Changes and Prospects of Safety Regulation Activities in Korean Nuclear Safety Research

Jin-Sung Kim, Soo-Yong Park, Dong-Hyung Lee

Abstract: ***Nuclear power can cause radioactivity problems because of its inherent characteristics. For the past 40 years, various studies have been carried out to secure nuclear safety at academia, industry and government level. In addition, the government's role as a safety regulator to protect human and natural environment from all the risks that may arise when using nuclear energy is becoming increasingly important. We intend to analyze the trends of nuclear safety research in Korea over the past 40 years, and the effects of safety regulation activities by the key elements of nuclear safety regulation. The results of analysis on the trends of changes in the research topics qualitatively or quantitatively are as follows; in the view point of quantitative on safety researches, the number of papers has been increased as interests in nuclear energy have increased. Also, the safety regulation activities are similar to the direction in which safety studies were conducted. Based on these preconditions, we conducted the statistical analysis on research topics of the representative domestic journals related on nuclear safety issues by periods, using the key elements components required for nuclear safety. From the 1970s to the late 1980s, the economic and engineering factors accounted for a large portion of the key elements for safety regulation. The economic factors have gradually decreased since the 1990s, but the share of political and social factors as key elements of safety regulation has started to increase rapidly. In this study, we suggest that the future nuclear safety regulations should focus on raising the social and psychological level of safety sympathized with the general public, based on the high level of engineering and technical expertise.***

Index Terms: Nuclear Power Plant, Nuclear Safety Research, Nuclear Safety Regulation Activity, Key Elements of Nuclear Safety Regulation.

I. INTRODUCTION

In 1957, the Korean domestic nuclear power industry began to establish the necessary system for the research, development and utilization of nuclear energy through joining the International Atomic Energy Agency (IAEA) for the peaceful use of nuclear power. The Korean domestic nuclear power industry has been steadily developed since the introduction of the first research reactor in 1962 and the commercial operation of nuclear power plant Kori-1 in 1978.

This industry becomes now an important axis of the national economy such as the electric power generation of nuclear power plants and the use of radioactive isotopes [1]. Starting from the first commercial nuclear power plant Kori-1 in Korea, the nuclear power plants have been increased since the 1980s, and now 24 nuclear power plants are in operation, accounting for about 28.4% of domestic electric power demand [2].

The proportion of the nuclear power industry which includes not only nuclear power plants but also nuclear facilities and radioactive isotopes is increasing in the national economy. Although the construction of new nuclear power plants in Korea has been recently suspended due to public consensus on the operation of nuclear power plants and lack of confidence in safety of nuclear power plants with the government's energy transition policy, Korea having the technology independence and excellent operation technology of Korean Standard Type Nuclear Power Plants is promoting to enter overseas.

The nuclear power causes an inevitable radiation problem by its nature in using it. In the case of domestic nuclear power plants, the severe accidents such as TMI nuclear power plant accident of USA, Chernobyl nuclear power plant accident in Russian and Fukushima nuclear power plant accident in Japan did not occur, but it always has several inherent hazard factors that affect the public health and environment of country. This is a basic precondition for operating the nuclear power plant.

To settle this problem, the research activities for guaranteeing and promoting nuclear safety over the past 40 years have been carried out variously in academia and industry under the government policy of nuclear promotion and regulation. In this study, we intend to analyze the trends of nuclear safety research in Korea over the past 40 years, and the effects of nuclear safety regulation activities by the key elements of safety regulation.

II. MATERIALS AND METHODS

In this study, It was conducted a keyword search called 'Nuclear Safety' using the Research Information Sharing Service (RISS) provided by the Korean Educational Research Information Service (KERIS). From 1970s to the first half of 2018, about 1100 articles in the domestic journals (abstracts, summaries, etc.) were collected from the viewpoint of securing nuclear safety and analyzed the trends of changes in the research subjects [3].

Revised Manuscript Received on May 23, 2019.

Jin-Sung Kim, Ph. D. Candidate, Dept. Industrial & Management Engineering, Hanbat National University, Daejeon, Korea

Soo-Yong Park, Professor, Dept. Convergence Technology, Hanbat National University, Daejeon, Korea

***Dong-Hyung Lee**, Professor, Dept. Industrial & Management Engineering, Hanbat National University, Daejeon, Korea

In addition, the contribution of the results of nuclear safety research conducted so far to changes in safety regulation policy or activities is analyzed qualitatively or quantitatively by history of nuclear safety research trends and safety regulatory activities in accordance with the changes in Korean domestic nuclear power industry, thereby I intend to present the goals that future safety regulation should purse.

