Analyzing the North Korean Nuclear Programs: Technical Approaches

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The second round of six-party talks held in Beijing, China on February 25-28 saw certain agreements on major principles, such as the non-nuclearization of the Korean Peninsula, but failed to make any progress on the most urgent issues such as North Korea's controversial highly enriched uranium (HEU) program, and on details such as freezing and dismantlement of North Korean nuclear programs, both those based on the plutonium program and on the HEU program, and the compensation that would follow. The result of the talks is that the six nations agreed to hold more senior-level talks before July and to form a lower-level working group to handle details, but without any breakthrough in the North Korean nuclear issues.

Background

Tensions on the Korean peninsula increased due to the North Korean plutonium program, and the prospect of war hung over the peninsula in June of 1994. Fortunately, following three high-level negotiations between the US and North Korea, the two countries concluded the 1994 U.S.-North Korea Agreed Framework (so-called Agreed Framework) to produce an overall settlement of the nuclear issues on the Korean peninsula on October 21, 1994 and calmed the crisis on the Korean peninsula.[1]

Until December 2002, the Agreed Framework had frozen the North Korean plutonium program in return for the supply of two LWRs and 500,000 tons of Heavy Fuel Oil (HFO) annually to North Korea.

However, North Korea lifted the freeze on its plutonium-based nuclear program and expelled the International Atomic Energy Agency (IAEA) inspectors in December 2002 because the US halted its shipment of HFO in November 2002, accusing North Korea of having a secret HEU program in violation of the Agreed Framework. The second North Korean nuclear crisis has begun then.

Since then, the situation on the Korean peninsula has continued to deteriorate. According to Dr. Sig. Hecker's findings at Yongbyon on January 8, the 5 MWe reactor has been restarted and the spent fuel pond, in which about 8,000 spent fuel rods had been stored, was empty. North Korea claimed to have processed all 8,000 spent fuel rods to extract plutonium during one continuous campaign between mid-January and end of June of 2003. North Korea showed Dr. Hecker what was claimed to be a sample of plutonium metal product produced during that campaign.

There were a couple of attempts to solve the North Korean nuclear crisis peacefully among the interested nations: the three-party talks in April 2003, and the first six-party talks in August 2003. However, they just resulted in confirming each side's arguments between the US and North Korea.

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[1] David Albright and Kevin O'Neill, Editors, *Solving the North Korean Nuclear Puzzle* (Washington, DC: Institute for Science and International Security Press, 2000), p.26.

The US has persistently demanded complete, verifiable and irreversible dismantlement (CVID) of the North Korean nuclear programs, both plutonium and HEU based. The United States did not back down from making this demand throughout the second round of six-party talks on the North Korean nuclear program that were held in Beijing, China February 25-28. North Korea has denied its HEU program and strongly refused the US demand of CVID.

Even though the U.S. welcomed the results of the second six-party talks, North Korea regarded the talks as having 'no positive result.' The results of the talks were that the six nations agreed to hold more senior-level talks before July and form a lower-level working group to handle details, but without any breakthrough in the North Korean nuclear issues.

The North Korean Plutonium Program

Before 1994 the US-North Korea Agreed Framework, North Korea might have removed a sufficient amount of spent fuel from the 5MWe reactor in 1989 while it was shut down for about 70 days.[2] The estimate on the North Korea's produced plutonium before the 1994 Agreed Framework largely depends on how much amount of spent fuel North Korea unloaded from the 5MWe reactor in 1989.

David Albright of the Institute for Science and International Security (ISIS) estimated that North Korea might have removed a sufficient amount of spent fuel from the 5MWe reactor in 1989 containing up to 6.3-8.5kg of plutonium. David Albright concluded that North Korea might have produced up to 6.9-10.7kg of plutonium, contained in the spent fuels from the 5MWe reactor and spent fuels from the IRT-2000 research reactor that could have produced up to approximately 2-4kg of plutonium.[3]

On the other hand, the South Korean, Japanese, and Russian intelligence reported the North Korea's produced up to approximately 7-24kg of plutonium before the Agreed Framework.[4]

