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ISSUE BRIEF

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North Korea's Nuclear Weapons Program

Introduction

North Korea conducted its third nuclear test on February 12, 2013, which, coming in the aftermath of its first successful launch of a satellite into orbit, aroused new worries about the threat of North Korea's nuclear weapons program and the pace of its technical advances. Since the test, North Korea has rebuilt and restarted its 5 megawatt (MWe) plutonium-producing reactor, doubled the size of its known uranium enrichment facility, and expanded its nuclear weapons test site. Construction of an experimental light-water reactor, which could potentially be geared toward producing additional fissile material for nuclear weapons, is also ongoing and possibly near completion.[1]

There are three key technical questions about North Korea's nuclear program: the size of its plutonium stockpile, the extent of its uranium enrichment capacity, and whether it has the capability to miniaturize a nuclear weapon to be paired with a ballistic missile. There is a reliable range of estimates in answer to the first question: North Korea is believed to have enough plutonium for about four to eight primitive nuclear weapons or a somewhat larger number of more sophisticated ones.[2] The other two questions are much more difficult to assess, based on open-source information. In addition to the known uranium enrichment facility at its Yongbyon nuclear site, North Korea is assumed by many analysts to have at least one additional, clandestine enrichment facility of unknown scale, making estimates of the country's highly-enriched uranium output uncertain. Various branches of the U.S. intelligence community and independent analysts, given a dearth of hard evidence, also differ on whether North Korea has the capability to deliver its nuclear weapons via missile.[3]

Plutonium Program

North Korea's gas-graphite 5 MWe experimental nuclear reactor at the Yongbyon nuclear complex, the centerpiece of its plutonium production efforts, began operating in 1986.[4] By 1990, North Korea began operating a reprocessing plant to separate plutonium from spent fuel at the 5MWe plant, producing up to 10 kilograms of plutonium by 1994 – possibly enough for one or two crude nuclear weapons. In the early 1990s, North Korea also began construction of two larger gas-graphite reactors: a 50 MWe reactor at Yongbyon and a 200 MWe reactor at Taechon.

Plutonium production halted when operations at the 5MWe plant and reprocessing facility, as well as construction of the larger reactors, were frozen under the Agreed Framework of 1994. However, following the collapse of the Agreed Framework in 2003, North Korea resumed

operation of the 5MWe reactor, and began reprocessing spent fuel rods from the reactor to produce plutonium. (Significant construction at the larger reactor sites did not resume.)[5] After operating for several years, the 5 MWe reactor was shut down and partially disabled in 2008, an action taken as a part of the Six Party Talks process.

In April 2013, North Korea announced its intention to rebuild and restart the 5MWe gas-graphite reactor at Yongbyon.[6] Analysis of satellite imagery indicated that, by September of that year, North Korea had successfully restarted the reactor.[7] However, problems with the reactors' new cooling system may have led to a temporary shutdown in early 2014, and an unreliable water supply may hinder the reactor's operations in the future.[8] The resumption of operations at the reactor does not mean that North Korea will immediately be able to add to its plutonium stockpile – it will take two to three years of operation before irradiated fuel can be discharged from the reactor, and another six to twelve months before plutonium can be separated from the spent fuel.[9] At that stage, if the reactor operates as it has previously, North Korea will be able to produce about six kilograms of plutonium annually.[10]

North Korea's experimental light water reactor at Yongbyon may provide a second route for plutonium production. In 2009, Pyongyang announced that it would construct a light-water reactor in conjunction with its uranium enrichment plans;[11] the following year, a team of U.S. experts was shown the 25 to 30MWe experimental light-water reactor under construction.[12] As of early 2014, exterior construction for the facility is apparently complete, but the reactor is not yet operational.[13] While Pyongyang has publicly stated that the LWR is intended for energy production, one report speculates that if the reactor were configured for producing weapons-grade plutonium and commensurate modifications were made to the Yongbyon reprocessing plant, North Korea could eventually produce up to about 20 kilograms of plutonium a year.[14]

