A Study on Development of the Nuclear Regulatory Issue Indicator (NRII)

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1. Introduction

The main purpose of international cooperation in nuclear safety is to exchange and share regulatory information, practices, and experiences with foreign counterparts and to learn valuable lessons from others in order to address national and global regulatory challenges.

Given the importance of information sharing among member states, International Atomic Energy Agency (IAEA) developed and promoted the NNSKP (National Nuclear Safety Knowledge Platform) to improve effectiveness and efficiency of information sharing through an on-line platform system [1]. While the NNSKP can provide regulatory information of member states in a consistent and easily accessible manner, it has limitations that the NNSKP mainly focuses on general information on nuclear safety regulation, overlooking thus major nuclear regulatory issues and trends of each member states. In addition, the major nuclear regulatory issues and their direction of changes in each country and international organizations can vary by different opinions and perspectives depending on the various document reviewers.

To overcome this limitation and in order to identify meaningful patterns and trends, as well as to extract potential knowledge in large volume of text data in the field of nuclear safety regulation, this paper identified the nuclear regulatory issues and their changes through developing the Nuclear Regulatory Issue Indicator (NRII).

2. Data Gathering

The analysis target documents are the publications and major meeting results released from 2014 to 2016 by international organization such as IAEA, and Committee on Nuclear Regulatory Activities (CNRA) of OECD Nuclear Energy Agency (OECD/NEA), and foreign nuclear regulatory bodies in USA, UK, and France.

3. Methodology

3.1 Issue analysis with text mining

To quantify importance of and differences in nuclear regulatory issues, the text mining is used with R-software, which is an open source program with several steps.

First, we extracted the important words from keywords and abstract of IAEA publications in a nuclear safety field, including Safety Fundamentals, Safety Requirements, Nuclear safety series, TecDoc, etc.

Second, we clustered the extracted important words into six categories (Aging management, HOF and safety culture, severe accident management, emergency preparedness, public engagement, and decommissioning and spent fuel), which were referred from major common nuclear safety issues identified at the IAEA 7th Convention of Nuclear Safety review meeting [2]. The words that were not included in these six categories were excluded from the scope of this study. The Important Word Cluster (IWC) is shown in Fig. 1.

Ageing Management	Aging/Ageing, Corrosion, AMP, Degradation, Exhaust/Fatigue, Life Extension, LTO, SALTO, Obsolescence, knowledge management, IGALL, Service Life
HOF and Safety Culture	HOF, Safety Culture, Leadership & Management, Individual Factor, Human error, Decision Making Process, Behavior, Multicultural, Technical and organizational (ITO) factors, Systemic approach,
Severe Accident Management	Defense in depth, External event/natural hazard, Seismic /tsunami / earthquake, Black out, Severe Accident Management Program / SAMG, Safety margin, DBA, PSA, Mitigation, Core damage, Cooling and venting
Emergency Preparedness	Radiation/radiological protection, Environmental monitoring, Emergency preparedness and response EPZ, Accident Response, Emergency Management, Emergency Plan, Radiological Emergency Public exposure, Protective Actions
Public Engagement	Public engagement, Public acceptance/trust, Transparency/Openness, Public Communication/Consultation, Stakeholders, Social/media, Public acceptance/participation, Stakeholder/public involvement, Public interests/concerns
Decommissioning and Spent Fuel	Radioactive Waste Management, Decommissioning, Dismantling, Termination/ shutdown, Remediation Disposal facility, Spent fuel waste / Radioactive waste, Interim / Dry/ Wet storage, Geological Repository Transition period