When the 5MWe reactor was shut down in April 1994, it contained approximately 8,000 spent fuel rods, which were estimated containing up to approximately 25-30kg of plutonium.[5] The 8,000 spent fuel rods had been stored in special canisters at a facility at Yongbyon under the IAEA monitoring until the late December 2002 when North Korea broke seals and disabled cameras that had been installed by the IAEA and expelled the IAEA inspectors from out of the country.[6]

On January 8, 2004 Dr. Siegfried Hecker, who visited Yongbyon as a member of five unofficial American delegations, confirmed that the spent fuel pond and the 8,000 spent fuel rods had been moved. And Dr. Hecker heard North Korea's claim that it had reprocessed all 8,000 spent fuel rods to extract plutonium during one continuous campaign between mid-January 2003 and end of June 2003 and was shown two glass jars North Korea said contained 150grams of plutonium oxalate power and 200 grams of plutonium metal, respectively.[7]

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[2] David Albright and Kevin O'Neill, footnote 1, p.115.
[3] David Albright and Kevin O'Neill, footnote 1, pp. 120-124.
[4] http://globalsecurity.org/wmd/world/dprk/nuke-plutonium.htm.
[5] David Albright and Kevin O'Neill, footnote 1, p. 118.
[6] http://www.nti.org/e_research/profiles/NK.
[7] Siegfried S. Hecker, Committee on Foreign Relations Hearing on "Visit to the Yongbyon Nuclear Scientific Research Center in North Korea," Los Alamos National Laboratory, LA-UR-04-0340, January 21, 2004 (http://www.nautilus.org/DPRKBriefingBook/nuclearweapons/HeckerTestimony040121.pdf)

North Korea already announced that it had finished reprocessing of its spent fuels on October 2, 2003. But, the United States has argued that it has no evidence on the North Korea's reprocessing at that time.[8] Whether or not North Korea had finished reprocessing of its 8,000 spent fuels in 2003 is still uncertain. Time allows, however, North Korea to have chances to separate more plutonium.

North Korea has been operating its 5MWe reactor loaded with another 8,000 fuel rods since early 2003, as described in the Dr. Hecker's report.[9] The 5MWe reactor could produce up to 5.9-6.7kg of plutonium per year in its 8,000 fuel rods, given the range of estimates of a capacity factor of 70 and 80 percent with an assumption of a specific power of 0.5 MWth per tonne heavy metal. This is based on Fig. 1[10] CIA estimated that restarting the 5MWe reactor would generate about 6kg of plutonium per year in November 2002.[11]

