste*	*Problem of risk*
Insecurity or understanding among citizen	*Plastics*	*Risk communication*
Renewable energy	*Recycle*	*Risk management*
Public opinion poll	*Circulative society*	*Risk information*
Radioactive waste	*Disposal cost*	*Risk cognition*
	Thermal supply system	*Risk analysis*
	Waste	*Environmental hormone*
	Responsibility for disposal	*Dioxin concentration*
	Illegal disposal	*Precautionary principle*

Table 2. The keywords at the designated lecture

The assumed basic mental model that consists of "instinct (inner part of mind)", "emotion (middle part of mind)", and "reason (outer part of mind) shows in Figure 2.

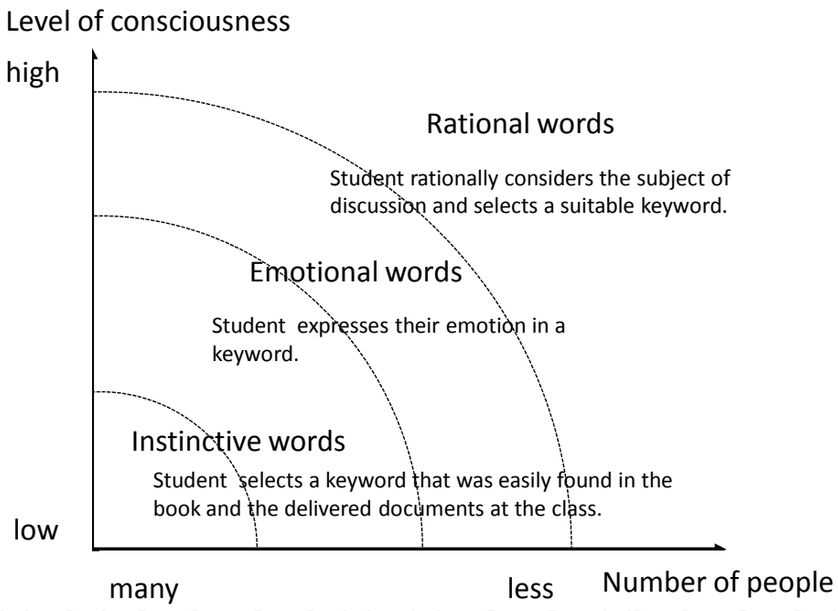

Fig. 2. The mental model of keywords chosen at the lecture (assumption)

If a student whose consciousness level was low submitted a keyword by request, he would try to choose a keyword that was easy to find through the lectures (lecture titles, words appeared in the book or the delivered documents, etc.). This action should be the appearance of representative heuristic decision making, in other words. Consequently, the frequency of occurrence of the keywords would be high.

On the other hand, students whose consciousness level was higher than the former would choose keywords that were emotional or used in the discussion time. The frequency of occurrence of these keywords would be less than that of keywords of low-consciousness level students. These words were not limited to in the documents but depended on the

students' internal idea. If a student's consciousness level were much higher than the other levels, the frequency of their keywords would be less than those of keywords of students whose consciousness levels were low or middle, since their keywords choice based on their own opinion.

After the lecture on nuclear power generation, the author implemented correspondence analysis and cluster analysis on the basis of "keywords - subjects cross table" in order to apply the assumption of the above described mental model.

If the mental model were well, the words chosen by many students would be the title of the lecture (i.e. nuclear power generation). The number of students who chose the keyword of "nuclear power generation" was twenty-seven, which was the most. The number of students who chose the keyword of "MOX Fuel utilization in LWRs" was eleven, which was the second. The numerical information about the number of keywords submitted in the lecture titled "nuclear power generation" shows in table 3.

In accordance with the assumed mental model, the keyword of "Insecurity or understanding among citizen", "Renewable energy", Public opinion poll", and "Nuclear energy revolution" might carry the subjective image or the meaning of something emotional. Conversely, "Nuclear power generation" and MOX fuel cycle", "radioactive waste" and "Friburg" might carry the objective image or neutral meaning. However, this understanding remains vague for the student classification. Therefore, in order to classify these keywords along with above described mental model, the author implemented text-mining analysis described next section.

Keywords of the lecture titled by "nuclear power generation"	Number of subjects
Nuclear power generation	27
MOX Fuel utilization in LWRs	11
Nuclear fuel cycle	3
Radioactive waste	3
Friburg (name of the city)	2
Insecurity or understanding among citizen	1
Natural renewable energy	1
Public opinion poll	1
Nuclear energy revolution	1
	50

Table 3. Numerical information of keywords of the lecture on nuclear power generation

2.2 Text mining for keywords

The method of textual data mining was useful for analyzing public opinion. Ohsumi and Levert reported the results of textual data mining method (Ohsumi and Levert, 2000). The summary of the text mining method that consists of cluster analysis and correspondence analysis shows below.

Every lecture gave the information of keyword list and their occurrences. This frequency of occurrence data calls a contingency table. This "m×n" contingency table indicates frequencies of the appearances of "n" different keywords of "m" different students in the class.

In other words, the co-occurrence data represent a matrix X which has m rows and n columns, or "$m \times n$-dimensional vector **F**".

$$\underset{m\times n}{\mathbf{F}} = \left(f_{ij}\right) \quad \left(f_{ij} \geq 0,\ i \in I,\ j \in J\right)$$

$I = \{1,2,...,m\}$, $J = \{1,2,...,n\}$

By using Chi-square statistics, the dimension of deviations from the expected values can be identified.