Siegfried Hecker, the former director of Los Alamos National Laboratory, estimated after North Korea's second nuclear test that the country had a stockpile of 24-48 kilograms of plutonium, based on the assumption that each of the first two tests used 6 kilograms of plutonium. David Albright and his colleagues at the Institute for Science and International Security have estimated that North Korea possesses 34-56 kilograms of plutonium, assuming the use of 2-4 kilograms per test for North Korea's initial two nuclear tests.[15] (These estimates have not been updated since North Korea's third nuclear test, as it is unknown whether the fissile material used was plutonium or highly-enriched uranium.) In 2008, as part of the Six Party Talks disablement process, North Korea declared that it possessed about 30 kilograms of separated plutonium – if one adds the approximately 8 kilograms separated in 2009 and subtracts 2-6 kilograms for the second nuclear test, this leaves 32-36 kilograms of plutonium in Pyongyang's declared stockpile.[16]

Uranium Enrichment

North Korea is believed to have received centrifuge-related equipment and know-how from the A.Q. Khan network beginning in the mid-to-late 1990s, although details of these transactions remain murky.[17] By the late 1990s, U.S. policymakers began to suspect the DPRK of operating a

clandestine uranium enrichment program, and the U.S. confronted North Korea about this issue during a 2002 meeting in Pyongyang. After this contested encounter, the U.S. delegation stated that North Korea had admitted to a uranium enrichment program, while North Korea subsequently denied making the admission or the existence of any enrichment program.[18] Even as the Six Party Talks process led to the partial dismantlement of North Korea's 5 MWe reactor in 2008, the DPRK continued to deny the existence of a highly enriched uranium program, though it acknowledged U.S. concerns over such a program.[19] Documents submitted as part of North Korea's 2008 declaration of its nuclear program did not include a reference to uranium enrichment, but reportedly contained traces of highly-enriched uranium.[20]

Following its second nuclear test in 2009, North Korea announced that it would commence enriching uranium, and that "enough success has been made in developing uranium enrichment technology" to produce fuel for its experimental light-water reactor.[21] In 2010, a U.S. delegation including Siegfried Hecker visited a newly-built enrichment facility at Yongbyon, which Hecker described as a "modern, small industrial-scale" facility that, unlike other North Korean nuclear facilities, was "ultra-modern and clean."

The chief process engineer at the enrichment facility told Hecker's delegation that it was operational, that it was enriching uranium to an average level of 3.5% (a low level of enrichment standard for light-water reactors), and that it contained 2,000 centrifuges with a capacity of 8,000 kilograms separative work units per year.[22] Based on this output level and North Korea's historical involvement with the A.Q. Khan network, analysts believe that North Korea's centrifuge design is based on the second-generation Pakistani P2 model.[23] In 2013, satellite imagery revealed that North Korea had expanded the centrifuge facility, with a new roof covering roughly twice the area of the previous one, hypothetically allowing the building to house 2,000 additional centrifuges.

Given the sophistication of the Yongbyon enrichment facility and the speed with which it was constructed, many analysts suspect that the country has a second, clandestine uranium enrichment facility.[24] The scale and fissile material output of such a facility is difficult to assess, and could vary based on North Korea's capacity to manufacture key components domestically.[25] The existence of such of a facility would complicate any future efforts for verifiable denuclearization in North Korea, particularly if the country is capable of manufacturing centrifuges domestically.

Estimates of North Korea's overall enrichment capacity and highly-enriched uranium stockpiles are highly speculative, hinging on a number of factors. These include:

- The scale and operational history of any clandestine enrichment facility;
- Whether the Yongbyon enrichment facility is used to produce light-water reactor fuel or weapons-grade uranium;
- Whether North Korea faces any technical or material barriers to operating its centrifuges; and

- The number of centrifuges currently installed at the Yongbyon enrichment facility.

