Evaluation Indicators for Analysis of Nuclear Fuel Cycle Sustainability

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1. Introduction

For the sustainability of nuclear energy, recycling and volume reduction of spent fuel (SF) is required. And it is urgent to resolve the uncertainty of SF management policy in Korea. The back-end fuel cycle issues including radioactive waste and SF accompany social conflicts so that deliberate approach is needed. Therefore, the nuclear fuel cycle system which can minimize the social conflicts and guarantee the energy sustainability has to be selected. In this study, establishment of evaluation standards and indicators for nuclear fuel cycle analysis and selection were derived through literature survey and collecting opinions by questionnaire. The weighting of each indicator were also surveyed and classified [1].

2. Methods and Results

The sustainability development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [2]. For assurance of sustainability in nuclear energy, sustainable fuel supply and settlement of radioactive waste (high-level) disposal site issue have to be secured along with economics, safety, proliferation resistance.

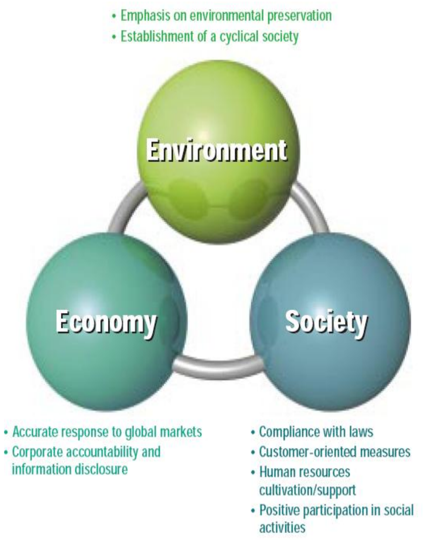

Fig. 1. Sustainable development: at the confluence of three constituent parts

2.1Literature Survey

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was launched in the year 2000, based on resolutions of the IAEA General Conference [3]. The mission of INPRO is to develop the methodology to assess innovative nuclear energy systems (INS) on a global, regional and national basis and to facilitate coordination and cooperation among Member States for planning of INS development and deployment. The INPRO method is structured in a hierarchical order. The highest level in the INPRO structure is a Basic Principle (BP) and the second level is called User Requirement (UR). The URs define the means of achieving the goal set out in the basic principle. Finally, a Criterion (CR) is required to enable the INPRO assessor to determine whether and how well a given user requirement is being met by a given INS. An INPRO criterion consists of an Indicator (IN) and an acceptance Limit (AL).

The evaluation criteria from GIF (Generation IV International Forum) which assess sustainability, safety and economics of Gen-IV nuclear system were also considered in this study. The ILK (Internationale Landerkommission Kerntechnik) has developed standards for evaluate nuclear energy sustainability. In the ILK report, the evaluation process should be transparent and the social effect has to be considered as well as economic and environmental effect [4].

In OECD/NEA research, it is said that the evaluation indicators should be measurable, quantifiable and logically independent. And the indicators should not be too detailed, so that the number of indicators can be manageable [5].

The Division of Nuclear Fuel Cycle and Waste Technology in IAEA Department of Nuclear Energy developed ISD-RW (Indicator of Sustainable Development – Radioactive Waste) for evaluating radioactive waste management system and sustainability. The ISD-RW is a dimensionless factor which is applied in form and disposal factor.

2.2 Questionnaire for Collecting Opinions

Indicator is that the measure of scale which explain attributes or situation of a certain idea. The indicator should be objective and specific.

Based on the literature survey the draft of the indicator has been settled. The importance and necessity of main standards has been examined by collecting opinion from questionnaire. The respondents are 20 nuclear-related people and 5 public (industry, university, research field). The order of priority and additional indicator are also surveyed.

2.3 Results

The order of priority in main criteria was technological and safety, environmental impact and economics and sociality have almost same preference. Technological and safety was integrated with environmental impact. And some of indicators are added, modified, integrated or deleted through collecting opinion by questionnaire.

Table I: Evaluation Indicators and Its Importance

Main Criteria	Requirement	Indicator	Importance
Environ mental impact	Safety of technology and facility	Probability of transportation accidents	main
		Probability of accidents in operation	main
	Technology and process efficiency	Recycling efficiency	main
		Processing efficiency	main
	Waste impact	Radioactive waste (hardly disassemblable) amount	main
		Greenhouse gas emission	main
		LILW amount	main
		MA amount	main
		Managed time period	main
	Radiation impact	Total toxicity	main
		Decay heat	main
		Operational exposure	main
		Public exposure	main
	Construction and operation of facility	Contamination of natural resources	main
		Total land occupation	secondary
Economi c	Investment scale	Unit cost	main
		Research installation/infrastructure cost	main
		Operational and maintenance cost	main
	Technical availability	Technical maturity	main
		R & D cost	main
		R & D period	main
		Utilization of domestic technologies	main
	Resource economics	Non-renewable resource consumption	secondary
		Additional resource consumption	secondary
Sociality	Proliferation resistance	Proliferation resistance	main
	Regional/Social acceptability	Acceptability	main
	Social impact	Economic effects	main
		Employment effects	secondary

The final evaluation indicators are shown in Table I. It is derived by literature survey and collection opinions by questionnaire. The importance of each indicator was classified into main and sub-standards.

3. Summary

The evaluation indicators for analysis of nuclear fuel cycle sustainability have been studied. The draft of requirement and indicator was derived through literature survey and it was amended for domestic situation. The questionnaire for asking and collecting opinions of evaluation indicators and its importance was performed. More objective and comprehensive assessment is needed for various back-end fuel cycle technologies in the future. And the weight of each indicator should be updated by expert opinion using methods such as AHP.

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