Gregory S. Jones
November 30, 2010

Iran's Rate of Enriched Uranium Production Continues to Increase: Centrifuge Enrichment and the IAEA November 23, 2010 Update

In six 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 November 23, 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 continue to be ineffective. Iran has increased its enriched uranium production rate from about 80 kilograms of 3.5% enriched uranium per month to 91 kilograms of 3.5% enriched uranium per month.[3] This is a 14% increase and represents a 60% increase over Iran's 2009 production rate.

As of the end of October, Iran had produced 2,152 kilograms of 3.5% enriched uranium (in the form of 3,183 kilograms of uranium hexafluoride). With this quantity of 3.5% enriched uranium, Iran could produce a weapon's 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 less than two and one half 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. By mid-November Iran had accumulated a stockpile of about 22 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.

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 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.

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[1] My most recent prior report is: "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, September 9, 2010, http://www.npolicy.org/node/1352

[2] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2010/62, November 23, 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.

Since February 2010, Iran has been processing 3.5% enriched uranium into 19.75% enriched uranium 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 October 31, 2010, Iran had produced a total of 2,152 kilograms of 3.5% enriched uranium (in the form of 3,183 kilograms of uranium hexafluoride).[4] This is an increase of 257 kilograms since August 6, 2010. The rate of production over this period was 91 kilograms per month which is a 14% increase over Iran's production rate for the first part of 2010 and a 60% increase over Iran's production rate in 2009.[5] As has been shown in my prior analysis and illustrated again in Table 1, Iran needs 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 surpassed this goal and can produce the HEU whenever it wishes. Using Iran's currently operating centrifuges at the FEP, the batch recycling would take less than two and one half months.

Table 1

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (29 Operating Cascades, 4,816 Centrifuges, 0.89 SWU per Centrifuge-Year)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	19.75% 158 kg	3.5% 1,870 kg	65
Second	90.0% 20 kg	19.75% 153 kg	13
Total			73*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by nine days to account for the 22 kilograms of 19.75% enriched uranium that Iran has already produced.

[4] Note that 280 kilograms of the 3.5% enrich uranium has already been further enriched at the PFEP.
[5] From May 1, 2010 to August 6, 2010 the average production rate was 80 kilograms per month, 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.

Iran has installed all 18 cascades in A24, A26 and A28 for a total of 54 cascades. This should give a total of 8,916 centrifuges (48 x 164 + 6 x 174) but the current IAEA update says that there are only 8,426. However, throughout 2009 and 2010 Iran has been running many fewer cascades than it has installed. As of November 5, 2010 only 29 cascades (4,816 centrifuges) were actually producing enriched uranium. This is an increase of six cascades (1,044 centrifuges, a 28% increase) since the last IAEA update. While the 23 cascades that have been operating previously are all 164 centrifuge cascades, the 6 new cascades brought on line have been modified to have 174 centrifuges. The reason for this modification is not known. Adding more centrifuges to each cascade could allow Iran to achieve higher uranium enrichment, or use its uranium resources more efficiently by lowering the enrichment of the tails or it could allow the cascade to operate more efficiently by allowing a more properly tapered flow. At any rate, this modification does provide an explanation for why many cascades have not been operating and it means that more cascades could be coming on line soon as Iran completes their modifications. The 4,816 centrifuges producing 0.89 SWU per centrifuge-year currently gives the FEP a total enrichment output of about 4,300 SWU per year. If all 54 cascades (8,916 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 42 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, 8,916 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			42*

*Includes four days to account for equilibrium and cascade fill time. The total time has been reduced by five days to account for the 22 kilograms of 19.75% enriched uranium that Iran has already produced.

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 as well in prior safeguards updates.[6] While this has been a theoretical possibility since 2007, the

[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

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.

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.[7] Further only about 600 kilograms of 3.5% would be required to produce 20 kilograms of HEU, so that current stockpile of 2,152 kilograms of 3.5% enriched uranium would be more than enough for three weapon's worth of HEU though this entire process would take more than one year to complete. Furthermore, 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 currently be implausible 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. Since it has now produced more 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 less than two and one half 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.

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peaceful activities." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2010/64, November 23, 2010, p.8.

[7] Using tails of 0.4%.