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Out of the Spotlight Iran's Rate of Enriched Uranium Production Continues to Increase: Centrifuge Enrichment and the IAEA May 24, 2011 Update

In eight previous reports, this author has outlined how Iran's growing centrifuge enrichment program could provide it with the ability to produce fissile material for nuclear weapons.[1] On May 24, 2011, the International Atomic Energy Agency (IAEA) released a further safeguards update.[2] This update shows that Western efforts to impede Iran's centrifuge enrichment program continue to be ineffective. Iran has increased its enriched uranium production rate to about 105 kilograms of 3.5% enriched uranium per month.[3] This is a 17% increase since the last IAEA report in February 2011 and it occurred despite repeated press reports of cyber attacks in 2009 having slowed Iran's enrichment efforts, Iran's current production rate of 3.5% enriched uranium has actually increased 84% over Iran's 2009 production rate. Iran is also maintaining a steady production rate of about 2.7 kilograms per month of 19.7% enriched uranium.

As of May 14, 2011, Iran had produced 2,775 kilograms of 3.5% enriched uranium (in the form of 4,105 kilograms of uranium hexafluoride). With this quantity of 3.5% enriched uranium, Iran could produce more than the 20 kilograms of highly enriched uranium (HEU) needed for a nuclear weapon by batch recycling at the Fuel Enrichment Plant (FEP) at Natanz. With Iran's current number of operating centrifuges, the batch recycling would take about two months once Iran decided to initiate the process.

Iran has already started the process of converting its stockpile of 3.5% enriched uranium into the HEU needed for nuclear weapons, as is evidenced by its production of 19.7% enriched uranium. This is an intermediate step on the road to the production of HEU. As of May 21, 2011, Iran had accumulated a stockpile of about 38.3 kilograms of 19.7% enriched uranium (in the form of 56.7 kilograms of uranium hexafluoride). As of that date, about 320 kilograms of 3.5% enriched uranium had already been processed into 19.7% enriched uranium, making Iran's stockpile of 3.5% enriched uranium about 2,455 kilograms. As Iran's stockpile of 19.7% enriched uranium continues to grow, the time required for it to be able to produce a weapons worth of HEU will continue to decline.

Iran has three known centrifuge enrichment facilities. Iran's main facility is the FEP at Natanz. The basic unit of Iran's centrifuge enrichment effort is a cascade which consists of 164 centrifuges, though Iran has begun to modify some cascades by increasing the number of centrifuges to 174. (All centrifuges installed up to now have been of the IR-1

[1] My most recent prior report is: "Cyber Attack, What Cyber Attack? Iran's Rate of Enriched Uranium Production Remains Steady: Centrifuge Enrichment and the IAEA February 25, 2011 Update," November 30, 2010, http://www.npolicy.org/article_file/What_Cyber_Attack.pdf

[2] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/29, May 24, 2011.

[3] To avoid problems with the fact that the length of a month is variable, we have adopted a uniform month length of 30.44 days.

type.) Each cascade is designed to enrich natural uranium to 3.5% enriched uranium. As of May 14, 2011, Iran had installed 53 cascades containing approximately 8,000 centrifuges at the FEP. Of these 53 cascades, only 35 (containing 5,860 centrifuges) were being fed with uranium hexafluoride and therefore producing 3.5% enriched uranium.[4]

Also at Natanz, Iran has the Pilot Fuel Enrichment Plant (PFEP) which is used to test a number of more advanced centrifuge designs. These are usually configured as single centrifuges or small ten or twenty centrifuge test cascades. However, Iran has indicated that it plans to install two full cascades containing more advanced centrifuges (one cascade using IR-4 centrifuges and one cascade using IR-2m centrifuges) which could significantly increase the rate of Iran's production of 3.5% enriched uranium. In addition, there are two full cascades each with 164 IR-1 type centrifuges at the PFEP. These two cascades are interconnected and are being used to process 3.5% enriched uranium into 19.7% enriched uranium. Iran began producing 19.7% enriched uranium at the PFEP in February 2010.