Profiles:

$$P_{IJ} = \left(P_{ij}\right) \quad (i \in I,\ j \in J)$$

$$P_I = diag\left(P_{i+}\right) \quad (i \in I)$$

$$P_J = diag\left(P_{+j}\right) \quad (j \in J)$$

diag : diagonal matrix

$$\left(P_{ij} = \frac{f_{ij}}{N},\ N = \sum_{i=1}^{m}\sum_{j=1}^{n} f_{ij} \left(\equiv f_{++}\right) \right)$$

$$\left(P_{i+} = \frac{f_{i+}}{N} = \frac{\sum_{j=1}^{n} f_{ij}}{N},\ P_{+j} = \frac{f_{+j}}{N} = \frac{\sum_{i=1}^{m} f_{ij}}{N} \right)$$

The data matrix (**Matrix X (m, n)**) shows below based on above matrix or two-way table.

$$\underset{m\times n}{\mathbf{X}} = \left(x_{ij}\right) \quad (i \in I,\ j \in J) \qquad x_{ij} = \frac{p_{ij}}{p_{i+}\sqrt{p_{+j}}} - \sqrt{p_{+j}} = \frac{q_{ij}}{\sqrt{p_{+j}}} - \sqrt{p_{+j}}$$

Matrix X (m, n) is the same for the equation below.

$$\underset{m\times n}{\mathbf{Q}} = \left(y_{ij}\right) \quad (i \in I,\ j \in J) \qquad y_{ij} = \frac{p_{ij}}{\sqrt{p_{i+}p_{+j}}} = \frac{f_{ij}}{\sqrt{f_{i+}f_{+j}}} \quad \left(p_{i+} \neq 0,\ p_{+j} \neq 0;\ f_{i+} \neq 0,\ f_{+j} \neq 0\right)$$

Then, **Matrix Q (m, n)** replaced like below.

$$\underset{m\times n}{\mathbf{Q}} = \mathbf{P}_I^{1/2}\mathbf{P}_{IJ}\mathbf{P}_J^{1/2}$$

Consequently, **Matrix V (m, n)** attributes to extracting an eigenvalue.

$$\underset{m\times n}{\mathbf{V}} = \mathbf{Q'Q} = \mathbf{P}_J^{-1/2}\mathbf{P}_{JI}\mathbf{P}_I^{-1}\mathbf{P}_{IJ}\mathbf{P}_J^{1/2} \qquad \begin{pmatrix} \mathrm{Q}^t = \text{transposed matrix Q} \\ \mathrm{P}_{JI} = \text{transposed matrix } \mathrm{P}_{IJ} \end{pmatrix}$$

Row and column coordinates can be plotted on the single screen by using component scores such as (Z_{ik}, $Z_{ik'}$) and (Z^*_{ik}, $Z^*_{ik'}$).

$$z_{ik} = \frac{1}{\sqrt{\lambda_k}}\sum_{j=1}^{n}\left(\frac{P_{ij}}{P_{i+}}\right)z_{jk}^* \quad \left(i \in I,\ k = 1,2,...,K\right)$$

$$z_{jk}^* = \frac{1}{\sqrt{\lambda_k}}\sum_{i=1}^{m}\left(\frac{P_{ij}}{P_{+j}}\right)z_{ik} \quad \left(j \in J,\ k = 1,2,...,K\right) \qquad \lambda : \text{eigenvalue}$$

The graphic presentation based on above calculation clearly shows the relationships between the keywords and students, with distance on the map being a representation of correspondence.

Such plotting does not indicate the relationship between row points and column points but only the distances between row and column points.

The result of analysis shows Table 4 that indicates the numerical information of the clusters and Table 5 that indicates the numerical information of the keywords. It also illustrates on the graphs shown in Figure3 and Figure 4. As shown in Table 4 and Table 5, fifty students were divided into five groups; the nine keywords were divided into five clusters in other words. Namely, The largest cluster of "I" (Cluster I) contains two keywords such as "the nuclear power generation" (theme of the lecture) and "MOX Fuel utilization in LWRs (Plu-thermal)" chosen by thirty-eight students. It should be safe to say that Cluster I represented the group of students who had chosen instinctive keywords. Therefore, Cluster I located in the vicinity of the centre by Chi-Square Distance (0.20).

The second cluster of "II" (Cluster II) contained only a keyword such as "insecurity or understanding among the citizen" that was chosen by a student. This cluster located far from the centre by Chi-Square Distance (3.68).

The third cluster of "III" (Cluster III) contained two keywords such as "nuclear energy revolution" and "Freiburg" that were chosen by three students. This cluster located more distant from the centre by Chi-Square Distance (5.57).

The fourth cluster of "IV" (Cluster IV) that contained three keywords such as "renewable energy", "radioactive waste" and "public opinion poll" that were chosen by five students. This cluster located far from the centre by Chi-Square Distance (7.92).

The fifth cluster of "V" (Cluster V) that contained only a keyword such as "nuclear fuel cycle" that was chosen by three students. This cluster located in the longest distance from the centre by Chi-Square Distance (10.07).

The relation between the Chi-Square Distance of each cluster and the number of student that belonged to the cluster shows in Figure 5.

Then, author interpreted the meaning of cluster deployment on the screen as follows.