David Albright and Christina Walrond argue that a credible upper bound for North Korea's production of weapons-grade uranium is 17 kilograms per year per 1,000 centrifuges dedicated to producing highly-enriched uranium rather than reactor fuel. A lower bound, assuming a less efficient enrichment process and operational difficulties, is 4 kilograms per year per 1,000 dedicated centrifuges.[26] (A uranium-based weapon would likely require 15-25 kilograms of weapons-grade uranium.)[27]

Weaponization and Tests

North Korea has conducted three underground nuclear tests at its mountainous Punggye-ri nuclear test site. The first two tests, in 2006 and 2009, both likely used plutonium-based devices, and had yields of under 1 kiloton and 2-7 kilotons, respectively.[28] (For comparison, the plutonium-based weapon dropped on Nagasaki in 1945 had a yield of 21 kilotons.) The yield for the third test was higher; a seismologist with expertise in underground nuclear explosions estimated it to be 2.5 to 3 times the yield of the previous test, or roughly between 5 to 15 kilotons.[29] The fissile material used for the third test is not known with certainty, as North Korea successfully sealed the test site to prevent any telltale gases from escaping, and either uranium or plutonium could have plausibly been used. However, many analysts assumed that the third test likely used a uranium-based device, in part because Pyongyang had a limited stockpile of plutonium and a potentially growing supply of highly-enriched uranium.[30]

One possible reason for the low yield of the first two nuclear tests is that North Korea may have tested relatively sophisticated devices using a small amount of plutonium in order to quickly develop a miniaturized nuclear warhead capable of pairing with its medium-range Rodong missiles. In 2008, as part of a declaration of its past nuclear activities, North Korea reportedly stated that its first nuclear test used only 2 kilograms of plutonium; if true, this would represent a relatively advanced weapon design.[31] It is possible, according to some analysts, that North Korea received warhead designs from the A.Q. Khan network, in addition to centrifuges.[32] Alternatively, A.Q. Khan has alleged that North Korea had already developed advanced warhead designs as early as 1999, although experts question the truthfulness of his testimony.[33]

After North Korea's third nuclear test, the Korea Central News Agency announced that it had tested a "smaller and light A-bomb unlike the previous ones, yet with great explosive power" – indicating that its nuclear weapons could be miniaturized to fit atop ballistic missiles.[34] After the test, an assessment by the Defense Intelligence Agency expressed "moderate confidence" that North Korea could produce a nuclear weapon small enough to be delivered via ballistic missile, but that the weapon's operational "reliability will be low."[35] However, a subsequent statement by the Director of National Intelligence indicated that the assessment was not shared by the entire U.S. intelligence community, and that "North Korea has not yet demonstrated the full range of capabilities necessary for a nuclear armed missile."[36] Analysts outside of government have been similarly divided on this question.[37]

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[1] "Major Development: Reactor Fuel Fabrication Facilities Identified at Yongbyon Nuclear Complex," *38 North*, December 23, 2013. http://38north.org/2013/12/yongbyon122313/

[2] See Siegfried S. Hecker, "Lessons learned from the North Korean nuclear crises," *Daedalus* (Winter 2010), pp. 44-56; David Albright and Christina Walrond, "North Korea's Estimated Stocks of Plutonium and Weapon-Grade Uranium," Institute for Science and International Security, August 16, 2012, pp. 8-10. http://isis-online.org/uploads/isis-reports/documents/dprk_fissile_material_production_16Aug2012.pdf

[3] Thom Shanker, David E. Sanger, and Eric Schmitt, "Pentagon Finds Nuclear Strides by North Korea," *New York Times*, April 11, 2013.

[4] An IRT-2000 research reactor, constructed in the early 1960s, may have also produced a small amount of plutonium. The IRT 2000 reactor has barely operated since 1994. In 1992, North Korean officials had told the IAEA that technicians had separated 300mg of plutonium from the reactor via hot cells in 1975. While the facility was under IAEA safeguards after 1978, one analyst estimates that the reactor could have produced up to 4 kilograms of plutonium while operational at declared power levels and load factors. Jared S. Dreicer, "How Much Plutonium Could Have Been Produced in the DPRK IRT Reactor?," *Science & Global Security*, Vol. 8 (2000), pp. 273-286.