Fig 1. Important Word Clusters

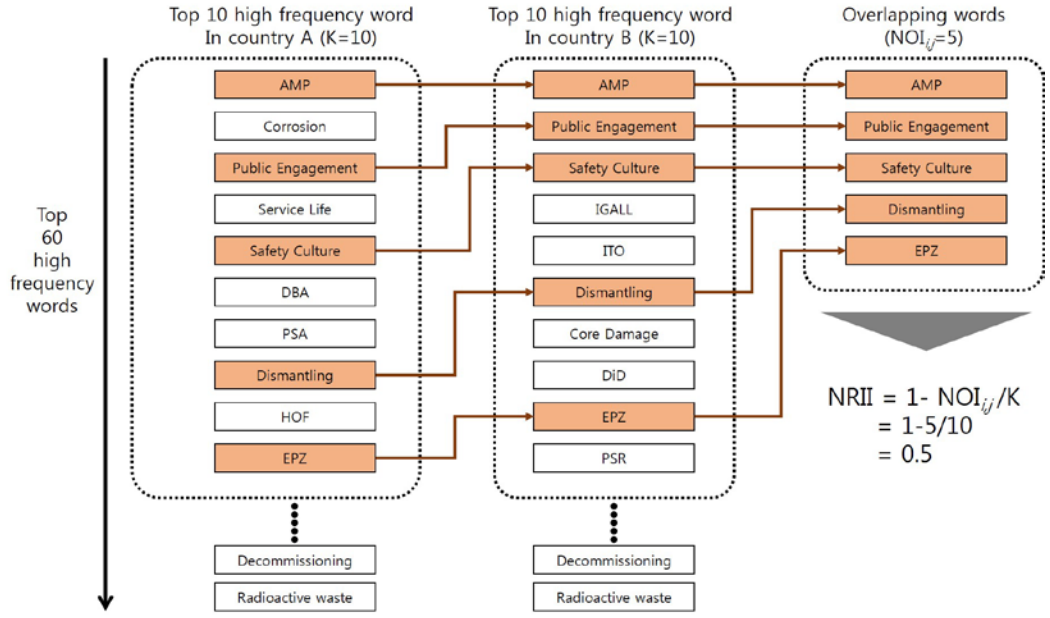

Fig. 2. Diagram for calculation of NRII

Third, Term Frequency (TF), i.e. a value representing how frequently a particular word appears in the documents, was calculated with the text mining package in R-software.

Fourth, Term Ratio (TR), which is calculated by dividing TF by the total number of words in the documents, was computed. This value that can evaluate how important a particular term is in the documents. TR is used to standardize TF, so it is useful for the analysis and comparison of documents of different volumes.

3.2 Development of indicator for issue analysis

To quantitatively show the nuclear regulatory issue trends and nuclear regulatory issue similarities between countries and international organizations, we proposed Nuclear Regulatory Issue Indicator (NRII) that is calculated as follows (see Eq. (1)):

$$\mathrm{NRII} = 1 - \frac{NOI_{i,j}}{K} \quad (1)$$

To calculate NRII, we first identified high frequent words in top K among all other words. $NOI_{i,j}$ is the number of overlapping words within K frequent words between countries (or between international organizations) i and j. NRII is also used in finding yearly change of nuclear regulatory issues from i year to j year. Fig. 2 gives an example of calculation of NRII. In this paper, K was set to 20.

The NRII value increases if nuclear regulatory issues are largely different between countries or between international organizations and also increases if nuclear regulatory issues are significantly changed from i year to j year. In other words, if the NRII value is close to 1, it means that major nuclear regulatory issues are largely changed. By contrast, the NRII value decreases and is close to 0, if nuclear regulatory issues are slightly changed. That is, countries or international organizations i and j, and year i and j mainly focus on very similar issues. Using NRII, we analyzed how nuclear regulatory issues have been changed, and how different they are between the countries and international organizations, and between the years 2014 to 2016 (see Section 4 for further detail).

4. Results

Fig. 3 shows the TR analysis of two international organizations and three countries and shows how the nuclear regulatory issues have been changed each year.

On the whole, nuclear regulatory issues covered by international organizations have been changed in line with the change of nuclear safety trends. For instance, there has been a decline in severe accident management covered by IAEA towards 2016. We can figure out that the IAEA and member states made much progress the follow-up measures related to Fukushima accidents by 2015. While OECD/NEA showed a similar tendency till 2015, their concerns were dramatically changed in 2016.