The keyword of the title of the lecture ("nuclear power generation") was chosen heuristically by most of the students. Therefore, the students who belong to the Cluster I did not have considered the theme so seriously. The author concluded Cluster I as an instinctive group. The keywords of "insecurity/understanding among citizen" (Cluster II) and "nuclear energy revolution" (Cluster III) could be holding the connotation of unstable condition. Students who belonged to these clusters must have expressed their emotion towards the subject of discussion. Thus, Cluster II and Cluster III that contained the emotional keywords were categorized into non rational groups. On the other hand, Cluster IV that contained the keywords of "renewable energy", "radioactive waste", "public opinion poll", and Cluster V that contained "nuclear fuel cycle" hold no subjective message. Students who belonged to these clusters must have grasped the topic of discussion and have expressed their result of consideration. Thus, the author concluded these Cluster IV and Cluster V as rational groups.

The curve of Number of Subjects – Chi square Distance relationship shown in Figure 5 had the consistency with the assumption of the mental model shown in Figure 2.

As the author considered the assumed mental model fit well, the author could classify the students into two groups along with the cluster deployment to investigate the attractive discussion points. The students who belonged to "Cluster I", "Cluster II", and "Cluster III" named the *Passive group*. The students who belonged to "Cluster IV" and "Cluster V" named the *Active group*. The concept of this classification shows in Figure 6.

The author investigated the difference in an attitude between *Active group* and *Passive group* by using questionnaire survey, which referred nuclear power generation and radioactive waste management, as described in the next section.

	Number of subjects	Chi-squqre distance	x-axis	y-axis	Variation within a cluster	Portion of cluster size
Cluster I	38	0.20	-0.11	0.44	0.011	0.22
Cluster II	1	3.68	1.47	-1.24	0.000	0.11
Cluster III	3	5.57	-2.31	-0.46	0.015	0.22
Cluster IV	5	7.92	0.02	-2.81	0.017	0.33
Cluster V	3	10.07	3.17	0.04	0.000	0.11
total	50	-	-	-	0.032	1.00

Table 4. Numerical information of the clusters of the keywords at the lecture on "nuclear power generation", based on the cluster analysis

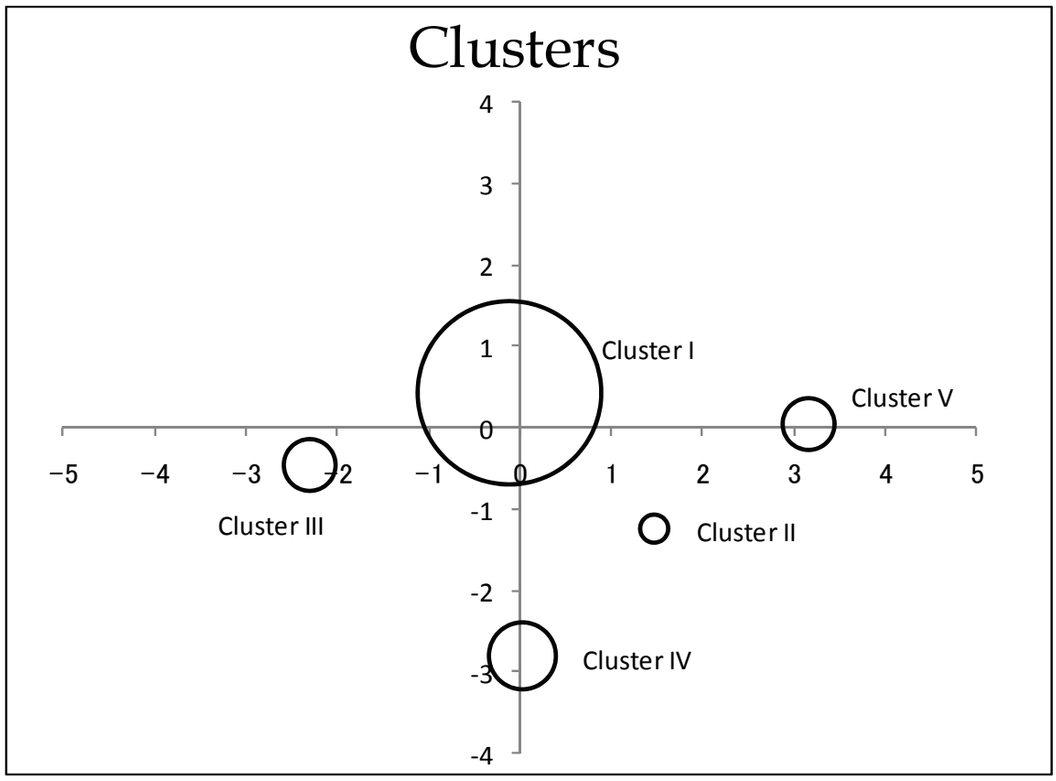

Fig. 3. Cluster deployment based on the cluster analysis of the keywords submitted at the lecture on “nuclear power generation”. The area of the circle shows the number of students

Keyword	Portion of keyword size	Number of subjects	Chi-square distance	x-axis	y-axis	Cluster
Nuclear Power generation	0.54	27	0.9	-0.08	0.51	Cluster I
MOX Fuel utilization in LWRs (Plu-thermal)	0.22	11	3.6	-0.18	0.27	
Insecurity or understanding	0.02	1	49.0	1.47	-1.24	Cluster II
Nuclear energy revolution	0.02	1	49.0	-1.74	-0.04	Cluster III
Friburg (name of city)	0.04	2	24.0	-2.60	-0.67	
Renewable energy	0.02	1	49.0	-0.13	-2.39	Cluster IV
Public opinion poll	0.02	1	49.0	0.68	-3.12	
Radioactive waste	0.06	3	15.7	-0.15	-2.85	
Nuclear fuel cycle	0.06	3	15.7	3.17	0.04	Cluster V
total: 9	1.00	50	-	-	-	

