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Development Proliferation Resistance Assessment Methodology for Regulation Purposes

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1. Introduction

The effects of global warming increased the concern to reduce green house gases while global energy consumption continuously increases. Since, it would be technically difficult to replace reliably the conventional base-load power stations with renewable energy, the use of nuclear power plants have increased as a share of total global energy used. More than 45 countries are considering embarking on nuclear power programs [1]. As a result, the worldôs nuclear power generating capacity is projected to continue to grow by 2030 [2]. The installed total nuclear capacity in 373 GWe in 2012 would reach 435 and 722 GWe by 2030 in low and high scenario predictions, respectively. In Korea, there are 23 nuclear power plants in operation. Thirteen more plants are either under construction or are being planned for completion by 2027. In addition, there are active researches is taking place into pyroprocessing technology for use in treating spent fuel and reducing storage [3, 4].

However, the increase in the number of nuclear facilities has also raised more security concerns. The fear is that a terrorist could release radioactive material during an attack at a facility. Weapon-grade nuclear material could also be produced at nuclear facilities. Under the Treaty on the Nonproliferation of Nuclear Weapons (NPT), the evaluation of a nuclear facilityôs proliferation resistance (PR) is an important parameter; however, no consensus has yet been made as to the best way to evaluate PR. There are two internationally accepted methodologies for PR evaluation. These the international project on innovative nuclear reactor and fuel cycle (INPRO) by the International Atomic Energy Agency (IAEA) and proliferation resistance and physical protection (PRPP) by the Generation IV International Forum (GIF). However, the two methodologies were developed for different users and purposes. Therefore, applying those methodologies to a PR assessment of South Koreaôs nuclear facilities would not be appropriate for regulation purposes. Therefore, the Korea Institute of Nuclear Nonproliferation and Control (KINAC) are currently developing a comprehensive methodology for PR&PP evaluation (COMPRE) from the point of view as a regulatory body [3].

In this paper, the development of the COMPRE methodology for PR and the computer tool used to implement will be presented.

2. PR Assessment Methodologies

Proliferation resistance is the characteristic of a nuclear system that attempts to prevent the diversion or undeclared production of nuclear material, or the misuse of technology to acquire nuclear weapons or other nuclear explosive devices.

2.1 IAEA INPRO

INPRO focuses on the possible contribution of a nuclear facility could make to a weapons program in a given state, as well as evaluating a nuclear system, in a state or region, throughout its full life cycle. The basic principle of the INPRO PR emphasizes the intrinsic and extrinsic features of a system. It highlights intrinsic features and extrinsic measures that should be implemented throughout the full life cycle in order to make the system unattractive as a means for a nuclear weapons program. The INPRO methodology provides a check-list to assess as to whether or not a system is unattractive a means to obtain a fissile material or to convert the facility into weapons. The check-list provides results qualitatively.

2.2 GIF PRPP

The PRPP methodology is an efficient measure of technical difficulty, proliferation time, proliferation cost, material type, detection probability, and detection resources. The methodology evaluates the response of a facility to a defined threat, based on a systemôs characteristics. The completed results can provide qualitative and quantitative results that can identify possible targets and potential pathways for a host state to divert targeted material. The diversion pathway results provide useful information to regulatory authorities. However, completing this methodology requires qualitative analysis of complex combinations. This is process that the INPRO methodology can provide.

3. KINAC COMPRE Methodologies

As a pyroprocessing greatly focuses on technical and material barriers in PR assessment, intrinsic features are strongly emphasized at the nuclear facility adoption stages. However, after the operation of a facility starts, extrinsic features of the system would become more important in PR. Since, the overall objective of PR is to utilize intrinsic and extrinsic features effectively in order to make a facility unattractive as a target for an attack or theft. The KINAC COMPRE methodology focuses on extrinsic features, such as stateœs commitments and obligations, and the implementation of safeguards. This method not only applies to next generation nuclear facilities but also to facilities currently being operated. Three measures are included in the COMPRE methodology: legal and institutional framework, safeguardability, and technical difficulties.

3.1 Legal & institutional framework

A stateœs legal and institutional framework regarding nuclear non-proliferation is an important factor in evaluating PR of a nuclear energy system. It is an extrinsic measure consisting of three categories: a stateœs commitment, obligations, and policies with regard to nuclear non-proliferation, domestic legal framework and competent authority.

