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Preliminary Analysis on the Management Options of IRT-DPRK Research Reactor

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1. Introduction

In Yongbyon nuclear complex, "IRT-DPRK", which is an IRT-2000 type nuclear research reactor, has been operated since 1965. Although IRT-DPRK was upgraded several times, operation lifetime was already exhausted [1] and thus management policy is needed to deal with the aging of IRT-DPRK. For example, IRT-2000 type nuclear reactors in Georgia and Bulgaria had been shut down to refurbish or decommissioned to establish new low power facilities [2,3]. However, the existing negotiations and agreements related to the nuclear issues on North Korea have been focused on the "denuclearization", and thus the issues on the IRT-DPRK were not handled [3].

In recent, a group of USA scientists has suggested that IRT-DPRK should be refurbished to establish the "Scientific cent for excellence" like the Cooperative Threat Reduction program applied in Russia and the former Soviet Union (FSU) [4]. In this paper, we examined the several options to manage the IRT-DPRK through the study of similar foreign cases.

2. Analysis

2.1 Characteristics of the IRT-2000 type reactor

The Soviet-designed/supplied IRT-2000 is a pool type reactor which is cooled and moderated by light water; the light water is also used as a reflector and biological shielding of the reactor. The reflector is composed of graphite blocks. The primary cooling system consists of circular pumps, special ejection pipe, heat exchangers, ion exchange columns and mechanical filters. And the secondary cooling system is open air sprinkling in pool.

IRT reactor have several vertical experimental channels for irradiation of samples in the vicinity and within of the core, and also have horizontal experimental channels of various diameters (100-150 mm) which border the core and serve for outlet neutron beams to the experimental installations. The maximum flux of thermal neutrons is several 10^{13}-10^{14} n/cm^2-sec at the center of the core, 10^{12}-10^{13} n/cm^2-sec at the water reflector of the core, and 10^8-10^{10} n/cm^2-sec at the outlet of the horizontal channels [3].

The reactor pool is an aluminum (or stainless steel) alloy tank (6 mm thick) surrounded by reinforced concrete biological shielding (1.8m thick). The pool (size: 4.5m(L) X 1.9m(W) X 7.6m(H), volume: about 60 m^3) is filled with distilled water up to the height of 7.2m. The reactor core (size: 0.5m(L) X 0.4m(W) X 0.5m(H)) is located at the bottom of the pool under the water layer of 6m. The core can be loaded with up to 48 fuels and graphite control rod assemblies. The fuel assembly consists of 15 or 16 cylindrical fuel elements (size: 0.01m(D), 0.5m(L)) [2].

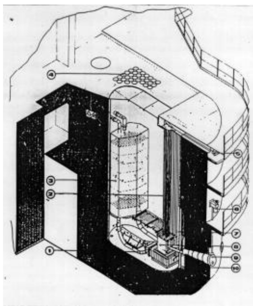

Fig. 1. View of the Georgian IRT-M reactor [2]

2.2 Characteristics and Status IRT-DPRK

IRT-DPRK was constructed in March, 1963 with the supports of FSU and went critical in August, 1965. It was initially the 2 MW using 10% LEU fuel. The reactor was subsequently upgraded three times in 1974, 1984, and 1987. In current, IRT-DPRK became the 8 MW reactor using 36% HEU fuel. It is known that, IRT-DPRK only has been operated intermittently (70 MWD per year) since 1992, because Russia had stopped the fuel supply. However, North Korea could afford to manufacture the enriched fuel after 2010. The use of IRT-DPRK is in variety, such as radioisotope production (medical, industrial, agricultural), education & training, material science investigations, and so on [1].

2.3 Operation history & status of the IRT-2000 type reactor

In the late 1960s and the early 1970s, IRT-2000 type reactors have been reconstructed twice to increase the power level (2 MW → 4 MW → 8 MW), to convert the fuel enrichment (10% LEU → 80% HEU → 36% HEU) and to replace the corrosive materials (ex. Aluminum) into the corrosion protective materials (ex. Stainless steel) [2].

IRT-2000 type reactors were built in Moscow, Tomsk, Sverdlovsk (Russia), Minsk (Belarus), Riga (Latvia), Tbilisi (Georgia), Sofia (Bulgaria), and Yongbyon (North Korea). Except for the DPRK and Russia, most Countries have decided to refurbish their reactors (ex. Bulgarian case) or to dismantle their reactors for establishment of new facilities (ex. Georgian case) or for completion of decommission [5].