Table 5. Numerical information based on the cluster analysis of the keywords submitted at the lecture on "nuclear power generation"

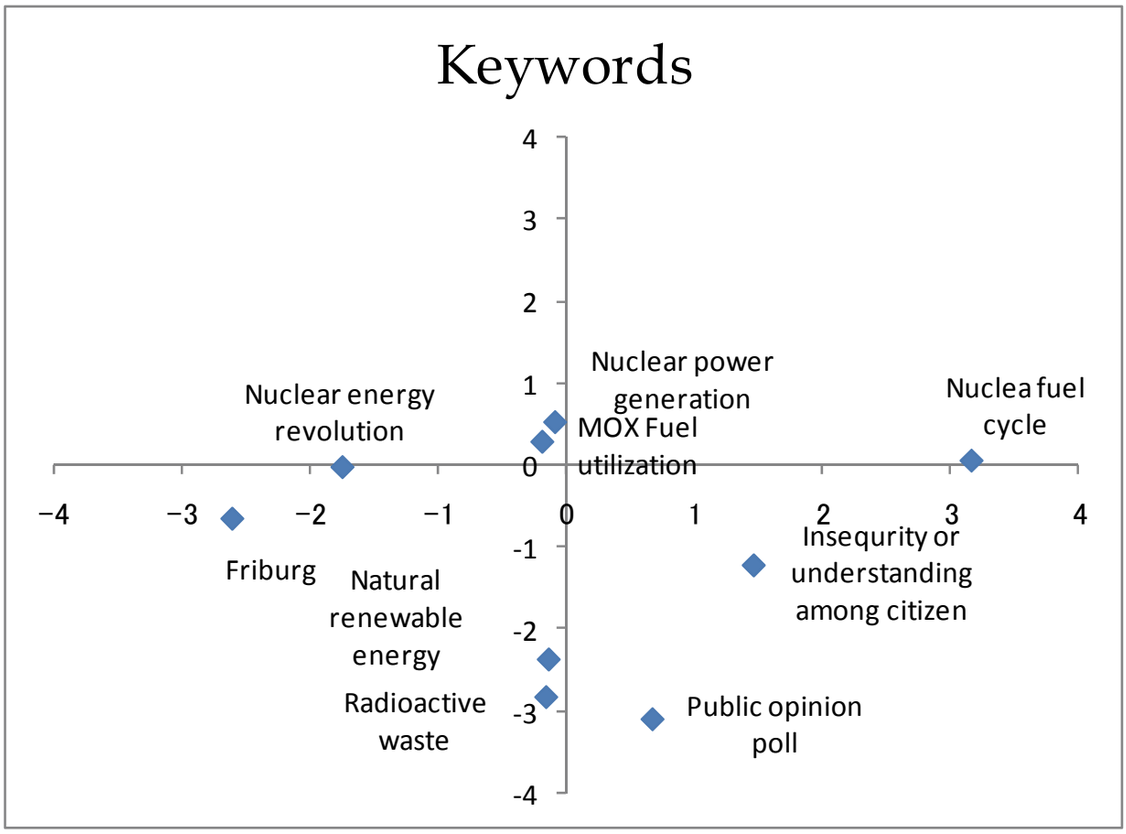

Fig. 4. Keywords deployment based on the cluster analysis of the keywords submitted at the lecture of "nuclear power generation"

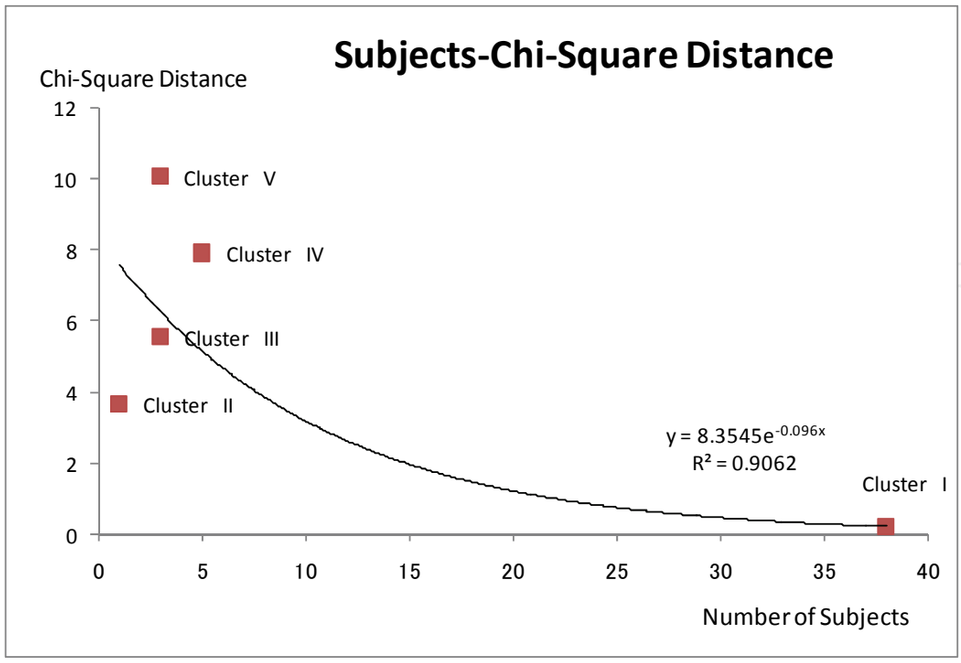

Fig. 5. Cluster deployment on the screen of number of Subjects vs. Chi Square Distance

