

Return trip to North Korea

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Six visits helped us make an assessment



Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

Nov. 2006 Pyongyang



August 9, 2007, Yongbyon

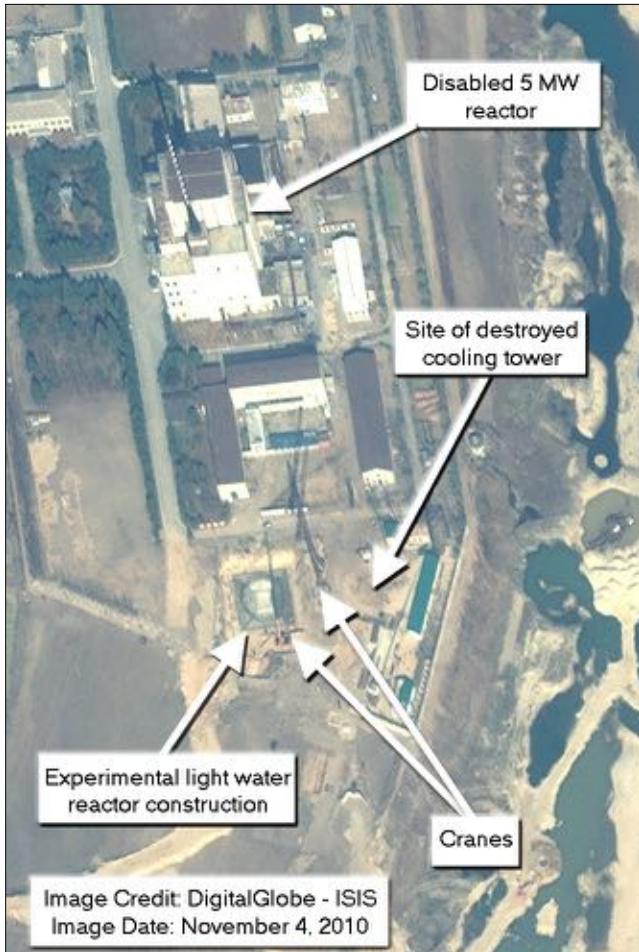
Feb. 14, 2008, Yongbyon

Feb. 27, 2009, Pyongyang

They had a specific message for each visit

Visit # 7: Yongbyon - Nov. 12, 2010

“We will convert our center to an LWR and pilot enrichment facility”



**“No one believed us when we announced this in 2009 -
including you, Dr. Hecker,” North Korean Official**

Status of Yongbyon plutonium program

- **5 MWe reactor - shut down, in standby**
 - No new plutonium being produced
 - No cooling tower, fresh fuel not ready
- **Reprocessing facility in standby**
 - All spent fuel reprocessed
 - No plutonium in the pipeline
- **Fuel fabrication facility**
 - Construction to convert to LWR fuel
- **50 MWe reactor being torn down**
 - 200 MWe at Taechon also not salvageable
- **Estimated plutonium inventory**
 - 24 to 42 kg (enough for 4 to 8 bombs)
 - Claimed that all of it is weaponized



If North Korea really wants to enhance and improve its nuclear arsenal, it would restart and rebuild these facilities



5 MWe reactor

LWR construction

Motivation and history of LWR for North Korea

- **North Korea chose gas-graphite reactor design in '70s**
 - Poor for electricity, good for bombs (like early UK and France)
- **By 1980s realized difficulty of nuclear electricity supply**
 - 1985 agreement to get two Soviet LWRs - dashed by end of SU
- **1994 Agreed Framework**
 - U.S., ROK, Japan to provide two modern LWRs - unfulfilled
- **Aug. 2005 meeting with Vice Minister Kim Kye-gwan**
 - No LWR, no deal - referring to Joint Statement (signed 9/19/05)
- **Aug. 2007 meeting with VM Kim Kye-gwan**
 - U.S. can run the LWR, we won't enrich, won't reprocess
- **2009 decision after rocket and nuclear test and sanctions**
 - We'll do it alone - begin experimental LWR and enrichment

The LWR has economic and symbolic importance

Vice Minister Kim Kye-gwan (Feb. 2007)

Experimental light-water reactor (LWR) construction

- **25 to 30 MWe (100 MW-thermal)**
 - We will start small, learn, then build a larger power reactor
- **Reinforced concrete containment shell started**
 - 22 m diam by 40 m high (excavation 7.1 m deep)
- **Steel pressure vessel**
 - To be manufactured indigenously
- **Two electrical generators for electricity**
 - Local communities and linked to national grid
- **Uranium dioxide (UO_2) fuel pellets in cladding**
 - Not yet decided (either zircaloy or stainless steel)
- **Fuel to be enriched (LEU) to 3.5% U-235**
- **Target completion date - 2012 (I believe, unrealistic)**