[5] In 2010, a North Korean technician told U.S. scientist Siegfried Hecker that the 50 and 200 MWe reactors "have become ruined concrete structures and iron scrap." Siegfried Hecker, "A Return Trip to North Korea's Yongbyon Nuclear Complex," Stanford University Center for International Security and Cooperation, November 20, 2010. http://iis-db.stanford.edu/pubs/23035/HeckerYongbyon.pdf

[6] "DPRK to Adjust Uses of Existing Nuclear Facilities," *Korean Central News Agency*, April 2, 2013.

[7] "North Korea Restarting its 5 MW Reactor," *38 North*, September 11, 2013. http://38north.org/2013/09/yongbyon091113/; "More Evidence that North Korea has Restarted its 5MWe Reactor," *38 North*, October 2, 2013. http://38north.org/2013/10/yongbyon100213/; David Albright and Robert Avagyan, "Steam Venting from Building Adjacent to 5 MWe Reactor: Likely Related to Reactor Restart," *Institute for Science and International Security*, September 11, 2013. http://isis-online.org/isis-reports/detail/steam-venting-from-building-adjacent-to-5mwe-reactor-likely-related-to-reac/10

[8] "Nuclear Safety Problems at North Korea's Yongbyon Nuclear Facility?" *38 North*, April 7, 2014. http://38north.org/2014/04/yongbyon040714/

[9] Albright and Avagyan, "Steam Venting from Building Adjacent to 5 MWe Reactor," *op. cit.*

[10] "North Korea Restarting its 5 MW Reactor," *op. cit.*

[11] "DPRK Foreign Ministry Declares Strong Counter-Measures against UNSC's 'Resolution 1874'," *Korea Central News Agency*, June 13, 2009.

[12] Hecker, "A Return Trip to North Korea's Yongbyon Nuclear Complex," *op. cit.*

[13] "Major Development: Reactor Fuel Fabrication Facilities Identified at Yongbyon Nuclear Complex," *38 North*, December 23, 2013. http://38north.org/2013/12/yongbyon122313/

[14] Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.,* pp. 10-13.

[15] Albright and Brannan (2007) estimate a stockpile of 28-50 kilograms of plutonium, and Albright and Walrond (2012) add that North Korean reprocessing of the last reactor core from the 5MWe reactor in 2009 yielded about an additional eight kilograms of plutonium. See David Albright and Paul Brannan, "The North Korean Plutonium Stock, February 2007," Institute for Science and International Security, February 20, 2007. http://isis-online.org/uploads/isis-reports/documents/DPRKplutoniumFEB.pdf; Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.*

[16] Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.,* pp. 8-10.

[17] David Albright and Paul Brannan, "Taking Stock: North Korea's Uranium Enrichment Program," Institute for Science and International Security, October 8, 2010. http://isis-online.org/uploads/isis-reports/documents/ISIS_DPRK_UEP.pdf

[18] Don Oberdorfer and Robert Carlin, *The Two Koreas*, Third Ed. (Basic Books, 2013), pp. 366-372.

[19] Testimony of Ambassador Christopher R. Hill, "The North Korean Six-Party Talks and Implementation Activities," Hearing before the Senate Committee on Armed Services, 110th Congress, 2nd Session, July 31, 2008.

[20] Mary Beth Nikitin, "North Korea's Nuclear Weapons: Technical Issues," Congressional Research Service, April 13, 2013, pp. 11-12.