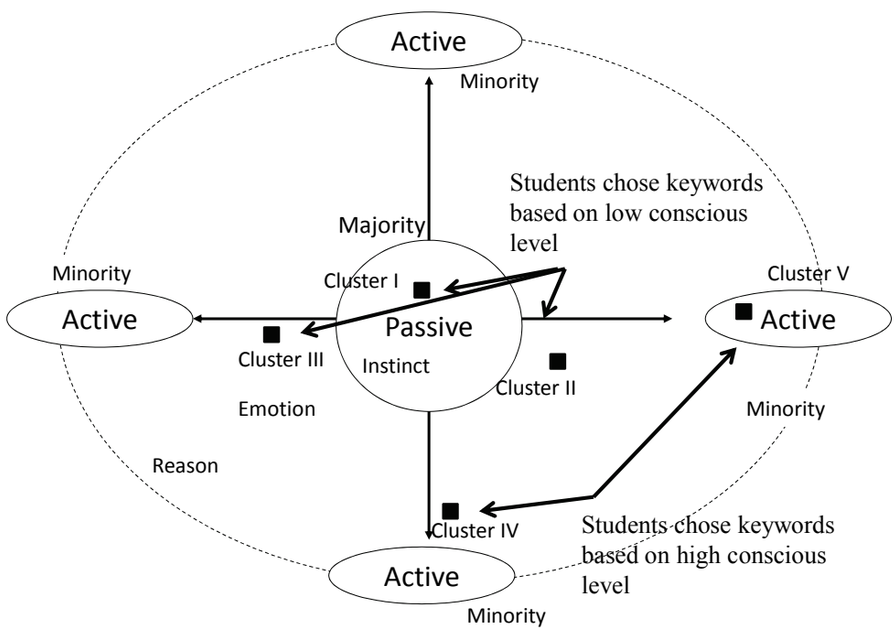

Fig. 6. The concept of the student classification

2.3 Questionnaire survey on nuclear power generation and HLW

At the last lecture, the students answered the questionnaire survey pertaining to the nuclear power generation and HLW (high level radioactive waste) disposal site selection in order to characterize the passive and the active group.

The questionnaire composed of these questions from A to G as below. The students selected the number from 7 (yes, I guess so very much) to 1 (no, I do not guess so at all) at every question.

Questionnaire A: necessity of nuclear power generation;
"Do you think nuclear power generation is necessary?"
Questionnaire B: approval for facility installation of nuclear power generation;
"Do you think it is no problem for the installation of nuclear power generation plant?
Questionnaire C: accepttance of adjoining nuclear power generation facility;
"Would you say "yes" if the local authority proposed you the construction of a nuclear power generation plant adjacent tot your place of residence?"
Questionnaire D: cognition of high level radioactive waste;
"Do you recognize HLW generated in the nuclear power plant?"
Questionnaire E: necessity of HLW disposal facility;
"Do you think the HLW disposal facility is necessary?"
Questionnaire F: approval for facility installation of HLW;
"Do you think it is no problem for the HLW disposal facility?"
Questionnaire G: acceptance of adjoining HLW disposal facility;
"Would you say "yes" if the local authority proposed you the construction of a geological disposal site adjacent to your place of residence?"

The author implemented ANOVA to find the significant difference between above two groups by using numerical answer of the questionnaires.
The result showed in Table 6, which revealed that there were no significant difference between the two groups in the consciousness toward nuclear power generation and necessity of HLW disposal facility and approval for the facility installation. However, there was a significant difference in the reluctant consciousness against adjoining facility installation.
This result suggested that the *Active group* in the theme of nuclear power generation had the positive stance toward the waste management of nuclear power generation. They felt the responsibility for the back-end procedure, in other words.
The students who belonged to the *Active group* believed that they had to face both side of science and technology, such as a benefit and disadvantage of nuclear power generation. They thought that nuclear power generation had the merit for energy security and environmental preservation. Conversely, they thought that it had the demerit of the requirement for long-life management of the high level radioactive waste.
On the other hand, the students who belonged to the *Passive group* did not have such a subjective attitude.
It would be the first to make an effort to share the feelings between a speaker and a listener (students of the passive group) by beginning the topics about their interest. If a speaker succeeded in getting the listeners' trust, a speaker would be easy to discuss the point of that theme. However, as the students of *Passive group* chose the keywords heuristically, it was difficult to get their interests. Therefore, the author paid attention to the keywords of other themes chosen by the *Active group* toward the HLW site selection.

Nuclear power generation			
Items of questionaire survey/group	Necessity of Nuclear power generation	Approval for facility installation	Accept of adjoining facility
Passive group	5.5 (1.20)	3.9 (1.25)	2.8 (1.67)
Active group	5.8 (0.87)	4.3 (0.99)	3.3 (1.31)
significance	n.s.	n.s.	n.s.

The numerical value in each group indicate the average of ordinal scale of approval, such as " I guess so very much (7 point)", "neutral (4 point)", "I don't guess so at all (1point)" respectivly. The numerical value in a parenthesis shows standard deviation.

