HEU DONE IT

Richard L. Garwin, From Foreign Affairs, March/April 2005,

In “Red-Handed,” by Mitchell B. Reiss, Robert Gallucci, et al.
Responses to Selig S. Harrison’s article, Did North Korea Cheat?, in Foreign Affairs, January/February 2005.

Selig Harrison argues that "it is much easier to make low-enriched uranium (LEU)--the fuel needed to power light-water plutonium reactors--than it is to make weapons-grade highly enriched uranium (HEU), as Washington has accused Pyongyang of doing." In fact, the centrifuge method is as easily used for producing HEU (nominally 95 percent U-235) as it is for making LEU (typically 4.4 percent U-235 in U-238). The performance of a gas centrifuge is measured by its yield of separative work units (SWU). Each of the centrifuges used in Pakistan or in the European enrichment enterprise, Urenco, may be assumed to produce about 3 SWU per year. The commercial nuclear-fuel market values an SWU at about $100. Technically, the number of SWU that would normally be used to produce a kilogram of U-235 as HEU (about 1.05 kg of HEU) is 232 SWU. The number of SWU that must be invested to make 1 kg of U-235 as LEU (in 22.7 kg of LEU) is about 151 SWU. In both cases one is assumed to start from natural uranium (0.711 percent U-235) and discard depleted uranium with 0.25 percent U-235.

Harrison argues that "a relatively small number of centrifuges is needed to make LEU, but the production of HEU in quantities sufficient for nuclear weapons requires the continuous operation of hundreds--or thousands--of centrifuges over a long period." If one assumes a Urenco centrifuge with a capacity of 3 SWU per year, then the production of LEU containing one metric ton of U-235--enough to replenish for a year a single large reactor producing a million kilowatts of electrical power (the standard-size reactor such as was being built by KEDO in North Korea)--would require 1,000 kg times 151 SWU/kg, or 151,000 SWU. At 3 SWU per year per centrifuge, this would require 151,000 divided by 3, or slightly more than 50,000 centrifuges working for a year. And the next year the plant's output would supply the following year's replacement fuel, and so on. Alternatively, these same 50,000 centrifuges could provide 150,000 divided by 232, or 647 kg of U-235 as HEU. One gun-type bomb using some 60 kg of U-235 as HEU would require 13,920 SWU. Although it is not trivial to make a centrifuge, once that art has been mastered, or once centrifuges have been procured from abroad, it is a much bigger task (by a power of ten) to make a year's worth of LEU to fuel a modern large power reactor than to enrich the 60 kg of HEU for a single gun-type bomb. Making the LEU for a single power reactor would require one year of operation of 50,000 centrifuges; on the other hand, fewer than 5,000 centrifuges would be required to operate for a year to make enough fuel for a gun-type bomb.

Harrison quotes me as estimating that "1,300 high-performance centrifuges would have to operate full time for three years to make the 60 kilograms of fissile material needed for a basic ('gun-type') nuclear weapon." This quote is correct. Three years of 1,300 centrifuges operating at 3 SWU per year would provide 11,700 SWU. The above 13,920 SWU requirement would thus take 3.57 years (or 13,920 divided by 11,700 multiplied by 3), or 3 years, if each of the 1,300 centrifuges can deliver 3.56 SWU per year. If one assumes that an implosion-type weapon uses 20 kg of HEU, then 1,300 centrifuges could produce the requisite HEU in about 14 months.

According to Harrison,

Accomplishing that would require an enormous sustained input of electricity, without fluctuation or interruption. Moreover, the operation of a multi-centrifuge "cascade" requires a high-powered motor with a speed twice that of a MiG-21 jet engine. North Korea cannot produce engines even for its Russian-supplied MiGs, and it has only limited, highly unreliable electricity capabilities. It is therefore unlikely that the country is able at present to build or operate the equipment needed, over a long period, to produce weapons-grade uranium.

This passage gives very much the wrong impression. Each centrifuge is driven by its own built-in motor. A centrifuge's power consumption is something like 100 kilowatt-hours per SWU (about $5 of the $100 price of a commercial SWU). Thus a machine producing 3 SWU per year consumes 300 kWh over a period of 8,766 hours, for an installed power of about 35 watts. This is less than that used by a 40-watt light bulb, and something like that required for a small desk fan. A park of 1,300 centrifuges needs 45 kWh, less power than a small car. There are many small computer centers that demand uninterrupted power, and commercial suppliers sell such systems with multiple small diesel generators for primary power or emergency backup.

Nevertheless, I support Harrison's advocacy of a "plutonium first" approach. If this includes North Korea's rapidly rejoining the NPT, with IAEA inspections, the scope of the enrichment effort would become clear, and the security threat could be brought under control in the context of a broader agreement.

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