Finally Iran is constructing an enrichment facility near Qom. Known as the Fordow Fuel Enrichment Plant (FFEP), this plant's construction was started clandestinely in violation of its IAEA safeguards. Its existence was only revealed by Iran in September 2009 after Iran believed that the plant had been discovered by the West. According to the IAEA, no centrifuges have yet been installed at FFEP.

From Iran's current monthly production rate of 105 kilograms of 3.5% enriched uranium, one can calculate that the centrifuges at the FEP produce about 4,600 SWU per year.[5] Given that in the past Iran's centrifuges were each producing about 0.89 SWU per year, 4,600 SWU per year would indicate that the equivalent of about 31 cascades (5,184 centrifuges) were in operation. Note that Iran had 31 cascades in operation at the end of the last IAEA reporting period on February 20, 2011. Since the IAEA has indicated that on May 14, 2011, Iran had 35 cascades producing 3.5% enriched uranium, this implies that either some cascades are not operating at full effectiveness or that the new cascades only came online near the end of the current IAEA reporting period. At any rate, one should expect further increases in Iran's uranium enrichment capacity at the FEP.

Given that Iran has the equivalent of 5,184 centrifuges in operation at the FEP and stockpiles of about 2,455 kilograms of 3.5% enriched uranium and 38.3 kilograms of 19.7% enriched uranium, it can use batch recycling at the FEP to produce the HEU needed for a nuclear weapon. This process is illustrated in Table 1.

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[4] The IAEA's description of the number of centrifuges being fed with uranium hexafluoride is rather ambiguous: "The 35 cascades being fed with UF_6 on that date contained a total of 5,860 centrifuges, some of which were possibly not being fed with UF_6." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/29, May 24, 2011, p.2.

[5] Assuming 0.4% tails. A SWU is a Separative Work Unit, which is a measure of the amount of enrichment a facility can perform. It is the product of the uranium flow though the facility and the increase in U-235 concentration between stages.

Two steps are required. In the first step, 3.5% enriched uranium is enriched to 19.7% enriched uranium. Iran would need to produce 158.2 kilograms of 19.7% enriched uranium (including 5 kilograms for the plant inventory in the second step). However, since it has already produced 38.3 kilograms of 19.7% enriched uranium, Iran would need only to produce an additional 119.9 kilograms. This step would require 1,415 kilograms of 3.5% enriched uranium as feed but Iran's current stockpile well exceeds this figure. In the second step, the 19.7% enriched uranium would be further enriched to the 90% level suitable for a nuclear weapon. Using Iran's currently operating centrifuges at the FEP, the batch recycling would take about two months.

Note however, that there would be nothing illegitimate about the first step of this process since Iran's current production of 19.7% enriched uranium at the PFEP has established the principle that Iran is permitted to produce and possess such material. Only at the second step would Iran have violated the NPT, but as the second step takes only about two weeks, there would be very little time for Western counteraction before the process was completed. Indeed since the FEP is not continuously monitored by the IAEA, the process could be well along or even completed before it was discovered.

Table 1

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (31 Equivalent Operating Cascades, 5,184 Centrifuges, 0.89 SWU per Centrifuge-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.7% 119.9 kg	3.5% 1,415 kg	46
Second	90.0% 20 kg	19.7% 153.2 kg*	12
Total			62**

* Includes 38.3 kilograms of 19.7% enriched uranium that Iran has already stockpiled.
**Includes four days to account for equilibrium and cascade fill time.

Nor is batch recycling of enriched uranium at the FEP the only pathway for Iran to produce the fissile material required for nuclear weapons, though it is the process that allows Iran to produce HEU most quickly. Iran could produce HEU at a clandestine enrichment plant. Since Iran continues to refuse to implement the Additional Protocol to its safeguards agreement, the IAEA would find it very difficult to locate a clandestine enrichment plant—a fact that the IAEA has continued to confirm.[6] While this has been a

[6] "While the Agency continues to verify the non-diversion of declared nuclear material at the nuclear facilities and LOFs declared by Iran under its Safeguards Agreement, as Iran is not providing the necessary cooperation, including by not implementing its Additional Protocol, the Agency is unable to provide

theoretical possibility since 2007, its salience increased with the discovery in September 2009 that Iran was actually building such a clandestine enrichment plant (the FFEP near Qom).