* : significant, $p < 0.05$

HLW				
Items of questionaire survey/group	Cognition of HLW	Necessity of disposal facility	Approval for facility installation	Accept of adjoining facility
Passive group	3.9 (0.64)	4.3 (0.71)	3.4 (0.92)	1.9 (1.13)
Active group	3.5 (0.88)	4.4 (0.65)	3.9 (0.68)	3.1 (1.25)
significance	n.s.	n.s.	n.s.	*

The numerical value in each group indicate the average of ordinal scale of approval, such as " I guess so very much (7 point)", "neutral (4 point)", "I don't guess so at all (1point)" respectivly. The numerical value in a parenthesis shows standard deviation.

* : significant, $p < 0.05$

Table 6. Result of ANOVA on the questionnaire survey pertaining to the nuclear power generation and HLW

The fifth theme of the lecture, household waste management, was a suitable issue to find the common element between the nuclear power generation and household waste management. The third theme of the lecture, precautionary principle, was also taken to find the common element. Because the characteristics to avert the risk at first would bring the chaos into the discussion of the site selection of HLW disposal, it would be difficult to achieve the social consensus.

3. Discussion

3.1 The attitude for the environmental scientific-related theme

In order to grasp the communication viewpoints, the author investigated the interest of the *Active group* in the field of environmental science such as the household waste management and the precautionary principle by using keyword cross table and correlation analysis.

3.1.1 Correlation with the keywords at the lecture on the household waste management and those on nuclear power generation

As shown in the Table 7 of the cross table which shows the keyword group obtained in the lecture of nuclear power generation and the lecture of household waste management,

twenty six of the students (the largest number of the students) submitted the keyword of "nuclear power generation". The eleven students (the second largest number of the students) submitted the keyword of "MOX fuel (plutonium-uranium mixed fuel utilization) "at the lecture of nuclear power generation.

At the fifth lecture of household waste management, seventeen of above mentioned students who had selected "nuclear power generation" and "MOX fuel (plutonium-uranium mixed fuel utilization) " submitted the keyword of "recycle"and four of above mentioned submitted the keyword of "waste". These two keywords of "recycle" and "waste" were also top two of the submitted keywords at the lecture of general waste management.

This indicated that the students who had chosen the most and the second most keywords of both lectures did not consider these topics rationally. Therefore, it can be safe to say that the students who selected these top two of the keywords tended to make a decision in a heuristic way. They can be subordinate to the theme of the lecture in other words.

On the other hand, eight students identified as the member of *Active group* by the analysis of questionnaire survey chose the keywords such as "fuel cycle", "radioactive waste", "public poll", and "renewable energy" at the lecture of nuclear power generation. They chose seven keywords such as "3R (Reduce, Reuse, Reduction)", "globalization"," costs of waste management", "disposal" and other keywords. Two students, who belonged to the *Active group,* did not express the positive attitude toward the problem solution in the field of the household waste management, since they chose the keyword of "recycle" in the heuristic way.

Therefore, the author investigated the keywords of the students who belonged to the *Active group* of Cluster IV and Cluster V by considering the connotation of the six keywords of the lecture on the household waste management.

The students who had an interest in "nuclear fuel cycle" had paid attention to "3R (Reduce, Recycle, Reuse)," and "expense of waste management" in the area of household waste management. The students who had an interest in "radioactive waste" had paid attention to "globalization" and "waste disposal".

"Nuclear fuel cycle" and "3R" implied the common image of the recycling process, and "Disposal cost (expense of waste management)" implied the economic viewpoint. Therefore, this suggested that the students had a deep interest in the economic issue when they considered the flow of household waste, or radioactive waste.

The concept of the global relationships between the waste discharging country and the waste reprocessing country could be extracted from three keywords ("radioactive waste", "globalization" and "discharge of the waste"). This suggested that the students had a deep interest in the international relationships when they considered the process of the waste management.

The other students who had an interest in "renewable energy" paid attention to "Calculative society (the society which put emphasis on recycling)", and those who had an interest in "public opinion poll" paid attention to "rubbish discharge quantity."

From the keyword of "renewable energy" and "calculative society (the society which put emphasis on recycling)", the concept of the sustainable society could be extracted. The concept that the public had an interest in the process of decision making could be extracted from the keyword of "public opinion poll" and "quantity of disposal waste", considering the current social trend that public require the residential opinion poll for unpleasant facilities site selection.

This suggested that special emphasis would be placed on the economical viewpoint, global relationships, sustainability, and the way of expression of individual opinion, when the students consider the problem solving toward HLW site selection. The correspondence of keywords between the area of "household waste management" and "nuclear power management" shows Figure 7.

		Nuclear Power generation	MOX Fuel utilization in LWRs	Insecurity or understanding among citizen	Nuclear energy revolution	Friburg	Renewable energy	Public opinion poll	Radioactive waste	Nuclear fuel cycle
Cluster		I	I	II	III	III	IV	IV	IV	V
total	49*1	26*1	11	1	1	2	1	1	3	3
Recycle	21	12	5		1	1			1*2	1*2
Waste	4	3	1							
Plastics	4	2	2							
Circulative society	4	3					1			
Disposal cost	3	1				1				1
3R(Reduce,Reuse,Recycle)	2		1							1
Globalization	2		1						1	
Discharge of the waste	2	1							1	
Responsibility for disposal	2	1		1						
Illegal disposal	2	1	1							
Quantity of disposal waste	1							1		
Incentive	1	1								
Thermal supply system	1	1								

*1 A student, who was present at the lecture on nuclear power generation, was absent at the lecture of household waste management.
*2 omitted from the objects of analysis