[21] "DPRK Foreign Ministry Declares Strong Counter-Measures against UNSC's 'Resolution 1874'," *Korea Central News Agency*, June 13, 2009.
[22] Hecker, "A Return Trip to North Korea's Yongbyon Nuclear Complex," *op. cit.*
[23] Siegfried Hecker, "Redefining Denuclearization in North Korea," *Bulletin of the Atomic Scientists*, December 20, 2010. http://thebulletin.org/redefining-denuclearization-north-korea-0
[24] Director of National Intelligence James R. Clapper testified before Congress in 2011 that "Based on the scale of the facility and the progress the DPRK has made in construction, it is likely that North Korea has been pursuing enrichment for an extended period of time. If so, there is clear prospect that DPRK has built other uranium enrichment related facilities in its territory, including likely R&D and centrifuge fabrication facilities, and other enrichment facilities. Analysts differ on the likelihood that other production-scale facilities may exist elsewhere in North Korea." James R. Clapper, "Statement for the Record on the Worldwide Threat Assessment of the U.S. Intelligence Community for the House Permanent Select Committee on Intelligence," February 10, 2011.
[25] Experts have disagreed on North Korea's capacities in this regard. See Choe Sang-hun, "North Korea Learning to Make Crucial Nuclear Parts, Study Finds," *New York Times*, September 23, 2013; David Albright and Olli Heinonen, "In Response to Recent Questionable Claims about North Korea's Indigenous Production of Centrifuges," Institute for Science and International Security, October 18, 2013. http://isis-online.org/isis-reports/detail/in-response-to-recent-questionable-claims-about-north-koreas-indigenous-pro/
[26] Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.,* pp. 22-25.
[27] Albright and Walrond estimate that a crude North Korea fission device using only uranium would require 15 to 25 kilograms of weapons-grade uranium. Albright separately writes that the warhead design that China reportedly transferred to Pakistan in the early 1980s required 25 kilograms of weapons-grade uranium, and that Pakistan further miniaturized the design in the 1980s and 90s. The A.Q. Khan network reportedly sold this weapon design to Libya, and analysts speculate that it may have sold the design to North Korea as well. Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.,* p. 25; David Albright, "North Korean Miniaturization," *38 North*, February 13, 2013. http://38north.org/2013/02/albright021313/
[28] Frank V. Pabian and Siegfried S. Hecker, "Contemplating a Third Nuclear Test in North Korea," *Bulletin of the Atomic Scientists*, August 6, 2012.
[29] Verification Science Interview with Paul Richards, "Seismic Detective Work: CTBTO Monitoring System 'Very Effective' in Detecting North Korea's Third Nuclear Test," *CTBTO Spectrum*, No. 20 (July 2013).
[30] Graham T. Allison Jr., "North Korea's Lesson: Nukes for Sale," *New York Times*, February 12, 2013.
[31] Albright and Walrond, "North Korea's Estimated Stocks," *op. cit.,* p. 9.
[32] See Bruce Klingner, "Going Beyond 'Strategic Patience:' Time to Get North Korean Sanctions Right," Testimony before the U.S. House of Representatives Foreign Affairs Subcommittee on Asia and the Pacific, hearing on "The Shocking Truth about North Korean Tyrannny," March 26, 2014. This analysis is partially predicated on the A.Q. Khan network's sale to Libya of detailed instructions on how to produce a Chinese-designed miniaturized nuclear warhead; China had reportedly transferred the weapons design to Pakistan in the early 1980s. See Joby Warrick and Peter Slevin, "Libyan Arms Designs Traced Back to China," *Washington Post*, February 15, 2004.
[33] R. Jeffrey Smith and Joby Warrick, "Pakistani Scientist Depicts More Advanced Nuclear Program in North Korea," *Washington Post*, December 28, 2009; Albright, "North Korean Miniaturization," *op. cit.*
[34] "KCNA Report on Successful 3rd Underground Nuclear Test," *Korean Central News Agency*, February 12, 2013.
[35] Thom Shanker *et al*., "Pentagon Finds Nuclear Strides by North Korea,"
[36] James R. Clapper, Director of National Intelligence, "DNI Statement on North Korea's Nuclear Capability," Office of the Director of National Intelligence, April 11, 2013.
[37] David Albright of the Institute for Science and International Security has assessed that "North Korea likely has the capability to mount a plutonium-based nuclear warhead on the shorter range Nodong missile," although it does not yet have this capability for ICBMs. Former WMD "Czar" Gary Samore has stated that "there is so little direct evidence that I don't think it's possible to come to a firm conclusion on whether or not they currently have a nuclear warhead that can be delivered by missile." See David Albright, "North Korean Miniaturization," *38 North*, February 13, 2013; David E. Sanger and Eric Schmitt, "Contrasting Views on North Korea Underscore Sensitivities and Lack of Evidence," *New York Times*, April 12, 2013.