INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

REPORT

Summary of North Korea's Known Gas Centrifuge Program

Institute for Science and International Security

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Knowing the status and extent of North Korea's gas centrifuge program remains a priority in denuclearization negotiations. The table on the following page is taken from a 2011 Institute study, ***Denuclearization and Verification of North Korea's Uranium Enrichment Program*****,** and is updated. It contrasts the expected centrifuge facilities and activities with a summary of what is known about each of them. The last column is an Institute expert ranking of what is known about each type of activity or facility. As can be seen, major gaps exist in the knowledge of North Korea's centrifuge program. An average score across all major categories, on a 1 to 5 scale, where 5 represents completely known and 1 unknown, is two, meaning that knowledge about North Korea's gas centrifuge program is rather unsubstantial in terms of knowledge of facilities and their status and accomplishments. In particular, estimates of the amount of enriched uranium produced by this program are highly uncertain. Summarized Institute estimates are that through 2017, North Korea made between about 250 and 1000 kilograms of weapon-grade uranium and an undetermined amount of enriched uranium at enrichment levels below weapon-grade, namely less than 90 percent enriched.

The following summarizes the scores drawn from the table on the next page.

Type of Activity	**Score**
Centrifuge research	3
Prototype centrifuge development	2
Procurement system	4
Centrifuge manufacturing	1.5
UF6 production (averaged over five subcategories)	2.8
Pilot centrifuge plant (averaged over two subcategories)	1
Production-scale centrifuge plant at Yongbyon (average over two subcat.)	2
Another production-scale plant	1.5
Possible research, development, and production of advanced centrifuges	1
Building of additional production-scale plants, e.g. a third plant	1
Maintenance of centrifuges (averaged over two subcategories)	2
Average	**2 (rounded)**

A near term priority of the North Korean negotiations is obtaining a commitment from North Korea to fully declare its enrichment program, disable it, allow effective verification of it, and dismantle it. North Korea has no need for enriched uranium that could not be met via international supply at a far cheaper price, and thus it should thoroughly dismantle the program.

Table: Known Gas Centrifuge Program Summary

TYPE	EXPECTED FACILITY OR ACTIVITY	SUBCATEGORIES	COMMENTS ON WHAT IS KNOWN ABOUT FACILITIES OR ACTIVITIES	EXTENT OF KNOWLEDGE OF FACILITY OR ACTIVITY (SCALE OF 1 TO 5, WITH 1 UNKNOWN AND 5 COMPLETELY KNOWN)
Centrifuge research	Access to classified centrifuge technology	Centrifuge design	AQ Khan network provided information and at least four P1 centrifuges and up to 25 P2 centrifuges. In addition, Pakistan declared that it supplied 53 kilograms of uranium hexafluoride, uranium hexafluoride cylinders, a uranium hexafluoride flowmeter, and 200 liters of Fomblin oil. It also performed tests of the purity of North Korean produced uranium hexafluoride.	3
		Enrichment plant design		
		Component manufacturing technology		
		Determine how to recruit and train a competent staff		
Prototype centrifuge development	Development of prototype centrifuge	Execute the centrifuge design, taking into account the resources available. Determine what can and cannot be produced domestically	Largely unknown but a suspect facility has been identified (see below) and extrapolations from the experience in Pakistan are made.	2
		Carry out single machine tests with and without uranium hexafluoride		
	Procurement for the prototype centrifuge	Initiate domestic production wherever possible		

		Strengthen and develop relationships to establish reliable procurement networks		
	Manufacture centrifuge components			
	Construction of a development facility; location suspected based on defector information and government analysis	Rigorously test the centrifuge individually and in small cascades		
		Start to solve centrifuge and cascade design flaws and problems		
Procurement system	Procurement entities and overseas procurement networks. Depends on having agreed upon designs of centrifuge or centrifuges.	Determine what will be developed indigenously and what will be procured abroad	North Korean procurement efforts have been detected by other countries; and Khan's confession has information.	4
		Establish transport routes		
		Establish bank routing and payment methods		
		Develop relationships with front companies		
Centrifuge manufacturing	Design and build centrifuge manufacturing facilities	Manufacture centrifuge parts	Unknown	1.5
		Gather materials, equipment, and components from international procurement efforts		
		Manufacture, assemble and balance large number of centrifuges prior to deployment in a centrifuge plant		

UF_6 production	Access to uranium ore	Develop uranium mines	Several mines known	4
	Access to uranium yellowcake	Develop milling facilities	At least three mills known	4
	Production of uranium hexafluoride	Execute research and development for uranium hexafluoride	Foreign and domestic sources	2
		Create a pilot scale uranium conversion facility – develop technology and designs, procure necessary materials and equipment, and execute laboratory scale tests	Unknown; some indications from Khan confession	1
		Construct large scale facilities for uranium hexafluoride production	North Korea has said it has a uranium hexafluoride production plant at or near Yongbyon. It may have a uranium tetrafluoride and uranium hexafluoride conversion facility in North Pyongsan province. With help of the AQ Khan network, North Korea provided 1.5 metric tonnes of uranium hexafluoride to Libya.	3
Pilot centrifuge plant	Build a centrifuge plant holding tens or up to 500-1,000 centrifuges	Decide upon cascade size and shape. Procure materials, equipment, and know-how for pilot plant	Some procurement efforts visible	1
		Test centrifuges in longer cascades	Suspect site possibly identified but little known about what was done in the plant or whether it was holding tens or hundreds of centrifuges	1
		Determine the plant's control system		
		Create feed and withdrawal stations		
		Build and troubleshoot production-scale cascades		

Production scale centrifuge plant at Yongbyon	Install thousands of centrifuges at Yongbyon	Implement cascade designs. For HEU production, decide on cascade steps necessary and the number of centrifuges in each step.	Centrifuge facility at Yongbyon; very little operational data known.	3
	Establish methods to maintain and improve centrifuges	Develop a system to replace broken centrifuges and trouble-shoot problems with centrifuge and cascade design	Unknown	1
Other production-scale plants			Earlier production-scale centrifuge plant identified; little known on number of centrifuges or operational status or data	1.5
Possibly research, develop, and produce advanced centrifuges	Facilities to do tests of single, more advanced centrifuges with and without uranium hexafluoride, and cascade testing of tens of centrifuges		Unknown	1
Build additional production-scale plants, e.g. third plant			Unknown	1
Maintenance of centrifuges, equipment, and complex	Update manufacturing capabilities		Unknown	1
	Maintain procurement networks		Much is known through procurement monitoring by governments and companies.	3