Table 7. Cross table of the keywords at the lecture on "nuclear power generation" and "household waste management"

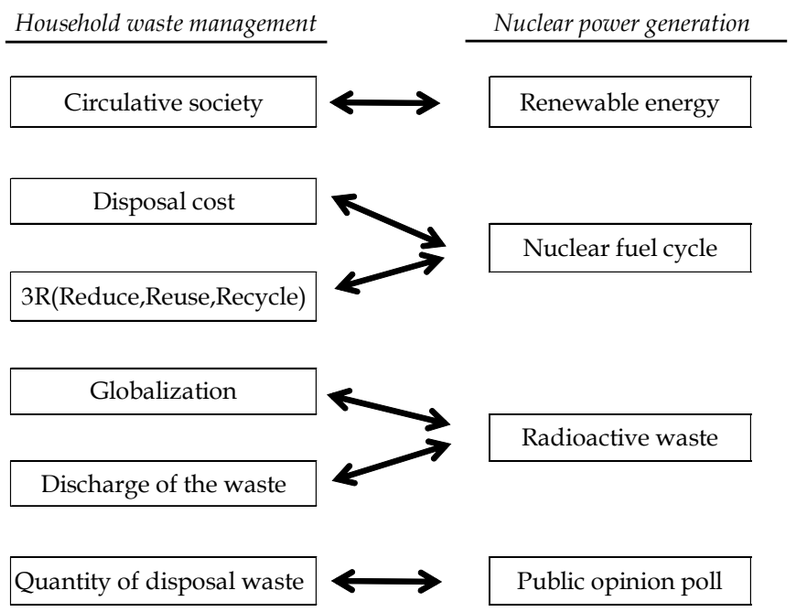

Fig. 7. Correspondence of the keyword (household waste management vs. nuclear power generation)

3.1.2 Correlation with the keywords at the lecture on the precautionary principle and those on nuclear power generation

As shown in the Table 8 of the cross table which shows the keyword group obtained at the lecture of nuclear power generation and the lecture of the precautionary principle, eight students out of twenty seven students who had chosen “nuclear power generation” chose the keyword of “risk” at the lecture of the precautionary principle. Two students out of eleven students who had chosen “MOX fuel (plutonium-uranium mixed fuel utilization)” also chose the keyword of “risk”. Six students out of twenty seven students who had chosen the “nuclear power generation” chose the keyword of “risk information” at the lecture of the precautionary principle. One of eleven students who had chosen “MOX fuel (plutonium-uranium mixed fuel utilization)” also chose the keyword of “risk information”.

According to the above mentioned mental model, the students who chose these keywords of “risk” and “risk information”, which were the top two of the selected keywords at the lecture of the precautionary principle, had the characteristics of decision making in the heuristic way. “The precautionary principle”, which ranked the fourth place of the number of chosen keywords, was the title of the lecture”. Consequently, the author decided to exclude the students who chose this keyword from the objects of analysis.

Therefore, the students, who chose the most and the second most keywords of lectures, and the student, who chose “the precautionary principle”, tended to make a decision in a heuristic way. They could be subordinate to the theme of the lecture in other words.

On the other hand, eight students identified as members of *Active group,* who belonged to the Cluster IV and V by the analysis of questionnaire survey, had chosen the keywords of "fuel cycle", "radioactive waste", "public poll", and "renewable energy" at the lecture of nuclear power generation.

The *Active group* chose six keywords of "zero risk”, "dioxin", "risk", "risk information" “dioxin concentration (in foods)” and “the precautionary principle” without their biasing on a particular keyword. Five out of eight students, who had been categorized as the *Active* member toward the HLW site selection, did not express the positive attitude pertaining to the problem solution in the field of the precautionary principle. They had just chosen the keyword of “risk”, “risk information” and “the precautionary principle”, which were chosen in a heuristic way by the large number of students.

On the other hand, three students who had chosen “public poll” and “radioactive waste” chose the keywords of “zero risk”, “dioxin”, and “dioxin concentration (in foods)” which were minor selections at all. They did not make a decision in a heuristic way but made rational consideration on the theme of nuclear power generation and the precautionary principle respectively.

When extracting the common underlying meaning from these non heuristic keywords such as “radioactive waste”, “public poll”, anti-centred policy style could be seen in the concept of demerit of the burden of nuclear power generation and the concept of individual opinion expression. When extracting the common underlying meaning from these non heuristic keywords such as “zero risk”, “dioxin” and “dioxin concentration in foods”, analytical or scientific attitude could be seen in the concept of quantitative thinking based on the numerical keyword such as the word of “zero” and “concentration”.

This suggested that the students would have the antipathy toward logical thinking with an upper class viewpoint, the scientific and analytical viewpoint, when they considered the problem solving toward the HLW disposal site selection. The correspondence of keywords

between the area of "the precautionary principle" and "nuclear power management" shows Figure 8.