The first category includes international treaties or agreements such as the NPT, the comprehensive IAEA safeguards agreements (CSA), and additional protocol (AP). The IAEA can conclude the CSA with states that ratify the NPT. In order for the IAEA to achieve its safeguards objectives, including the detection of undeclared nuclear materials and activities, a state should be apply the AP in force. The IAEA can draw a broad conclusion to a state if the agency can be assured that a stateœs nuclear activities are only used for peaceful purposes and the integrated safeguards (IS) approaches are applied. Therefore, what approaches a state has applied can be a useful measure for evaluating PR. The legal framework and competent authority are necessary in order to implement international agreements on nuclear non-proliferation. If a state has an independent legal system and competent authorities, with regarding nuclear to non-proliferation, it can be said that PR has been strengthened.

3.2 Material characteristics

The characteristics of the fissile materials such as isotopic composition, chemical form, radiation level, volume and weight and material detectability can provide barriers for misuse. It is one of the intrinsic features that can decide the degree of PR of a nuclear energy system. There are many ways to classify fissile materials, which are critical for evaluating PR, the lead time and the modifiability to convert the fissile materials into weapons grade material. In this study, material characteristics measure is divided into three attributes such as material quality, material quantity, and technical difficulty. Several steps may be required so as to obtain sufficient nuclear material that could produce a weapon depending on the material type and material category. The probability of early detection will increase if more steps are required. The effort and time for processing nuclear material will be higher if more nuclear material is diverted and processed in order to extract sufficient quantity required to produce a weapon. Facility attractiveness that can be evaluated by the extent to which facilities, equipment, and processes are resistant to the production of weapons grade materials is an important intrinsic feature.

3.3 Safeguardability

Safeguardability is one extrinsic measure which can be implemented. The IAEA defined it as ñthe degree of ease with a nuclear system can be effectively and efficiently put under international safeguardsò. Safeguardability is dependent on characteristics such as nuclear material, process implementation and facility design. There are several attributes that are necessary to evaluate the safeguardability of a nuclear energy system. These include design information (DI), material counting and accountancy (MC&A), verification, and containment and sealing (C&S). A national safeguards system can be established using these four ways. With regard to future nuclear energy systems, a more complicated safeguards system may be needed. This could result from problems associated with the verification of different types of nuclear materials and the installation new systems.

4. Computerization of COMPRE methodology

KINAC developed a computer tool to implement the COMPRE methodology. This computerization of PR evaluation would increase usability and decrease evaluation time. This tool can separately input intrinsic and extrinsic attributes, which can be grouped and assigned weighting factors for the group as shown in Fig. 1. Scores are assigned to questionnaires for each attribute so that a final quantitative evaluation is possible.

5. Conclusion

A COMPRE methodology for evaluating PR was developed. Measures for analyzing PR of a nuclear energy system were derived by collecting attributes that influence PR and then were categorized into groups. Three measures were then developed by a series of processes; legal and institutional framework, material characteristics, and safeguardability. Since, the extrinsic features are more practical to evaluate when a regulatory body evaluates a system. Therefore, the COMPRE methodology focuses more on extrinsic features and gives quantitative evaluation results. To verify the validity of the COMPRE methodology, a case study will be performed and then later compared with the INPRO and PRPP methodologies.

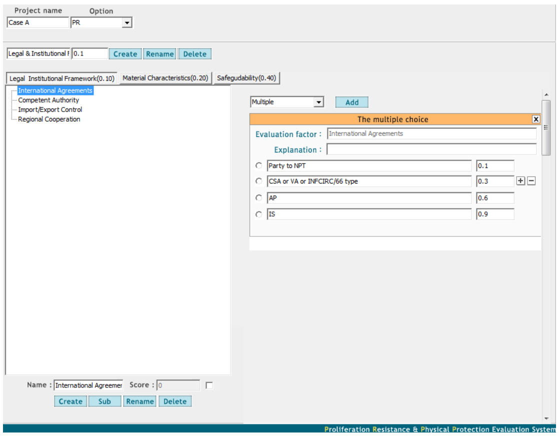

Fig. 1. Input configuration of questionnaires of attributes

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