III. RESULTS AND DISCUSSION

A. Nuclear Safety Research Trends and Safe Regulation Activities

A.1 Introduction of Nuclear Power - 1970s (1970 ~ 1978)

A.1.1 Historical Situation

In Korea, as a country that imports nuclear power, it is highly reliant on technology of nuclear power supply countries such as USA, France and Canada. In order to transfer technology smoothly, Korea established the Nuclear Power Bureau of the ministry of science and technology, Korea Atomic Energy Research Institute, and the Korea Atomic Energy Technology Corporation, accordingly subdivided and specialized in the structure of the nuclear power business [1].

A.1.2 Historical Situation Research Status [Number of academic articles: 15]

With the exception of some proposals for nuclear safety, most of research topics were on the use and development of nuclear energy.

A.1.3 Safety Regulation Activities

At that time, the concept of safety regulation was not well established as the early stages of the domestic nuclear industry. It was limited to the level of establishing regulatory technology and regulatory administrative systems for safety management of research reactors, radioactive isotopes and generators. It was focused on the introduction of the advanced safety regulation system and securing regulatory skills of nuclear suppliers (USA and Canada) through participation in the IAEA training course [1].

At the time, by adopting and applying the regulatory requirements and technical standards of the nuclear suppliers (USA and Canada) in consultation with the IAEA experts in the main regulatory activities, the operation of Kori-1 and the construction of Wolsong-1 were approved.

A.2 Beginning of nuclear safety - 1980s (1979 ~ 1989)

A.2.1 Historical Situation

Due to nuclear accidents at TMI (Three Mile Island) nuclear power plant of USA (1979) and Chernobyl nuclear power plant in Russian (1986), it had been created awareness of the need for multi-disciplinary consideration for severe accidents caused by reactor failure [4,5]. The effectiveness and clarity about nuclear safety regulations had begun to be emphasized in an environment focused on nuclear power usage and development [1].

A.2.2 Historical Situation Research Status [Number of academic articles: 83]

Along with nuclear energy research, which focuses on the nuclear energy - development, the researches to suggest new safety regulation direction through analysis of nuclear power plant accident and failure cases had begun to increase rapidly. However, the nuclear safety research had been still recognized as an auxiliary and incidental means with an emphasis on research and development for nuclear energy promotion.

A.2.3 Safety Regulation Activities

In the wake of the TMI nuclear power plant accident of USA, the government installed the Nuclear Safety Center (1982) at Korea Atomic Energy Research Institute (KAERI) to strengthen nuclear safety regulatory functions, and dispatched resident safety management personnel to each nuclear power plant for on-site safety regulation. Also, it had established the safety review standard suitable for our situation by benchmarking to the advanced regulatory system and experience of the nuclear power supplier countries.

The review for construction permission of Kori-3,4, Yonggwang-1,2,3,4, Uljin-1,2 was conducted. In addition, the Radiological Emergency Management Headquarters was established and operated (1986) to evaluate the domestic impact of radioactive leakage accidents caused by the reactor core explosion of the Chernobyl nuclear power plant in Russia, and a comprehensive safety inspection was conducted for operational plants. Externally, by joining IAEA's early notification and technical support arrangements, it had begun to strengthen international cooperation on nuclear power plant accidents [1].

A.3 Nuclear Leap and Growth - 1990s (1990 ~ 1999)

A.3.1 Historical Situation

After TMI and Chernobyl's accident, the ideology, philosophy and basic principles of nuclear safety and regulation were formally presented through the announcement of severe accident prevention measures (1991) and the Nuclear Safety Policy Statement (1994). On the one hand, to enhance the national credibility of nuclear safety, a specialized institute (named Korea Institute of Nuclear Safety; KINS) was established to take charge of the technical expertise of nuclear safety regulation (1990).

A.3.2 Historical Situation Research Status [Number of academic articles: 218]

In order to comply with the safety goals and safety standards of nuclear power plants, researches on optimal design, diagnosis and verification technologies for major facilities of nuclear power plants had emerged, and the policies and related studies had been started to introduce nuclear safety culture.

