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Setting the Record Straight about Plutonium Production in North Korea

Recommended Citation

David Albright and Holly Higgins, "Setting the Record Straight about Plutonium Production in North Korea", Briefing Books DPRK, December 31, 2000, https://nautilus.org/briefing-books/dprk/settin--the-record-straight-about-plutonium-production-in-north-korea/

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Institute for Science and International Security, 2000

In debating the merits of the Agreed Framework, critics have repeatedly charged that the provision of the two light-water reactors (LWRs) to North Korea will actually enhance North Korea's ability to make nuclear weapons, compared to its pre-Agreed Framework nuclear capability. A typical version of this criticism was distributed on April 11, 2000 by the House Policy Committee, chaired by Representative Christopher Cox (R-CA), that stated that "the plutonium produced by the new light-water reactors U.S. taxpayers are financing can be reprocessed to arm 65 bombs a year-more than five times as many" that could have been produced from facilities North Korea was building on its own.

This appendix discusses the fallacies in these types of statements. It is correct that LWRs produce these quantities of plutonium. But these types of statements ignore the plutonium that would have been produced in the third, and largest, gas-graphite reactor that North Korea was building. They also ignore or downplay the difficulty of chemically separating the plutonium from the spent LWR fuel compared to spent gas-graphite reactor fuel.

Plutonium Production and Separation

- If the LWRs slated to be built in North Korea are operated to optimize power production, they will discharge about 500 kilograms of reactor-grade plutonium a year in highly radioactive spent fuel.3 However, this plutonium cannot be used in nuclear weapons until it is separated from this radioactive fuel. Typically, such separation occurs inside heavily shielded chemical reprocessing plants. North Korea's existing reprocessing plant, which is shut down and under on-site IAEA monitoring under the Agreed Framework-mandated freeze, would require extensive modification to separate the plutonium from LWR spent fuel. The plant was built to dissolve metallic uranium spent fuel with a relatively low burnup. The plant would need to handle high burnup uranium oxide fuel. Alternatively, North Korea could build another reprocessing plant in secret, though such a step would violate the Agreed Framework, be difficult to accomplish, and be hard to hide, given that the resulting plant would be relatively large if it were to separate 500 kilograms of plutonium per year.

