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Iran Nears the Finish Line in its Quest to Acquire the Ability to Produce Fissile Material for Nuclear Weapons:
Centrifuge Enrichment and the IAEA May 31, 2010 Update

In four prior reports, this author has outlined how Iran's growing centrifuge enrichment program will be able to provide it with the ability to produce fissile material for nuclear weapons.[1] On May 31, 2010 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 has thus far been ineffective and Iran has actually increased (by 4%) its production rate of 3.5% enriched uranium. At Iran's current rate of production its stockpile of 3.5% enriched uranium will reach 1,900 kilograms by the end of July 2010. With this amount of 3.5% enriched uranium Iran could then produce a weapon's worth (20 kilograms) of highly enriched uranium (HEU) any time it wishes by batch recycling at the Fuel Enrichment Plant (FEP) at Natanz. With Iran's current number of operating centrifuges the batch recycling process would take just over three months so that the earliest Iran could have enough HEU for a nuclear weapon is early November 2010.[3]

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 (all centrifuges installed up to now have been of the IR-1 type). Each cascade is designed to enrich natural uranium to 3.5% enriched uranium. These cascades are organized into "Units" of 18 cascades (2,952 centrifuges). Iran has installed centrifuges in three Units (A24, A26 and A28) and work is proceeding on five more Units (A21, A22, A23, A25 and A27). 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 as single centrifuges or small ten or twenty centrifuge test cascades. There are two full cascades each with 164 IR-1 type centrifuges at the PFEP. 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

[1] "Iran's Increasing Progress towards a Nuclear Weapons Capability: Centrifuge Enrichment and the IAEA February 18, 2010 Update", February 23, 2010, http://www.npec-web.org/files/20100223-Jones_Iran_Enrichment_Update.pdf, *IAEA November 16, 2009 Update, Implications for Iran's Ability to Produce Fissile Material for Nuclear Weapons*, November 17, 2009, http://npec-web.org/files/20091117-Jones%20Iran%20Enrichment%20Update.pdf; *Iran's Centrifuge Enrichment Program as a Source of Fissile Material for Nuclear Weapons: An Update*, August 17, 2009, appendix added August 31, 2009, http://www.bipartisanpolicy.org/sites/default/files/Iran%20Enrichment%20Update%20%282%29.pdf and *Iran's Centrifuge Enrichment Program as a Source of Fissile Material for Nuclear Weapons*, April 8, 2008. http://www.npec-web.org/Essays/20081017-Jones-IranEnrichment.pdf

[2] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions 1737 (2006), 1747 (2007), 1803 (2008) and 1835 (2008) in the Islamic Republic of Iran*, GOV/2010/28, May 31, 2010.

[3] Iran could produce an actual weapon in one year or less. The weaponization process could take place in parallel to the production of HEU. See: Greg Jones, "When Could Iran Have the Bomb? An Analysis of Recent Statements That Iran is 3 to 5 Years Away", April 27, 2010, http://www.npec-web.org/node/1255

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. No centrifuges have yet been installed at FFEP.

Iran began producing 3.5% enriched uranium at the FEP in 2007. According to the latest IAEA update as of May 1, 2010, Iran had produced a total of 1,641 kilograms of 3.5% enriched uranium (in the form of 2,427 kilograms of uranium hexafluoride). This is an increase of 245 kilograms since January 29, 2010. The rate of production over this period was 81 kilograms per month which is a 4% increase since the last update.[4] As has been shown in my prior analysis and illustrated again in Table 1, Iran will need around 1,900 kilograms of 3.5% enriched uranium to be able to produce 20 kilograms of HEU by batch recycling at the FEP. At its current rate of production Iran will achieve this goal by the end of July 2010. Using Iran's currently operating centrifuges at the FEP, the batch recycling would take a little more than 3 months so that the earliest Iran could produce a nuclear weapon by this process is early November 2010.

Table 1

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (24 Operating Cascades, 3,936 Centrifuges, 0.87 SWU per Machine-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.75% 157 kg	3.5% 1,860 kg	81
Second	90.0% 20 kg	19.75% 153 kg	16
Total			95*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by six days to account for the 12 kilograms of 19.75% enriched uranium that Iran will have produced by the end of July 2010.

The latest IAEA update indicates that Iran has installed all 18 cascades in A24 and A26 and 16 cascades in A28. This is a total of 52 cascades (8,528 centrifuges). However, as of May 24, 2010 only 24 cascades (3,936 centrifuges—18 cascades in A24 and 6 cascades in A26) were actually producing enriched uranium. The reason that the additional cascades continue to be non-operational is unclear. At the last update Iran had 23 cascades in operation so that the increase to 24 operating cascades represents an increase of 4%--the same as the increase in 3.5% enriched uranium production. This fact indicates that the enrichment output per centrifuge remains at 0.87 SWU per centrifuge-

[4] 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.

year—the same as at the last update. Since the value during the first part of 2009 was only 0.5 SWU per centrifuge-year, this result shows that the 75% increase that I found in my last analysis was real and not some reporting artifact. The 3,936 centrifuges producing 0.87 SWU per centrifuge-year currently gives the FEP a total enrichment output of about 3,400 SWU per year. If all 52 cascades (8,528 centrifuges) were to become operational then the time to produce a weapon's worth of HEU by batch recycling at the FEP would drop to just 50 days (see table 2).