A.3.3 Safety Regulation Activities

In case of a construction nuclear power plant, its own domestic technical standards (e.g. guidelines for safety inspection of light-water reactors, improved standard operating technology guides, and guidelines for in-service test of safety-related pumps and valves) were prepared and started to use them as standards for safety regulations to escape from the application of regulatory standards of nuclear power supply countries.

While the nuclear power plants have been operating, the general periodic inspections was carried out during overhaul of nuclear power plant. And the special safety inspections by special government programs were carried out whenever occurrence of safety issues such as leakage of heavy water pump moderator and radiation exposure of workers in Wolsong-3, damage of nuclear fuel assembly supporting grid in Yonggwang-2 [1].

A.4 Nuclear maturity - 2000s (2000 ~ 2009)

A.4.1 Historical Situation

As the frequency of accidents and failures of Korean Standard Type Nuclear Power Plants had accumulated, the interest in the cause analysis, safety evaluation methods and standards began to increase. The occurrence of earthquakes in the vicinity of nuclear power plants (Gyeongju, Odaesan) (2005) had led to widespread anxiety about the safety of long-term operation nuclear power plant built on domestic site which was recognized as relatively earthquake - safe zone.

A.4.2 Historical Situation Research Status [Number of academic articles: 257]

Safety regulation studies derived from the operation experiences of the Korean Standard Type Nuclear Power Plant were actively conducted. In the mid-1990s, basic researches for advanced future reactor design and related safety regulations (e.g., probabilistic safety assessment techniques, etc.) began to be realized through technical information exchange with advanced nuclear power nations [1].

A.4.3 Safety Regulation Activities

PSR (Periodic Safe Review) recommended to the IAEA was actively adopted by government for reflecting the review experiences for construction/operation permit of the Korean Standard Type Nuclear Power Plant. The comprehensive safety assessment of the nuclear power plant's overall system was carried out by PSR. Also, the diverse safety regulation systems and related activities for continued operation of nuclear power plant was introduced to check the safety of nuclear power plants after the design life of the plant.

In particular, the Standard Design Approval System was introduced pro-actively and the related review was conducted to verify safety of the next-generation reactor design and assess the validity of the new technology introduced in the standard design [1].

A.5 Nuclear Tribulations – First half of the 2010s (2010~ 2014)

A.5.1 Historical Situation

Due to climate change, the nuclear power energy was highlighted as an energy source for global greenhouse gas reduction, the age of nuclear renaissance had arrived, such as expansion of domestic construction nuclear power plants and industrialization of nuclear power exports.

However, the spray accident of reactor coolant in reactor containment building at Shin Kori-1(2010), the concealment of nuclear power failure at Kori-1 (2012), counterfeiting of nuclear equipment quality documents and worker corruption (2012) declined public confidence on the long-term safety of nuclear power. Therefore, the strengthening the role of regulatory agencies for nuclear safety began to be urgently required. In addition, the Fukushima nuclear power plant accident (2011) in Japan caused by the tsunami made increase the public concern and demand in the field of nuclear safety enhancement against natural hazards exceeding the design basis accident [6].

A.5.2 Historical Situation Research Status [Number of academic articles: 270]

The lessons learned from the Fukushima's nuclear power plant accident led policy research on the necessity of strengthening the international response system of nuclear accident, and research on technical issues. In addition, research on the treatment of radioactive wastes and the ageing management of major nuclear facilities had been actively carried out due to the increase in the number of long-term nuclear power plants.

A.5.3 Safety Regulation Activities

Since the Fukushima nuclear power plant accident, concerns about nuclear safety had increased, the IAEA recommendations had been accepted, Nuclear Safety and Security Commission (NSSC) had been established as a central administrative body under the president to carry out safety management in the independent status from the Nuclear energy utilization and promotion department. As a result, the regulatory independence has been structurally enhanced and safety regulatory activities have been developed [7].

In 2012, the nuclear safety comprehensive plan, which was led by Nuclear Safety and Security Commission (NSSC) had been separated from the nuclear promotion comprehensive plan which was led by the Ministry of Science and Technology since 1997, and an independent safety regulation policy establishment and implementation system had been established.

On the other hand, the regulatory review for continued operation of nuclear power plants Kori-1 & Wolsong-1 was conducted. However, the concern about safety of the nuclear power plant had not been sufficiently resolved due to the lack of public consent about the review results.