		Nuclear Power generation	MOX Fuel utilization in LWRs	Insecurity or understanding among citizen	Nuclear energy revolution	Friburg	Renewable energy	Public opinion poll	Radioactive waste	Nuclear fuel cycle
Cluster		I	I	II	III	III	IV	IV	IV	V
total	50	27	11	1	1	2	1	1	3	3
Risk	14	8	2	1		1	1*1		1*1	
Risk information	9	6	1							2*1
Dioxin news report	6	3	3							
Precautionary principle	5	1	3							1*1
Risk management	4	3	1		1					
Risk cognition	3	2				1				
Risk communication	2	1								
Environmental hormon	2	1	1							
Dioxin concentration	2	1						1		
Problem of Risk	1	1								
Zero Risk	1								1	
Dioxin	1								1	
Risk analysis	0									

*1 omitted from the objects of analysis

Table 8. Cross table of the keywords at the lecture on the precautionary principle and household waste management

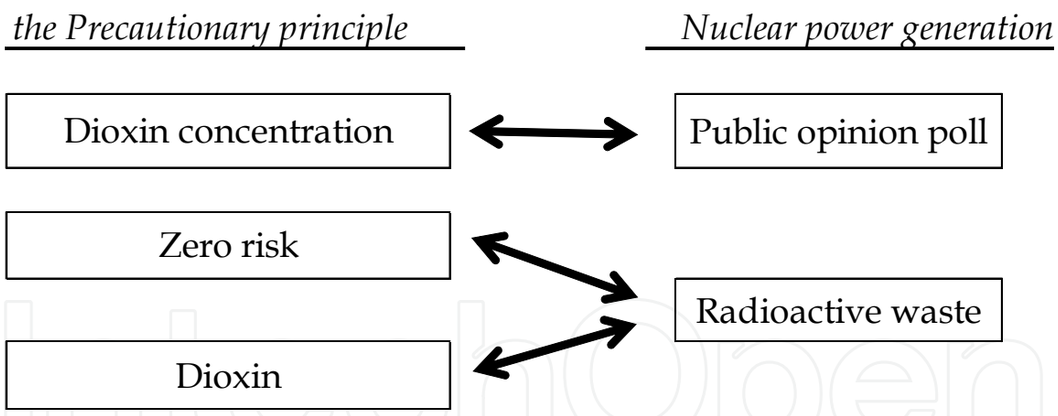

Fig. 8. Correspondence of the keyword (the Precautionary principle vs. nuclear power generation)

4. Conclusion

To find the communication point to promote the positive attitude toward the HLW disposal site, the author proposed the new approach of analyzing the consciousness of the students who stud rationally on the active position for constructive problem solution.

The previous analysis on the public risk communication had targeted on the majority of the subjects based on the assumption that the majority would represent the public so far. However, this new approach targeted on the minority of the subjects based on the

assumption that a rational answer would not be made by the majority that was easy to make a heuristic decision but by the minority.

In this research, the author gave the lectures on the risk and desirable autonomous attitude in the some areas of environmental science. The students submitted the most impressive keyword after each lecture. The keywords were categorized by correspondence analysis and cluster analysis into two groups based on the assumed mental model. The two groups were characterized by the analysis of ANOVA on the result of questionnaire survey on nuclear power generation and high level radioactive waste disposal. One group consisted of the students who made a decision positively considering they were responsible for high level radioactive site selection. The other group consisted of the students who made a decision negatively considering they would not like to be involved in this issue.

The author paid attention to the former group and succeeded in deriving the common consciousness from the keywords of lectures on nuclear power generation, household waste management, and the precautionary principle.

It was observed from the keywords of nuclear power generation and household waste management, that economic efficiency, global relationship, sustainability and respect of individual opinion were common value among the active group, whose consciousness were positive towards HLW disposal site selection.

It was observed from the keywords of nuclear power generation and the precautionary principle, that antipathy for the seeing from up to down were common. Scientific or analytical viewpoints were also common among the *active group*.

In order to alleviate the reluctance for uncertainty of those who show resistance of being in the contiguity of HLW disposal facility, it should be significant for utilizing those common values interpreted along with this research for risk communication between citizen and governmental authorities. However, since this research has been mainly focusing on the area of risk communication between nuclear power generation and household waste management, and between nuclear power generation and the precautionary principle, there should be further researches conducted in the remaining areas such as global warming and other themes.

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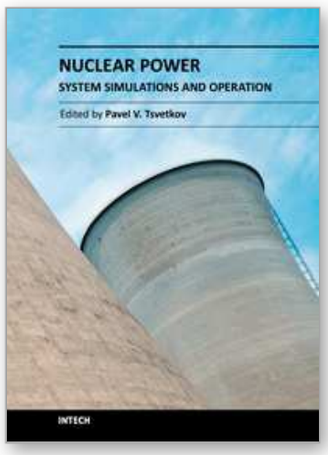

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At the onset of the 21st century, we are searching for reliable and sustainable energy sources that have a potential to support growing economies developing at accelerated growth rates, technology advances improving quality of life and becoming available to larger and larger populations. The quest for robust sustainable energy supplies meeting the above constraints leads us to the nuclear power technology. Todayâ€™s nuclear reactors are safe and highly efficient energy systems that offer electricity and a multitude of co-generation energy products ranging from potable water to heat for industrial applications. Catastrophic earthquake and tsunami events in Japan resulted in the nuclear accident that forced us to rethink our approach to nuclear safety, requirements and facilitated growing interests in designs, which can withstand natural disasters and avoid catastrophic consequences. This book is one in a series of books on nuclear power published by InTech. It consists of ten chapters on system simulations and operational aspects. Our book does not aim at a complete coverage or a broad range. Instead, the included chapters shine light at existing challenges, solutions and approaches. Authors hope to share ideas and findings so that new ideas and directions can potentially be developed focusing on operational characteristics of nuclear power plants. The consistent thread throughout all chapters is the â€œsystem-thinkingâ€ approach synthesizing provided information and ideas. The book targets everyone with interests in system simulations and nuclear power operational aspects as its potential readership groups - students, researchers and practitioners.

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