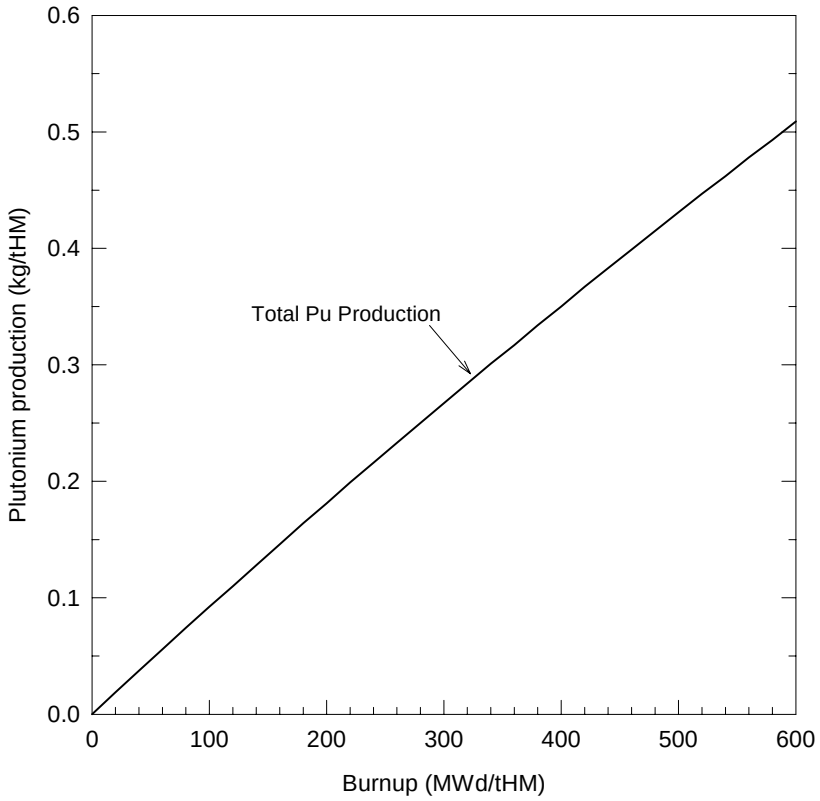

Fig. 1 Plutonium production as a function of burnup in a 5 MWe graphite reactor

The 50MWe reactor of Yongbyon and 200MWe reactor of Taechon could produce roughly more than 50kg and 200kg, respectively, of plutonium per year if their constructions are finished, with an assumption of a capacity factor of higher than 80 percent.[12] CIA estimated that the 50MWe reactor

[8] "North Korea says fuel rods processed for nuclear bombs" (http://www.pbs.org/newshour/updates/northkorea_10-02-03.html); "Nuclear chronologies of North Korea" (Korean) (http://www3.yonhapnews.co.kr/cgi-bin/naver/getnews?092003122704300+20031227+1916)
[9] Siegfried S. Hecker, footnote 7.
[10] Calculations by Jungmin KANG, using HELIOS code that is used to calculate the transmutation rates of actinides and fission products in nuclear reactors, in April 2004.
[11] http://www.fas.org/nuke/guide/dprk/nuke/cia111902.html.
[12] Jungmin KANG, footnote 10.

and the 200MWe reactor would generate about 275kg of plutonium per year in November 2002.[13] However, the construction of the 50MWe reactor would take much more than one year, as Dr. Hecker confirmed.[14] It is the same situation for the construction of the 200MWe reactor.[15]

North Korea stated that the capacity of its reprocessing facility is 375kg heavy metal of spent fuel per day, as described in the Dr. Hecker's report.[16] It is exactly consistent with an estimate described in the ISIS report.[17] This means that North Korea could reprocess the 8,000 spent fuel rods weighted approximately 50t in less than 134 days under normal operating condition. The maximum capacity of the reprocessing facility could be roughly doubled if the 2nd reprocessing line of the facility is constructed. The 2nd reprocessing line was a nearly completed in March 1994.[18]

However, the practical capacity of the reprocessing facility would be much lower than the normal capacity because the facility has been frozen for a decade, even though its maintenance has been kept.

The North Korean HEU Program

On 16 October 2002, the United States announced that North Korea acknowledged its secret highly enriched uranium (HEU) program when US Assistant Secretary of State James Kelly visited Pyongyang. The United States claimed this program was a serious violation of North Korea's commitments under the Agreed Framework, the NPT, its IAEA safeguards and the Joint North-South Declaration on the Denuclearization on the Korean peninsula.[19] This led to the second North Korean nuclear crisis. North Korea has been denying its HEU program, acknowledging only a program to extract weapons-grade plutonium from its nuclear plant in Yongbyon, since then.

About existence of evidences related with North Korea's HEU program, it is said that Kelly simply told the North Korean officials that the United States knew North Korea was violating the Agreed Framework by covertly enriching uranium without any evidences during talks in Pyongyang on October 3-5.[20] And the US does not open its evidences on the North Korea's HEU program yet.

The HEU production capability of North Korea depends on how many centrifuges North Korea has. A modern centrifuge is roughly assumed to have uranium separation capability of about five separate work units (SWU). Then, the centrifuge could produce up to about 30g of weapon-grade (WG) HEU per year with an assumption of uranium tail assay 0.4-0.5%.[21] Since 34 centrifuges are needed to produce approximately 1kg of WG HEU per year, more than 500 centrifuges are needed to produce 15 kg of WG HEU, which is regarded as an amount of a uranium weapon, annually.