Their claim that Yongbyon is being converted to LWR and uranium enrichment is credible

Experimental light-water reactor (LWR) concerns

- **Safety** - can it be constructed and operated safely
 - Nuclear regulatory approval and oversight is imperative
 - Claim to have a National Nuclear Safety Commission
 - LWR is a new design - entirely new design team at work
 - INPO and WANO - lessons learned?
- **Plutonium production**
 - Like all uranium fueled reactors, this LWR will produce plutonium
 - Annual plutonium production estimated at 10 to 15 kg
 - Typical LWR plutonium is not very suitable for bombs
 - The existing 5 MWe reactor can produce 6 kg/year of super-bomb grade plutonium
 - Diversion to bomb plutonium production readily detected
- **LWR requires uranium enrichment**
 - Centrifuge facilities that produce LEU (3.5% U-235) can readily be reconfigured to make bomb-grade HEU (~90% U-235)

Uranium enrichment facility

- **Started construction in April 2009**
 - Claimed to have completed a few days before our visit (11/12/10)
- **Reconstruction and renovation of Bldg. 4**
 - U.S. technical team and IAEA on site until mid-April 2009
 - 120 meters by 18 meters
 - Fresh exterior stucco
 - Blue roof entire length of building (from overheads)
- **Several other new buildings visible at the FFF site**



A high-resolution aerial satellite photograph showing a large industrial complex. The facility is densely packed with various buildings, including several long, low-profile structures with dark roofs and numerous smaller, rectangular buildings. The complex is situated in a hilly, brownish terrain. A winding road or railway line cuts through the lower-left portion of the site. In the upper right, a body of water is visible. The overall scene suggests a major industrial or manufacturing operation.

Fuel Fabrication Facility Site

Nov. 4, 2010, Digital Globe
Allison Puccioni, Analyst, HIS Jane'



Bldg. 4 during disablement - Feb. 2008 visit



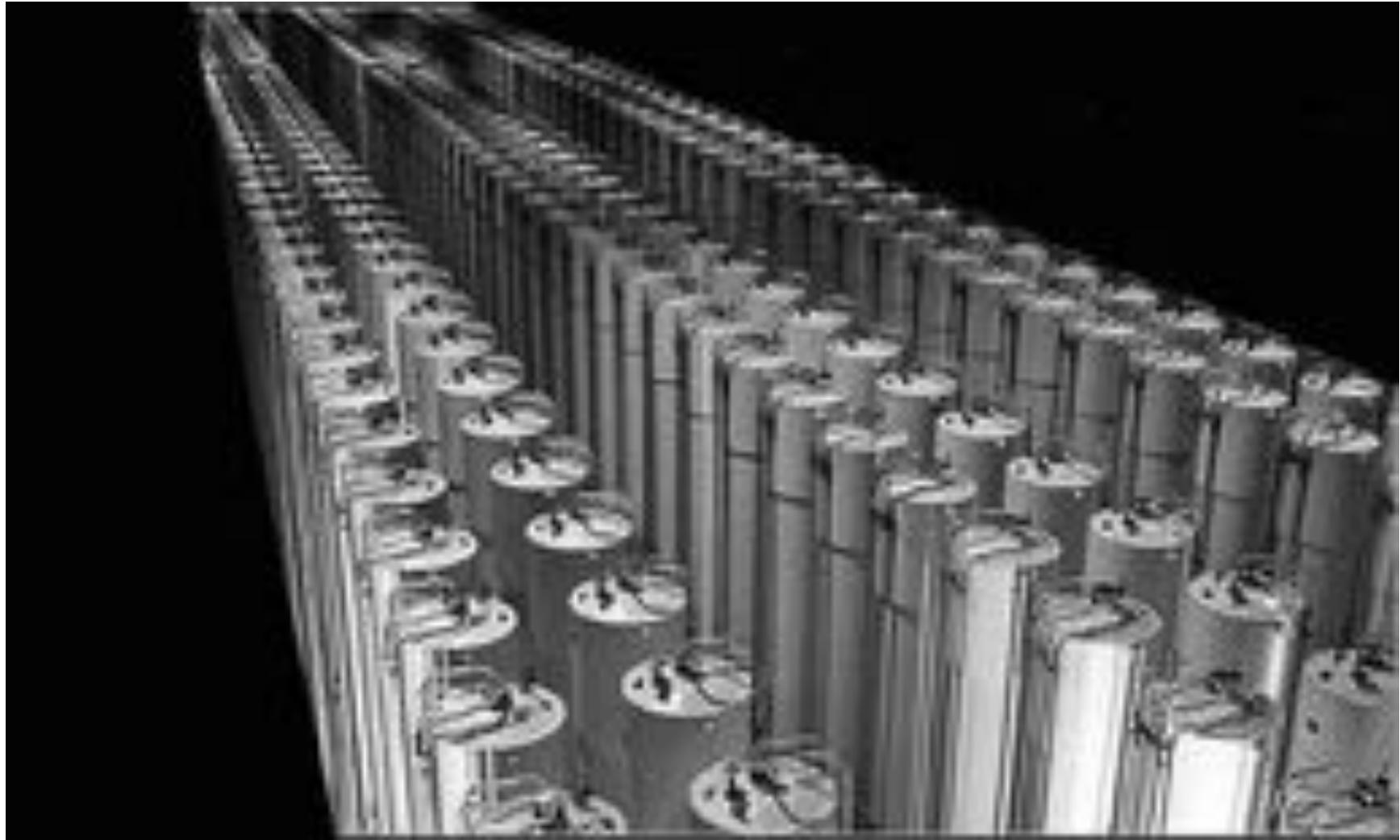
Bldg. 4 after disablement
of a casting furnace