A.6 Nuclear Awareness Transformation – The second half of 2010 (2015 ~ 2018)

A.6.1 Historical Situation

Since the announcement of the nuclear energy transition policy (2017) by government, the nuclear energy-centered policy has been transformed by the policy of emphasizing the life, safety and the environment of the people [8], [9]. In addition, as shown by the survey on the public's perception of the government's energy transition policy, 71 percent of respondents generally have been aware of the government's energy transition policy, 62 percent of respondents have shown a positive responses to the nuclear power reduction policy [10].

The public interest in the reduction of the new construction nuclear power plants and the safety issues of operational nuclear power plants (spent fuel disposal, radiation issue in the natural environment, cyber terror and security issues, etc.) has increased dramatically. As a result, the disclosure of information on the operation and regulatory activities of nuclear facilities and the communication with the public began to be emphasized.

A.6.2 Historical Situation Research Status [Number of academic articles: 249]

Research on the treatment and management of radiation waste from nuclear power plants decommissioning has begun to be implemented, and research on improvement measures against the weak elements of cyber security and safety culture of nuclear power plants has begun.

In addition to research on safety evaluation technology of nuclear power plant in response to the 4th Industrial Revolution Period, the policy tasks for improving nuclear safety reliability that emphasize empathy and communication have begun to appear [11].

A.6.3 Safety Regulation Activities

As the public's expectations for nuclear safety have increased, the government prepared a comprehensive measure to strengthen safety standards in order to embody the vision and policy direction established in the 2nd nuclear safety comprehensive plan (2017 – 2021).

In this way, Regulatory authority suggests ways to strengthen safety standards as follows. 1) strengthening periodic safety review of nuclear power plants, 2) strengthening safety of nuclear power plant against seismic, 3) strengthening Probabilistic Safety Assessment(PSA) by multi-unit plants, 4) establishing a safety regulatory system for spent fuel and high-level radioactive waste, 5) strengthening the safety of radiation products in the natural environment, 6) expansion of information disclosure through legislation on the disclosure and communication of nuclear safety information, and strives to secure public trust through active communication with the public [12].

B. Comprehensive Analysis

B.1 Analysis of quantitative change of research result

As mentioned in Chapter A, From the 1970s to the first half of 2018, about 1100 domestic journals (abstracts, summaries, etc.) were collected to analyze the trends of changes in the research subjects published in view of securing nuclear safety. First of all, from the viewpoint of quantitative research results, the interest in nuclear power has increased, as shown in Fig. 1, Starting in 2000s, the rate of increase in the number of articles began to be the most outstanding.

This is due to the fact that the operation, design, production and safety regulation technologies, etc. about the nuclear industry accumulated in the academic and industrial fields since the introduction of the nuclear power plant in the 1970s under the government policy of nuclear promotion and regulation began to be specified and matured from the latter half of 1990.

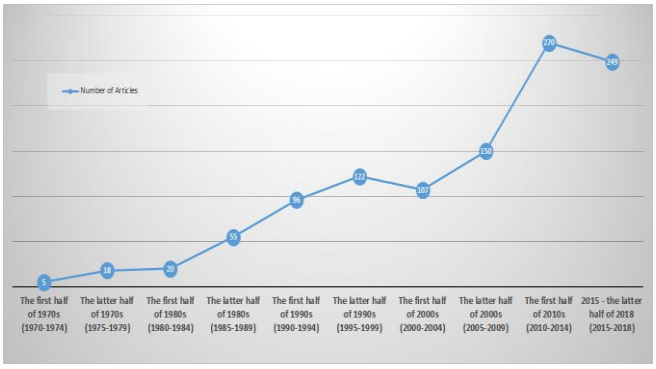

Fig. 1. Change in the number of nuclear safety research results (articles) by periods

B.2 Directional analysis of nuclear safety research and its safety regulation activities

B.2.1 Direction of nuclear safety research

From the viewpoint of research direction, it was found that, except in the mid-1990s and early 2000s, the research about policy and evaluation technology for enhancing the utilization of nuclear energy and solving the safety issues was carried out as if the action is taken only when a problem arises.

In particular, as shown in Fig. 2, the safety research results tend to increase relatively near the time of major safety issues in the period. In addition to the research for the settlement of current issues, the long-term and future-oriented nuclear safety research environment and activities will be needed.