A clandestine enrichment plant containing 23 cascades (3,772 centrifuges, 0.89 SWU per machine-year) could produce around 20 kilograms of HEU (the amount required for one nuclear weapon) each year using natural uranium as feed. Since this option does not require any overt breakout from safeguards, the relatively slow rate of HEU production would not necessarily be of any concern to Iran. Such production could be going on right now and the West might well not know. A clandestine enrichment plant would need a source of uranium but Iran is producing uranium at a mine near Bandar Abbas.[7] Since Iran has refused to implement the Additional Protocol to its IAEA safeguards, this uranium mining is unsafeguarded and the whereabouts of the uranium that Iran has produced there is unknown.

A clandestine 23 cascade enrichment plant could also be used to convert Iran's stockpile of 3.5% enriched uranium into the HEU required for weapons. The 20 kilograms of HEU needed for a weapon could be produced in about four and one half months.[8] Further only about 600 kilograms of 3.5% would be required to produce 20 kilograms of HEU, so the current stockpile of about 2,450 kilograms of 3.5% enriched uranium would be more than enough for four weapon's worth of HEU, though this entire process would take more than one year to complete. Additionally, using its current stockpile in this fashion would require Iran to violate IAEA safeguards. The time required could be shortened by assuming that the clandestine enrichment plant contains more that 23 cascades but a very large clandestine enrichment plant appears to be implausible currently, given Iran's resources.

Overall Iran continues to make increasingly rapid progress towards acquiring the ability to produce fissile material for nuclear weapons completely unimpeded by any Western counteraction. While one can argue about the existence of possible Iranian clandestine enrichment facilities, the ability of Iran to produce HEU by batch recycling at the FEP at Natanz is undeniable. Using its current stockpiles of 3.5% enriched uranium and 19.7% enriched uranium, Iran can now produce a weapon's worth (20 kilograms) of HEU any time it wishes. With Iran's current number of operating centrifuges, the batch recycling process would take about two months. As Iran produces additional 19.7% enriched uranium and/or brings additional centrifuges on line, this time span will only decrease.

Since the last IAEA report on Iran in February, there have been a large number of momentous news events that have pushed Iran and its drive for nuclear weapons out of

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credible assurance about the absence of undeclared nuclear material and activities in Iran, and therefore to conclude that all nuclear material in Iran is in peaceful activities." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/29, May 24, 2011, p.9.

[7] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/7, February 25, 2011, p.9.

[8] Using tails of 0.4%.

the spotlight.[9] This fact was illustrated by the reporting of Israeli Prime Minister Benjamin Netanyahu's speech to a joint session of the U.S. Congress on May 24, 2011, the same date as the IAEA released its latest report on Iran. Though roughly a fifth of this speech dealt with the nuclear threat from Iran, there was no mention of this fact in the U.S. media accounts of this speech.

Regarding Iran's nuclear program, Netanyahu said "Israel always reserves the right to defend itself," indicating that Israel might yet preemptively strike Iran's nuclear program.[10] However, Netanyahu clearly would prefer that the U.S. be the one to take action, saying, "This is why I ask you to continue to send an unequivocal message: that America will never permit Iran to develop nuclear weapons."

Unfortunately, it is unclear what actions the U.S. or Israel could take (short of militarily occupying Iran) that could now prevent Iran from producing nuclear weapons. The reality is that both the U.S. and Israel have failed to prevent Iran from gaining the ability to produce nuclear weapons whenever Iran wishes to do so. It is time to recognize this policy failure and decide what to do next, based on a realistic assessment of Iran's uranium enrichment efforts.

[9] These have included a magnitude 9 earthquake off Japan, leading to a devastating tsunami as well as a nuclear disaster at Fukushima to rival Chernobyl; the worst tornado spring in U.S. history; and the Arab Spring which led to the overthrow of the governments in Egypt and Tunisia, civil war in Libya, and unrest in Syria, Yemen and Bahrain.

[10] For the text of this speech see: http://www.israelemb.org/index.php/en/latest-news/461-prime-minister-netanyahu-addresses-a-joint-meeting-of-congress