Bldg. 4 after removal of lathes



U.S. technical team had access until April 2009 - a lot has happened since

Purely illustrative - this is not Yongbyon, but close to what we saw.



Piketon, Ohio Centrifuge plant, 1984 (Department of Energy)

Several additional centrifuge lines were removed graphically to try to get this as close as possible to the centrifuge cascades we saw in Bldg. 4 at Yongbyon

Uranium enrichment program

- 2,000 centrifuges in a divided 100-meter cascade hall
- Centrifuges ~ 6 ft high by 8 in diameter
- Claimed to have steel rotors
 - Likely maraging steel, hence P-2 (G-2) centrifuges
- Through-put claimed at 8,000 kg SWU/year
 - Capable of producing 2 tonnes LEU/yr (adequate for small LWR)
- Claimed to be operating, producing LEU now
 - We cannot confirm, but not inconsistent with what we saw
- Modern control room

Facility and capacity is consistent with fuel requirements for experimental LWR



U.S. Piketon, Ohio plant (1984)

URENCO Centrifuge cascades



Kim Il-sung University e-Lab



5 MWe reactor control room

Dual-use problem

- **Enriched uranium is required for LWRs**
 - If in good international standing, easy to obtain from suppliers
- **Same equipment, same technologies permit HEU**
 - The Iran problem - LEU can serve as cover for HEU
 - Breakout or parallel covert facilities allow HEU production
- **2,000 centrifuge cascades**
 - Can produce 2 tonnes/year of 3.5% LEU reactor fuel or
 - 40 kg of 90% bomb-grade HEU/year (enough for ~ 1 or 2 bombs)

How does this change the security risk?

- **Not much for the current capacity**
 - Much better off continuing to produce plutonium if they want bombs
 - Modern nuclear arsenals use plutonium
- **But, once demonstrated, could duplicate anywhere**
 - Small footprint and signature, difficult to detect
- **Number of facilities limited by materials and components**
 - High-strength steel, high-strength aluminum, etc.
 - Components - ring magnets, frequency converters, bearings, vacuum valves, molecular pumps, etc.
 - Indigenous manufacturing capability unknown, but questioned
- **Large HEU capability could lead to increased arsenal size**
 - Could become more like Pakistan arsenal
 - More sophisticated bombs require testing but plutonium is superior

How did North Korea get enrichment and when?

- What we saw requires many years of development, manufacture and testing
- Most likely decades of R&D, procurement and training
- HEU particles in North Korea and UF₆ to Libya questions
- Current system likely built and tested outside Yongbyon
- Unlike the original reactors, centrifuges require help*
 - Cooperation with Pakistan and A.Q. Khan since 1993
 - Included training of their technical specialist at Khan Research Lab
 - Supply of two dozen centrifuges by Khan around 2000
 - Complex web of procurement - i.e. aluminum from Russia & Germany
- Possibly cooperation with Iran

* See D. Albright and P. Brannan, "Taking Stock: North Korea's Uranium Enrichment Program, ISIS, Oct. 8, 2010

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But, we can speculate

Why did they show us this and why now?

- **Serious about building an LWR - and a reactor under construction would have been visible soon**
 - Head off speculation and hype
- **Admit the uranium enrichment program with a cover story - it's needed for LWR**
- **Don't underestimate us - we are not about to collapse**

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We are open for suggestions

The 3-26 Wire Factory





Textile Factory



Pyongyang University
of Music





Kim Il-sung University





Phone booths in Feb. 2009





So, what to do now?

- Take threat seriously, but don't hype it
- Remember Perry process recommendation
- Deal with North Korea as it is, not the way we'd like it to be
- Do policy review to see what's changed since 2000
- Stay the course on denuclearization, but contain threat
- For now - three no's in return for one yes
 - No more bombs
 - No better bombs
 - No export
- Yes - address fundamentals of North Korea's insecurity