B.2.2 Direction of nuclear safety regulation activities

Until the early 1990s, the nuclear safety research activities had little or no impact on government's safety regulation activities, because they were mainly carried out at the civilian level such as academia and industry. But, since the mid-1990s, the nuclear promotion comprehensive plan and nuclear safety comprehensive plan which were led by the government have been established and promoted every five years, it is considered that the propulsion system necessary for nuclear safety regulatory activities is appropriately secured. However, as with the direction of safety research, it is considered that the preemptive and preventive nuclear safety regulation activities are insufficient, as the safety regulation activities are limited to resolve only current issue.

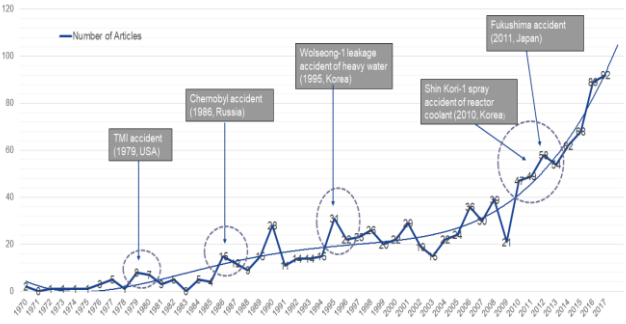

Fig. 2. Number of articles on nuclear safety research & major safety issues by periods

B.2.3 Correlation between nuclear safety research and its safety regulatory activities

As a result of analysis of the nuclear safety research and regulatory activities conducted over the past 40 years, basically, the research and regulation activities for nuclear safety are analyzed as not reversing the current situation or change of the times. However, the safety regulation activity basically requires conservativeness, clarity, and objectivity. So, the tendency or trend of the safety regulation activity was analyzed to have a similar orientation to the direction of safety research, although there were some time differences at the time of application.

B.3 Analysis of Key Element Components and Future Direction of Nuclear Safety Regulations

As mentioned in the previous section, it was analyzed that the direction between the nuclear safety research and the safety-regulated activities were not significantly different over the past 40 years. Based on this, the tendency of safety regulation activities was analyzed by finding out how key element necessary for nuclear safety regulation are embedded in the research results for securing nuclear safety. We suggest the future direction of nuclear safety regulations that ultimately should be oriented as follows.

B.3.1 Characteristics and Key Element of Nuclear Safety Regulations

The IAEA defines 'Nuclear Safety' as the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, protection of workers, the public and environment from undue radiation hazards [13]. In the end, the goal of nuclear safety is to minimize the possibility of various accidents from radiation hazards caused by the production and use of nuclear energy, and to minimize the damage when an unavoidable accident occurs. Meanwhile, nuclear safety regulations refer to the administrative restrictions imposed by the government to protect the human and natural environment from all risks (including radiation hazards) that may arise during the use of nuclear energy [14]. These administrative regulations include legal, technical, and institutional activities, and securing nuclear safety through them is a precondition for the use of nuclear energy.

In addition, nuclear energy has the problem of justification, efficiency, optimization and rationalization because it has the characteristic that the probability of occurrence of a nuclear accident is extremely low [15]. Therefore, in this paper, considering these characteristics comprehensively, the key element components required for nuclear safety regulation were largely classified into three categories, and related main detailed keywords were presented as shown in Table 1.

Table 1. Key Element Components for Safety Regulations

Key Element Components for Safety Regulations	Detailed Keywords
1	Engineering Aspect	Construction, Design, Operation, Performance, Maintenance, Diagnosis, Inspection, Analysis, Testing, Qualification, Integrity
2	Economic Aspect	Utilization/Promotion, Quality, Development, Cost, Economics, Efficiency / Effectiveness, Localization, Standardization
3	Political & Social Aspects	Environment, Independence, Safety Culture, Human Error, International cooperation/ response, Acceptability, Reliability, Communication

B.3.2 Distribution of Key Element Components for Safety Regulations by periods

In this section, the statistical analysis of distribution about detailed keywords by period was conducted on research topics of the representative domestic journals on nuclear safety issues in order to analyze the distribution of key components required for nuclear safety regulation. The analysis results are shown in Fig. 3, Fig. 4, Fig. 5.