- Just prior to the signing of the Agreed Framework, North Korea was producing weapon-grade plutonium in gas-graphite reactors and was able to separate this plutonium. In 1994 North Korea was operating a reprocessing plant capable of extracting about 60-70 kilograms per year of weapon-grade plutonium from spent gas-graphite fuel. North Korea was also finishing a second reprocessing "line" that would have doubled the throughput of this plant. It could have further expanded this plant, or built another one, to reprocess the rest of the gas-graphite spent fuel expected from the large gas-graphite reactor at Taechon. Although this experience is important in developing the capability to reprocess LWR spent fuel, it is by no means sufficient. Many advanced industrialized countries, such as Britain and France, experienced many difficulties in making the jump to facilities that could reprocess irradiated fuel from LWRs, even after they had accumulated years of experience reprocessing irradiated fuel from gas-graphite reactors like those built by North Korea.
- Separated reactor-grade plutonium can be used to make nuclear explosives, and typically eight kilograms are enough to make a crude nuclear explosive. Using this amount, and ignoring the asymmetry in North Korea's ability to separate gas-graphite and LWR spent fuel, the two LWRs could produce enough plutonium for about 60-65 weapons per year, close to the estimate cited in the House Policy Committee publication. However, weapon designers prefer weapon-grade plutonium to make nuclear explosives. The two reactors at Yongbyon, and the third larger reactor at Taechon, were designed to make weapon-grade plutonium. If all three reactors were producing weapon-grade plutonium, and they would have likely all been capable of doing so by about 2000, then they would have been producing 280 kilograms of weapon-grade plutonium per year, assuming a capacity factor of 85 percent.4 A lower capacity factor of about 60 percent in the larger two reactors would result in the production of about 210 kilograms of weapon-grade plutonium per year in all three reactors. Because less weapon-grade plutonium is needed per nuclear weapon, each weapon is assumed to contain 5 kilograms of weapon-grade plutonium. These quantities of weapon-grade plutonium are enough to make about 40-55 nuclear weapons a year.
- The two LWRs can clearly make more raw plutonium per year, but a more legitimate comparison is between roughly enough raw plutonium for 60-65 weapons per year in the case of the LWRs versus about 40-55 weapons per year in the case of the three gas-graphite reactors. Moreover, by 2007, when the first LWR is expected to start, the gas-graphite reactors would have produced between 1,700-2,400 kilograms of weapon-grade plutonium, or enough for about 350-500 nuclear weapons. By this time, North Korea could have had one of the largest stocks of weapon-grade plutonium and nuclear weapons outside of the United States and Russia. North Korea's projected stock would be significantly larger than India's or Israel's present or projected stocks of weapon-grade plutonium. By the end of 2010, when North Korea is expected to start discharging spent LWR fuel containing 500 kilograms of plutonium per year, the three gas-graphite reactors would have produced 2,600-3,500 kilograms of weapon-grade plutonium, or enough for 500-700 nuclear weapons.
- If the Taechon reactor would have been optimized to produce electricity, thus producing reactor-grade plutonium instead of weapon-grade plutonium, this reactor would have still produced a large quantity of plutonium, sufficient for an enormous number of nuclear weapons. If optimized for electricity production, the Taechon reactor would have produced about 100-150 kilograms of reactor-grade plutonium a year, assuming a capacity factor of 60 to 85 percent. The three gas-graphite reactors, two of which would have produced weapon-grade plutonium as above, would have produced in total enough plutonium for about 20 to 30 nuclear weapons per year. In this case, by 2007 North Korea would have produced about 1,260-1,800 kilograms of plutonium, enough for about 190-270 nuclear weapons. By the end of 2010, North Korea would have produced about 1,850-2,650 kilograms of plutonium, or enough for about 300-400 nuclear weapons.

- One way to reduce the amount of plutonium produced in the LWRs is to use a "high burnup" fueling strategy, which is increasingly used in LWRs worldwide. Insisting that North Korea irradiate its fuel to higher burnups would reduce the total quantity of plutonium discharged from the reactors each year and lead to even poorer quality plutonium that is harder to extract and use in the production of nuclear explosives or weapons.

Clandestine Plutonium Production

- Under Article XIII "Assurances" in the supply agreement under the Agreed Framework, North Korea agreed that the LWRs are exclusively for peaceful, non-explosive purposes. The agreement also states: "The DPRK shall at no time reprocess or increase the enrichment level of any nuclear material transferred pursuant to the Agreement, as well as any nuclear material used therein or produced through the use of such items, for the useful life of such reactors and nuclear material."
- North Korea does not have a suitable plant to separate plutonium produced in LWRs. Moreover, the construction of such a plant would violate the Agreed Framework. Building one large enough to separate the annual plutonium discharges from the LWRs would be difficult to build and easy to detect. North Korea could build a small, clandestine plant to reprocess LWR fuel, but again the diversion of a significant quantity of irradiated fuel from the LWRs would be straightforward to detect. If diversion was detected or suspected, the United States can insist that KEDO withdraw irradiated fuel from North Korea. Under Article VIII of the supply agreement, if KEDO requests, North Korea must relinquish ownership of the LWR spent fuel and transfer it out of the country as soon as technically possible after the fuel is discharged, through appropriate commercial contracts.
- Instead of reactor-grade plutonium, a LWR could produce significant quantities of weapon-grade plutonium. To do so on any large scale, however, the reactors would need to be run at less-tha--economically optimized levels. For example, once the reactors were operating, each reactor could discharge about 40 kilograms of weapon-grade plutonium by under-irradiating fresh fuel, in essence unloading replacement fuel soon after it was inserted into the reactor. This type of activity would be easy to detect by IAEA safeguards and unlikely to be repeated.

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