Table 2

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (52 Operating Cascades, 8,528 Centrifuges, 0.87 SWU per Machine-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.75% 163 kg	3.5% 1,930 kg	38
Second	90.0% 20 kg	19.75% 153 kg	8
Total			47*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by three days to account for the 12 kilograms of 19.75% enriched uranium that Iran will have produced by the end of July 2010.

As was reported in the last IAEA update, Iran is using one of its 164 centrifuge cascades at the PFEP to process 3.5% enriched uranium into 19.75% enriched uranium. As of April 7, 2010 Iran had produced 3.9 kilograms (in the form of 5.7 kilograms of uranium hexafluoride). Given that such production began on February 11, 2010, the production rate is 2.2 kilograms per month. At this production rate Iran will have produced a total of about 8 kilograms of 19.75% enriched uranium by the end of May 2010 and about 12 kilograms of 19.75% enriched uranium by the end of July 2010.

Iran's production of 19.75% enriched uranium means that it is moving even closer to the production of HEU. Iran is carrying out the first enrichment cycle shown in Tables 1 and 2, albeit at a low rate. Given that Iran would need about 160 kilograms of 19.75% enriched uranium per weapon's worth of HEU, the current rate will only produce this amount of 19.75% enriched uranium by about February 2016. However, Iran could easily achieve this goal much faster. Having established the principle that it can produce 19.75% enriched uranium while under IAEA safeguards, Iran would not need to limit this effort to only one cascade. For example if it were to use 12 cascades instead, the time required would only be six months i.e. before the end of 2010. Even if Iran were to continue to use only one cascade to produce the 19.75% enriched uranium, the time

required to produce HEU by batch recycling at the FEP would decline since less 19.75% enriched uranium would need to be produced in the first cycle. This effect is shown in Tables 1 and 2 for the 12 kilogram stockpile of 19.75% enriched uranium that Iran will have produced by the end of July 2010. As Iran's stockpile grows even larger, the times shown in Tables 1 and 2 will be further reduced.

Another important development at the PFEP is that Iran has installed a second 164 centrifuge cascade. According to Iranian statements to the IAEA, the purpose of this second cascade is not to increase Iran's rate of 19.75% enriched uranium production but rather to strip the tails produced by the cascade that is producing the 19.75% enriched uranium. Iran produces the 19.75% enriched uranium by using 3.5% enriched feed along with its standard 164 centrifuge cascade. With this setup the tails produced would be about 2% enriched uranium. Leaving this material fallow would waste a good deal of U-235. Iran plans to use the second cascade to reduce the tails enrichment from 2% to about natural concentration i.e. about 0.7%.[5]

This development has a significant impact on the amount of 3.5% enriched uranium Iran would need to use to produce a weapon's worth of HEU. Our calculations in Tables 1 and 2 assumed no stripping of the intermediate tails and as a result about 1,900 kilograms of 3.5% is needed. But by reducing the tails produced by the first recycle from 2% to 0.7%, the required amount of 3.5% enriched uranium feed would drop to about 1,100 kilograms—an amount already exceed by its May 1, 2010 stockpile of 1,641 kilograms.

Iran has yet to put this second cascade into operation and even when it does Iran will still be using just one cascade to produce 19.75% enriched uranium. But this development illustrates that in the long-term, Iran will be able to use its 3.5% enriched uranium stockpile more efficiently and produce more HEU from a given amount of 3.5% enriched uranium. Ultimately if Iran were to strip the tails from the second recycle stage shown in Tables 1 and 2 (which would be about 9.2% enriched uranium), then Iran could produce a weapon's worth of HEU from about 600 kilograms of 3.5% enriched uranium feed. Likewise the amount of 19.75% enriched uranium required to produce a weapon's worth of HEU would decline from about 160 kilograms to about 105 kilograms.

Nor is batch recycling of enriched uranium at the FEP the only pathway for Iran to produce the fissile material required for nuclear weapons. 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. The IAEA has admitted as much in its latest safeguards update.[6] While this has been a theoretical possibility since 2007, the discovery in September 2009 that Iran was actually building such a clandestine enrichment plant (the

[5] The 0.7% enriched uranium could then be used as feed at the FEP.

[6] "While the Agency continues to verify the non-diversion of declared nuclear material in Iran, Iran has not provided the necessary cooperation to permit the Agency to confirm that all nuclear material in Iran is in peaceful activities." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions 1737 (2006), 1747 (2007), 1803 (2008) and 1835 (2008) in the Islamic Republic of Iran*, GOV/2010/28, May 31, 2010, p.8.

FFEP near Qom) has increased the salience of this concern. A clandestine enrichment plant containing 24 cascades (3,936 centrifuges, 0.87 SWU per machine-year) could produce around 20 kilograms of HEU (the amount required for one nuclear weapon) each year. 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. Another consequence of Iran's refusal to implement the Additional Protocol to its IAEA safeguards is that this uranium mining is unsafeguarded and the whereabouts of the uranium that has been produced here is unknown.

Overall Iran continues to make steady 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. At Iran's current rate of production its stockpile of 3.5% enriched uranium will reach 1,900 kilograms by the end of July 2010. With this amount of 3.5% enriched uranium Iran could then produce a weapon's worth (20 kilograms) of highly enriched uranium (HEU) any time it wishes. With Iran's current number of operating centrifuges the batch recycling process would take just over three months so that the earliest Iran could have enough HEU for a nuclear weapon is early November 2010.

It appears that Iran may well soon join Pakistan, India, and North Korea on the list of U.S. nonproliferation failures. One hopes that the residents of Tel Aviv, New York or Washington D.C. will not have to pay too great a price for this latest failure.