First of all, as shown in Fig. 3, the direction of safety regulation from the engineering point of view shows that the number of use of detailed keyword related to the engineering aspect increases as time goes by. It can be seen that trends in increasing demand for the advancement, segmentation, and specialization of safety regulation technology has been prominent since the second half of 1990. Also, such a demand had caused by advances in science technology necessary for design, operation, analysis and qualification among the engineering factors.

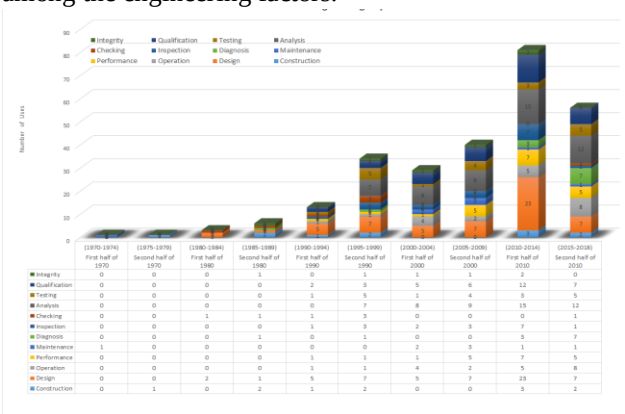

Fig. 3. Distribution of Key Element Components for Safety Regulations - Engineering Aspect

Second, as shown in Fig. 4, the direction of safety regulation from the economic point of view shows that the number of use of detailed keyword related to the economic utilization and development aspects of nuclear energy has increased since the 1970s.

But the optimistic perception about the economics and efficiency of nuclear energy is gradually declining as the keyword use decrease gradually since the late 1990s. However, from 2000s, it can be seen that there is renewed interest in economic effectiveness through cost benefit analysis of nuclear industry.

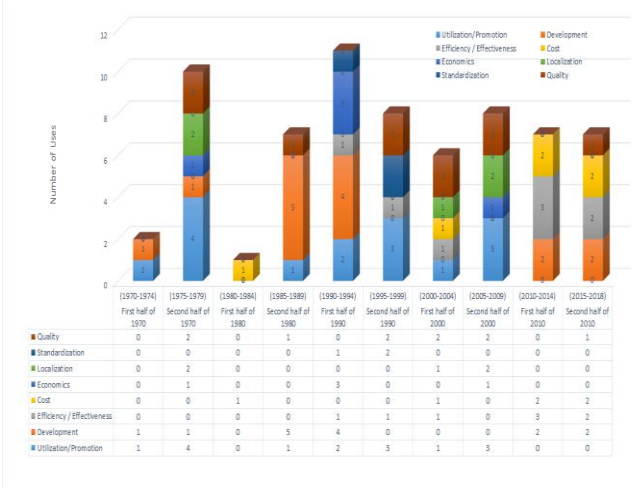

Fig. 4. Distribution of Key Element Components for Safety Regulations - Economic Aspect

Third, as shown in Fig. 5, the direction of safety regulation from the political and social point of view shows that the detailed keywords related to the political and social aspects were hardly presented from the 1970s to the late 1980s, but the key elements for safety regulation in the political and social aspects have been starting to appear since the 1990s.

In particular, after Fukushima nuclear accident in Japan, which is close to Korea, the elements such as transparency, acceptability and communication capacity of nuclear safety information have emerged as an important part of key elements for nuclear safety regulation since 2010.

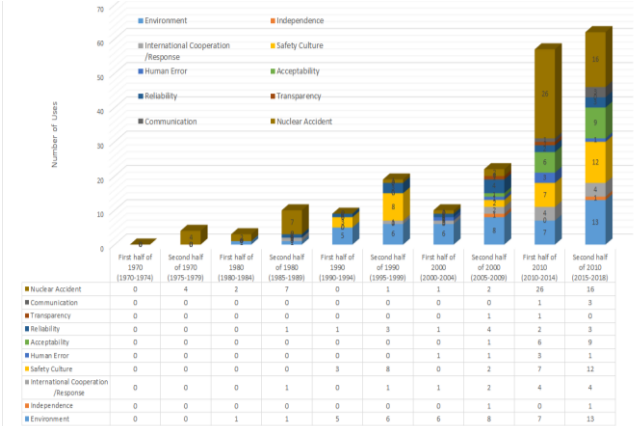

Fig. 5. Distribution of Key Element Components for Safety Regulations - Political and Social Aspect

B.3.3 Nuclear Safety Regulation Trends and Direction of Key Element for Safety Regulation

The percentage of key element components required for nuclear safety regulation from 1970 to first half of 2018 is as follows. As shown in Fig. 6, the economic factors and engineering factors accounted for a large portion of the key elements for safety regulation in the introduction period of nuclear power (from the 1970s to the late 1980s).