North Korea might not have high technology to make modern centrifuges or better ones by itself in a near future, considering its low level of industrial technology. The typical rotor of the current

[13] http://www.fas.org/nuke/guide/dprk/nuke/cia111902.html.
[14] Siegfried S. Hecker, footnote 7.
[15] Thomas Cochran and Matthew McKinzie, "Research on North Korea using Commercial Satellite Imagery," presented at *2004 PSNSS Topical Seminar: Northeast Asia Security and Stability*, Beijing, China, January 12-14, 2004.
[16] Siegfried S. Hecker, footnote 7.
[17] David Albright and Kevin O'Neill, footnote 1, p.123.
[18] Ibid.
[19] Press Statement, Richard Boucher, Spokesman, "North Korean Nuclear Program," U.S. Department of State, October 16, 2002.
[20] Private communication with Henry Sokolski of Nonproliferation Policy Education Center on January 14, 2003.
[21] Calculation by Jungmin KANG.

centrifuge is spun rapidly at 50,000 – 70,000 rpm.[22] There might be a possibility for North Korea to fabricate much slower speed centrifuges with weaker material. However, North Korea needs eight times more centrifuges or longer time in order to get the desired quantity of HEU than the current centrifuges. And running slower of centrifuges could bring out of problems such as balancing problem.[23] The DPRK appears need to smuggle quite a large number of high performed centrifuges from abroad to produce a significant amount of HEU.

The following statement of John Bolton, Under Secretary of the US DOS, might implicit the current status of HEU production capability of North Korea.

"What we have said publicly and in consultation is not that the North Koreans have nuclear weapons produced through the uranium enrichment program, but that the North Koreans are seeking a production scope capability to produce weapons-grade uranium."[24]

Even though there is still controversial on the North Korea's HEU program, there is also a serious suspicion about Pakistan's alleged shipments of centrifuge technology to North Korea in 1990s.[25] Therefore, the existence of the North Korean HEU program needs through verification on it.

Priority of Concerns

Besides up to about 11kg of plutonium that North Korea might produce before 1994, North Korea could separate 25-30 kg of plutonium from the 8,000 spent fuel rods sooner or later or already has separated, as it claimed.

The restarted 5MWe reactor at Yongbyon could produce up to 5.9-6.7kg of plutonium per year in its newly reloaded 8,000 fuel rods. Accumulation of plutonium in the fuel rods increases with time.

Considering the low industrial technology of North Korea and required large number of centrifuges and time-consuming job in enriching uranium, it might be hard for North Korea to produce significant amounts of HEU in the near future.

Therefore, we need to pay for more attention to stop urgently the progress of the North Korean plutonium program rather than the HEU program.

Suggestions

If the US sticks the CVID policy on the North Korean nuclear programs, especially HEU based, the North Korean nuclear crisis might be continued and future six-party talks might be dragged on without breakthrough. This allows North Korea to have time to produce and separate more plutonium and might let North Korea go into a nuclear club. Therefore, serious negotiations between the US and North Korea are urgently required for peaceful resolution of the current North Korean nuclear impasse.

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[22] *Uranium Enrichment*, Nuclear Issues Briefing Paper 33, Uranium Information Center, June 2003 (http://www.uic.com/au/nip33.htm)

[23] Private communications with Trevor Edwards of IAEA in March 2004.

[24] Fred McGoldrick, "The North Korea Uranium Enrichment Program: A Freeze and Beyond," *Verifying North Korean Nuclear Disarmament: A Technical Analysis*, A Joint Publication of the Carnegie Endowment for International Peace and the Nautilus Institute for Security and Sustainability, June 2003.

[25] "Pakistan Says Khan Takes Full Responsibility for Nuclear Transfers," Global Security Newswire, February 4, 2004 (http://www.nti.org/d_newswire/issues/2004/2/4/b1247743-9751-4d74-82c5-89d569451959.html).

On the assumption that the US and North Korea reach agreement in removing the North Korean nuclear program by whatever negotiations as soon as possible, followings are suggested for resolving the current North Korean nuclear conundrum peacefully.

First of all, North Korea should immediately refreeze its restarted plutonium program and accept the return of the IAEA inspectors or a specially organized inspection group for its purpose.

Secondly, North Korea should be cooperative in the verification process of its plutonium program as well as of its HEU program if it has, with inspections performed by the IAEA or other special inspection groups.

Thirdly, after verification completed, North Korea should be cooperative in the process of dismantlement of its nuclear facilities relevant to its plutonium program as well as of its HEU program if it has.