Table I: Status of the IRT-2000 type reactors

Country	Location	Facility Name	Type	First Critiaclity	Thermal Power (kW)	Status
Dem. P.R. of Korea	Yongbyon	IRT-DPRK	POOL, IRT	1965	8000	OPERATIONAL
Georgia	Tbilisi	IRT-M Tbilisi	POOL, IRT	1959	8000	DECOMMISSIONED
Russian Federation	Moscow	IRT	POOL, IRT	1961	2500	OPERATIONAL
Russian Federation	Sverdlovsk	IRT	POOL, IRT	1967	2500	OPERATIONAL
Russian Federation	Tomsk	IRT-T	POOL, IRT	1967	6000	OPERATIONAL
Bulgaria	Sofia	IRT-SOFIA	POOL, IRT	1961	2000	SHUT DOWN
Latvia	Riga	IRT	POOL, IRT	1961	5000	SHUT DOWN
Belarus	Minsk	IRT-M MINSK	POOL, IRT	1962	5000	DECOMMISSIONED
Iraq		IRT-5000	POOL, IRT	1967	5000	SHUT DOWN
Libya		IRT-1	POOL, IRT	1981	10000	TEMPORARY SHUTDOWN

2.4 Options of the Management of the IRT-DPRK

The options and the details are shown in Table II. The estimation is based on the foreign related cases. Many countries had been suffered from the limitations in the availability of the necessary resources [5].

Table II: Options and details of the IRT-DPRK reactors [4]

Option	Detail description	Period	Cost	Related Case
Decommissioning	Complete Decommissioning	5 yrs	EUR 17-20 million	Latvia
	Partial Decommissioning	2 yrs	??	Georgia, Bulgaria
Refurbishment	Conversion to LEU fuel	2-3 yrs	$ 1.5-2 million	Libya, Russia, U.S., Uzbekistan, Vietnam
	Spent Nuclear Fuel Return	2-3 yrs	$ 6-10 million	Czech, Hungary, Russia, U.S., Uzbekistan
	I&C Upgrade	2-3 yrs	$ 1.5-2 million	Libya, Russia, U.S.Uzbekistan
	Other refurbishment	2-3 yrs	$1-4 million	
Enhancing Utilization and Scientific Applications	Isotope Production	1-4 yrs	$ 2-5 million	ROK, China
	Education & Training	1-4 yrs	$100,000	ROK
	Neutron Activation Analysis	1-4 yrs	$300,000	ROK
	Silicon Transmutatioin Doping	1-4 yrs	$250,000	ROK, China
	Neutron Radiography	1-4 yrs	$100,000	ROK
	Netruon Scattering	1-4 yrs	$500000~	ROK, China

3. Conclusions

The existing negotiations and agreements related to the nuclear issues on North Korea have been focused on the "denuclearization". Since IRT-DPRK cannot produce a significant quantity of plutonium, IRT-DPRK was not frozen or shut down by the Agreed Framework and several agreements of Six-party talks. However, IRT-DPRK should not be operated by the existing way anymore.

Above all, IRT-DPRK uses about 10 kg of 36% HEU. The fact that HEU is “direct use” material can provide an excuse to North Korea’s enrichment program, similar to the Teheran Research reactor case. Management of IRT-DPRK might be less sensitive and soft issues than the other agenda such as disabling the 5 MWe reactor, reprocessing plant, and so on. And in respect to the required time, cost, technique, it is the good incentives for North Korea.

Due to the lack of the detailed and standardized information, it is impossible to suggest the best option at this moment. In order to do that, the further research on the detailed procedures, radioactive wastes, the standards of safety and security are needed.

REFERENCES

[1] Jared S.Dreicer, How much Plutonium Could Have been Produced in the DPRK IRT Reactor?, Science & Global Security, 2000, Volume 8, pp.273–286, 2000.
[2] Sh.P.ABRAMIDZE et al., DECOMMISSIONING OF THE NUCLEAR RESEARCH REACTOR IRT-M AND PROBLEMS CONNECTED WITH RADIOACTIVE WASTE, IAEA-CN-17/58, 2000.
[3] K.KREZHOV, THE RESEARCH REACTOR IRT-SOFIA:50 YEARS AFTER FIRST CRITICALITY,2012.
[4] Ira N. Goldman and Pablo Adelfang, Possible Cooperative Projects for Utilization of the DPRK’s IRT-2000 Research Reactor, US-ROK Workshop on DPRK Nuclear Scientist Redirection, Seoul, South Korea, October 20, 2008.
[5] IAEA Research Reactor Database Website (as of March 2015).
[6] IAEA Technical Reports Series no.463, Decommissioning of Research Reactors and other Small Facilities by making Optimal Use of Available Resources, 2008.