However, it is believed that the reason for the temporary increase in the proportion of political and social factors in the 1980s was due to the increase in social interest caused by nuclear accidents at TMI nuclear power plant of USA and Chernobyl nuclear power plant in Russian.

On the other hand, the economic factors have gradually decreased since the period of nuclear leap and growth (1990s), but the share of political and social factors as key elements of safety regulation has started to increase rapidly.

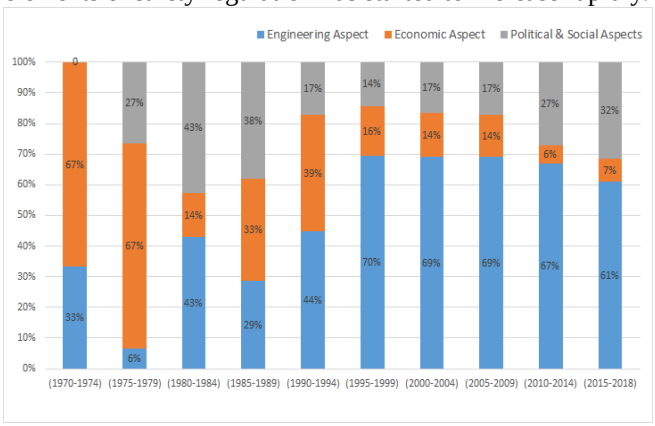

Fig. 6. Percentage of Key Element Components required for Nuclear Safety Regulation by periods

Based on the comprehensive analysis of the distribution of key element components required for nuclear safety regulation by period and their proportion, we suggest that future's nuclear safety regulation should be pursued as bellows. First, the efforts are needed to continuously secure and strengthen the engineering and technical expertise necessary for safety regulation. Second, the other efforts are urgently needed to narrow the gap between the engineering & technological safety level claimed by nuclear regulatory experts and the social & psychological safety level recognized by the public. Third, in order to enhance the public acceptance of nuclear safety, it is also necessary to provide policy or institutional support so that the expansion of contacts and communication with the public, and transparent disclosure of safety information etc. can be carried out consistently and sincerely.

IV. CONCLUSION

In this study, Trend analysis was conducted on the research topic of representative domestic research results (articles in the domestic journals) about the nuclear safety issues of the past 40 years in response to changes in domestic nuclear development and safety regulation. As a result of examining the quantitative changes of safety research results, and the relationship between safety research and safety regulatory activities, and their trends are as follows.

1) From the point of view of quantitative research results, the number of related academic papers has been increased as interests in nuclear energy have increased. From 2000, the rate of increase in the number of articles began to be the most significant.

2) From the viewpoint of the direction of safety research and safety regulation activities, most except for the mid-1990s and the early 2000s, the policy and evaluation technology research to solve the safety issues of the times and related safety regulation for the effective utilization of nuclear energy were carried out as if the action are taken only when a problem arises. We think that the preemptive and future-oriented nuclear safety regulation research and related safety regulation activities are insufficient. However, it was considered that the safety regulation activities showed a direction that is similar to the direction in which safety studies were conducted.

3) Based on these preconditions, we suggest the direction that future's nuclear safety regulation should be pursued by investigating how key element required for nuclear safety regulation are embedded in safety research results. The future nuclear safety regulations should focus on raising the social and psychological level of safety sympathized with the general public, based on the high level of engineering and technical expertise.

The results of this study are expected to contribute to development of nuclear power industry by suggesting safety research and safety regulatory direction necessary for enhancing public acceptance and reliability of nuclear energy in the future.

