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September 9, 2010

Iran Achieves the Ability to Produce Fissile Material for Nuclear Weapons and Maintains Steady Enriched Uranium Production: Centrifuge Enrichment and the IAEA September 6, 2010 Update

In five 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 September 6, 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 have thus far been ineffective. Iran maintains a steady production rate of about 80 kilograms of 3.5% enriched uranium per month.[3] Iran has maintained this production rate throughout all of 2010 and this rate is about 40% higher than its production rate in most of 2009.

As of early August, Iran had produced 1,895 kilograms of 3.5% enriched uranium (in the form of 2,803 kilograms of uranium hexafluoride). This quantity of 3.5% enriched uranium is almost exactly the amount required to produce a weapons worth (20 kilograms) of highly enriched uranium (HEU) by batch recycling at the Fuel Enrichment Plant (FEP) at Natanz. With Iran's current number of operating centrifuges the batch recycling would take just over three 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. It is producing the intermediate product of 19.75% enriched uranium. Iran has increased its production rate of 19.75% enriched uranium from 2.2 kilograms per month to 2.9 kilograms per month and by early August had accumulated a stockpile of about 15 kilograms of 19.75% enriched uranium. As Iran's stockpile of 19.75% enriched uranium continues to grow, the time required for it to be able to produce a weapons worth of HEU will continue to decline. At its current rate of production, four years from now, the time required will have dropped from the current three months to just a few weeks even assuming that Iran does not increase its number of operating centrifuges.

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

[1] My most recent prior report is: "Iran Nears the Finish Line in its Quest to Acquire the Ability to Produce Fissile Material for Nuclear Weapons", June 2, 2010, http://www.npolicy.org/node/1299. This document contains references to the other four prior reports.

[2] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2010/46, September 6, 2010.

[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.

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 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 August 6, 2010, Iran had produced a total of 1,895 kilograms of 3.5% enriched uranium (in the form of 2,803 kilograms of uranium hexafluoride).[4] This is an increase of 254 kilograms since May 1, 2010. The rate of production over this period was 80 kilograms per month which is about the same as it as been for all of 2010 and represents about a 40% increase over the rate in 2009.[5] As has been shown in my prior analysis and illustrated again in Table 1, Iran needed around 1,900 kilograms of 3.5% enriched uranium to be able to produce 20 kilograms of HEU by batch recycling at the FEP. Iran has now achieved this goal and can produce the HEU whenever it wishes. Using Iran's currently operating centrifuges at the FEP, the batch recycling would take a little more than 3 months.

Table 1

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (23 Operating Cascades, 3,772 Centrifuges, 0.89 SWU per Centrifuge-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.75% 157 kg	3.5% 1,860 kg	82
Second	90.0% 20 kg	19.75% 153 kg	17
Total			94*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by nine days to account for the 18 kilograms of 19.75% enriched uranium that Iran will have produced by the first part of September 2010.

[4] Note that 210 kilograms of the 3.5% enrich uranium has already been further enriched at the PFEP (see below).

[5] From January 29, 2010 to May 1, 2010, the average production rate was 81 kilograms per month, from November 23, 2009 to January 29, 2010 the average production rate was 78 kilograms per month whereas from January 31, 2009 to November 22, 2009 the production rate was only 57 kilograms per month.

The latest IAEA update indicates that Iran has installed all 18 cascades in A24, A26 and A28. This is a total of 54 cascades (8,856 centrifuges). However, as of August 28, 2010 only 23 cascades (3,772 centrifuges—17 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 24 cascades in operation so that the decrease to 23 operating cascades should represent a 4% decrease in the amount of 3.5% enriched uranium produced. However, the real decrease was only about 2% which would imply a 2% increase in the amount of enrichment output per centrifuge (0.89 SWU per centrifuge-year).[6] The 3,772 centrifuges producing 0.89 SWU per centrifuge-year currently gives the FEP a total enrichment output of about 3,400 SWU per year. If all 54 cascades (8,856 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 43 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 (54 Operating Cascades, 8,856 Centrifuges, 0.89 SWU per Centrifuge-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.75% 162 kg	3.5% 1,920 kg	36
Second	90.0% 20 kg	19.75% 153 kg	7
Total			43*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by four days to account for the 18 kilograms of 19.75% enriched uranium that Iran will have produced by the first part of September 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 August 2, 2010 Iran had produced 15 kilograms of 19.75% enriched uranium (in the form of 22 kilograms of uranium hexafluoride). The production rate has increased from 2.2 kilograms per month to 2.9 kilograms per month during the interval April 8, 2010 to August 20, 2010. At this production rate Iran will have produced a total of about 18 kilograms of 19.75% enriched uranium by the first part of September 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

[6] Another possibility is that Iran actually operated 24 cascades during much of this reporting period and there just happened to be 23 in operation when the plant was inspected by the IAEA.

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 October 2014. 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 3 cascades instead, the time required would only be sixteen months i.e. January 2012.[7] 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 will 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 18 kilogram stockpile of 19.75% enriched uranium that Iran has produced by the first part of September 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 designed the second cascade to reduce the tails enrichment from 2% to about natural concentration i.e. about 0.7%.[8] This stripping cascade started operation on July 13, 2010.

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. This means that by having already produced about 1,900 kilograms of 3.5% enriched uranium, Iran is well on its way to having the 2,200 kilograms of 3.5% enriched uranium needed to produce the HEU required for two nuclear weapons.

This development illustrates that in the long-term, Iran intends 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)[9], 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

[7] There is space for four additional cascades at the PFEP but assuming that each enriching cascades will have a stripping cascade attached (see next paragraph), two additional cascades producing 19.75% enriched uranium could be installed.
[8] The 0.7% enriched uranium could then be used as feed at the FEP.
[9] If the 9.2% tails were stripped to 3.5% enriched uranium then this recovered material could be fed back into the enrichment process.

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.[10] 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 FFEP near Qom) has increased the salience of this concern. 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. 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. Since it has now produced the required 1,900 kilograms of 3.5% 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 just over three months. As Iran produces additional 19.75% enriched uranium and/or bring additional centrifuges on line, this time will only decrease.

It appears to be too late to prevent Iran from obtaining the HEU required to produce a nuclear weapon and Iran must now rank along with Pakistan, India and North Korea as U.S. nonproliferation failures. The discussion must now shift to the issues of how fast Iran will be able to acquire the fissile material for additional weapons and what the configuration of Iran's nuclear arsenal might be.

[10] "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 in the Islamic Republic of Iran*, GOV/2010/46, September 6, 2010, p.10.