Meanwhile, major nuclear regulatory issues addressed by each country have not been considerably changed. USA steadily paid attention to the field of severe accidents and decommissioning and spent fuel.

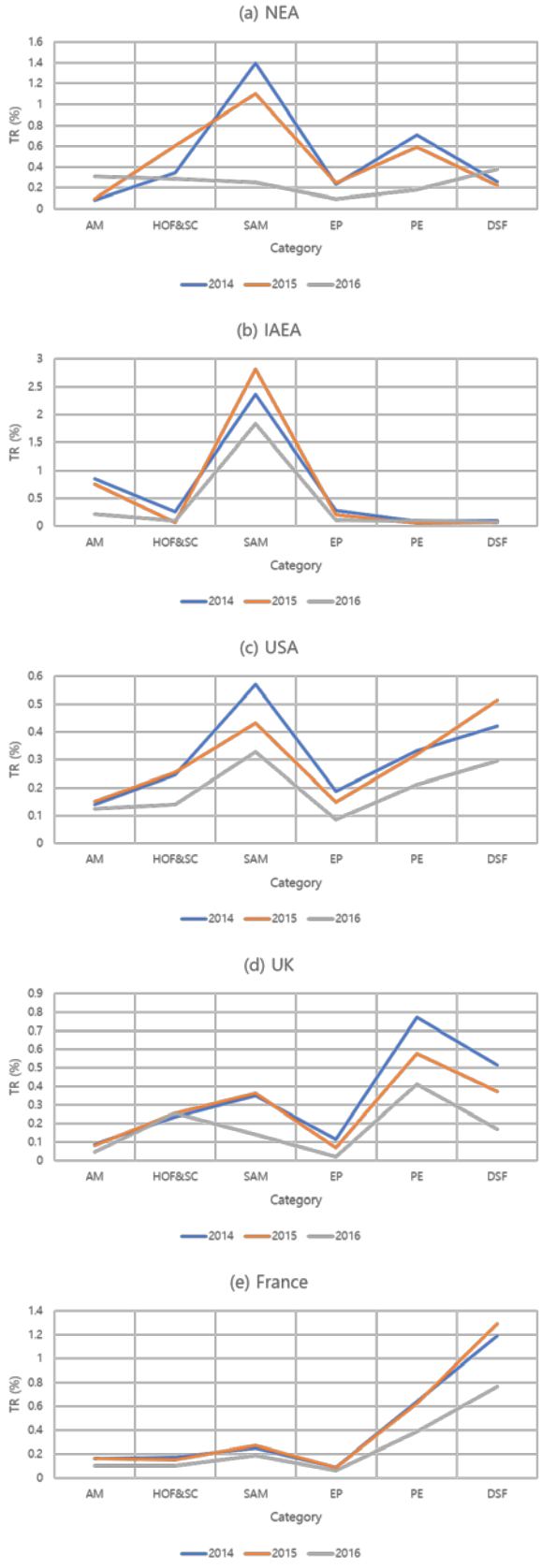

Fig. 3. TR analysis of two international organizations and three countries

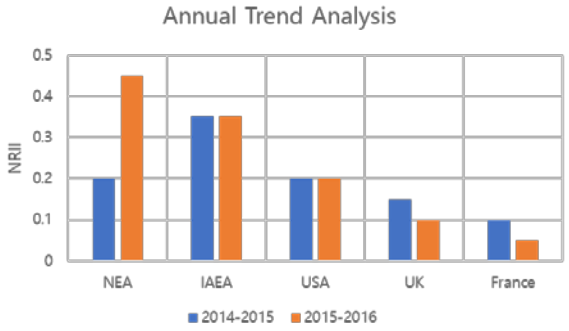

Fig. 4. Annual trend analysis with NRII

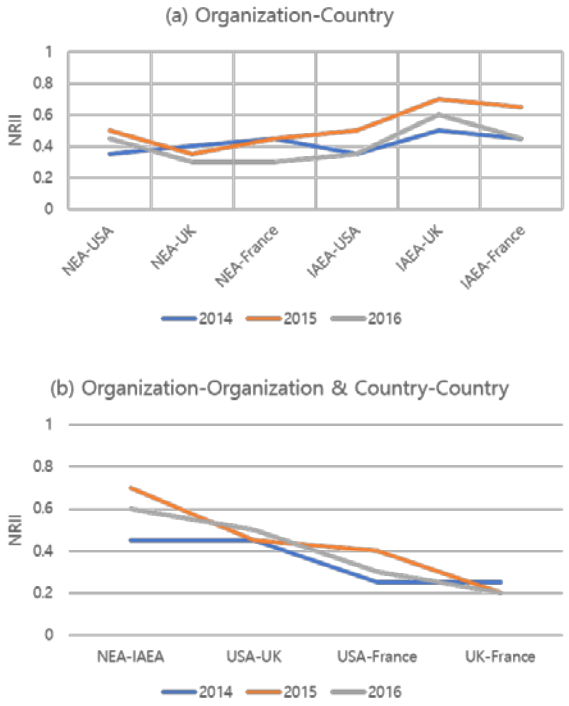

Fig. 5. NRII analysis between international organization and country.

France continued to address public acceptance and decommissioning and spent fuel as primary nuclear regulatory issues. In addition, we could identify that nuclear regulatory issues in the US have been most rapidly changed among the countries in this study, whereas regulatory issues were rarely changed in France, as compared to other countries. Furthermore, we could figure out which cooperation agendas have high-demand in each country and which countries are appropriate as foreign counterparts for each nuclear regulatory issue.

Fig. 4 describes the results that are very similar to those presented Fig.3. Nuclear regulatory issues in international organizations have comparatively changed much. The NRII values indicate that international organizations have shifted their focus from the Fukushima accident and the lessons learned from it to

the legacy of nuclear power plants: ageing, decommissioning, radioactive waste management, and etc. corresponding to the current and future regulatory challenges in member states. By contrast, annual trend analysis of each county showed that primary nuclear regulatory issues have been generally consistent over the past 3 years on the national level.