REFERENCES

1. C. H. Yoon, *A Safe Promise for a Bright Future - 20 Years History of KINS*. Daejeon: Korea Institute of Nuclear Safety, 2011, pp. 28–29. pp. 36-37. pp. 42-47. pp. 61-63. pp. 130-131. pp. 276-279.
2. J. G. Kim, *Statistics of Electric Power in Korea No. 87(2017).* Naju: Korea Electric Power Corporation, 2018, pp. 27.
3. Korea Education and Research Information Service (c1998-2016). Research Information Sharing Service (RISS). [Online]. Available: http://www.riss.kr/index.do.
4. M. Don, G. Felix, H. Kenneth, *Three Mile Accident of 1979 Knowledge Management Digest Overview (NUREG/KM-0001, Rev.1).* Washington: Office of Nuclear Regulatory Research-Unite State Nuclear Regulatory Commission, 2016, pp. 3. pp. 12.
5. International Nuclear Safety Advisory Group, *the Chernobyl Accident Updating of INSAG-1 (Safety Series No.75-INSAG-7).* Vienna: International Atomic Energy Agency (IAEA), 1992, pp. 84-88.
6. Nuclear Safety and Security Commission (2013, August), *Sixth National Report for the Convention on Nuclear Safety* [Online]. Available:http://www.kins.re.kr/en/img/global/pdf/National%20Report%20for%20the%206th%20CNS.pdf
7. Nuclear Safety and Security Commission, *Nuclear Safety and Security Commission 2011 Annual Report.* Seoul: NSSC, 2011, pp. 32-33.
8. Ministry of Trade, Industry and Energy (2017, October 24), *Press Release: Confirmation of Shin-Kori 5 & 6 Construction Reopening Policy and Energy Transition Roadmap* [Online]. Available: http://www.motie.go.kr/motie/ne/presse/press2/bbs/bbsView.do?bbs_seq_n=159746&bbs_cd_n=81
9. Ministry of Trade, Industry and Energy (2018, June 21*), Press Release: Follow-up and Supplementary Measures for Energy Transition (Nuclear Power Plant)* [Online]. Available: http://www.korea.kr/goNews/resources/attaches/2018.06/21/ff680e07cd560d6aae286ea88dbca71f.pdf
10. Green Energy Strategy Institute (GESI), *A survey on public perceptions of the government's low-carbon, eco-friendly energy transition policy (final report).* Ulsan: KEEI, 2018, pp. 5-6. pp. 14-15.
11. G. H. Min, *Nuclear industry monthly magazine-[Policy] the fifth Nuclear Promotion Comprehensive Plan (2017 - 2021).* Seoul: Korea Atomic Industrial Forum (KAIF), 2017, pp. 6-8. pp. 15-16.
12. Nuclear Safety and Security Commission (2018, October 10), *The 89th Nuclear Safety Commission-Report No.1 (Comprehensive measures (draft) for strengthening nuclear safety standards)* [Online]. Available: http://www.korea.kr/news/pressReleaseView.do?newsId=156297991
13. International Atomic Energy Agency, *IAEA safety glossary: Terminology Used in Nuclear Safety and Radiation Protection*. Vienna: IAEA, 2007, pp. 133.
14. Korea Institute of Nuclear Safety, *A Guide to Nuclear Safety Regulations*, Daejeon: KINS, 2007. pp. 12-14
15. H. J. Kim, *Nuclear Safety and Regulations*. Seoul: Hans house, 2012, pp. 294–295.

AUTHORS PROFILE

Jin-Sung Kim received B. D. in Mechanical Engineering from So-gang University, Seoul, Korea in 2001 and M.D. in Mechanical Engineering from Korea Advanced Institute of Science Technology (KAIST), Korea in 2003. He is working at KINS (Korea Institute of Nuclear Safety) for more than thirteen years with field experience on regulation of nuclear safety. Also, He is currently in Dept. Industrial & Management Engineering, Hanbat National University, Korea as Ph. D. Candidate.

Soo-Yong Park received his Ph.D in Industrial Engineering from Hanbat National University has been a professor at Hanbat National University since 2015. He is also a member of the Daejeon·Chungcheong CTO Forum Academy Director, Director of the Adult Education Society of Korea, and Director of the Industrial and System Engineering (KSIE). Key areas of interest are management innovation, leadership, positive organizational behavior, and organizational behavioral psychology.

Dong-Hyung Lee received Ph.D. in Industrial Engineering from Hanyang University and has been a professor at Hanbat National University since 1988. He has served as Chairman of the Society of korea Industrial and System Engineering (KSIE), Director of The Korean Federation of Science and Technology Societies (KOFST), etc. Currently, he is the Advisor of KSIE, Auditor of Korean Federation of Teachers' Associations (KFTA), the Evaluation Committee of Ministry of SMEs and Startups. Key areas of interest include facility management, industrial safety engineering, project management, and economic success.