Fig.5 (a)-(b) shows the difference between countries and between international organizations. The difference between IAEA and OECD/NEA is large as compared to others. 50 percent of nuclear regulatory issues mainly addressed by IAEA and OECD/NEA were similar to each other. This trend is caused by the fact that the IAEA was supposed to deal with various challenges from all member states, while OECD/NEA focused on their members' major concerns. As USA, UK, and France are the actively participating members of OECD/NEA, similar patterns appeared in Fig. 5(b).

4. Conclusions

In this study, we analyzed the important words from the IAEA, OECD NEA and foreign nuclear regulatory bodies in USA, UK, and France to determine the main concerns, the trends that have appeared in their nuclear regulatory issues over the past 3 years, how they have changed, and how they are different between the nations and international organizations, and between the years 2014 to 2016.

The results of the present study are significant in that we apply the quantitative methodology to analyze international and foreign nuclear regulatory issues. Furthermore, our results can inform future regulatory demands and challenges by analyzing other advanced nuclear regulatory bodies to identify the direction of change in regulatory issues and trends. In addition, the results of NRII can provide objective standards to decide which country is the most suitable for which regulatory issue for targeted and strategic international cooperation.

For a more comprehensive analysis and practical results, it is necessary to perform the text mining and to apply the NRII to domestic regulatory issues covered by the Korean regulatory body and related organizations in the follow-up study.

REFERENCES

[1] IAEA Global Nuclear Safety and Security Network, National Nuclear Safety Knowledge Platform (NNSKP), www.gnssn.iaea.org

[2] 7th Convention on Nuclear Safety Review Meeting Summary Report, IAEA, pp. 6-8, 2017