May 24, 2011

IAEA Iran Safeguards Report:

LEU Monthly Production Dramatically Higher but Centrifuges less Efficient than Optimal; Deployment of Advanced Centrifuges Delayed; IAEA's Knowledge about Iran's Enrichment Activities Continues to Diminish (Revised May 25)

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The International Atomic Energy Agency (IAEA) released on May 24, 2011 its latest report on the implementation of NPT safeguards in Iran and the status of Iran's compliance with Security Council Resolutions. The following analysis highlights the IAEA's key findings, including: 1) continuing clearer statements about Iran not meeting its obligations under its safeguards agreement and United Nations Security Council resolutions; 2) the average monthly rate of low enriched uranium (LEU) production increased significantly from the last reporting period, and the number of centrifuges slightly increased, which raises the possibility of ongoing problems in its centrifuge modules; 3) two 164-machine cascades of new advanced centrifuges have not yet been deployed at the Natanz Pilot Fuel Enrichment Plant, as expected; 4) the IAEA's information about Iran's enrichment activities continues to diminish; 5) monthly production rates of 20 percent enriched LEU slightly increase; 6) the Bushehr nuclear power reactor went critical on May 10, 2011; and 7) the IAEA has more new evidence about Iran's weaponization activities.

One special note: The IAEA continues to release less information about the Natanz Fuel Enrichment Plant (FEP)'s operation, making it more difficult to evaluate the plant's performance. The IAEA should again release this information.

LEU production and centrifuge levels at Natanz Fuel Enrichment Plant

Iran's total LEU production at the FEP through May 13, 2011 is reported to be 4,105 kg of low enriched uranium hexafluoride, including 499 kg estimated by Iran to have been produced since February 5, 2010. The FEP is Iran's primary enrichment facility, where the majority of its IR-1 centrifuges are installed. Activity at the pilot fuel enrichment plant (PFEP), where Iran has begun to enrich uranium up to the 20 percent level, is discussed below.

The average production of LEU at the FEP reached 156 kg per month of LEU hexafluoride (for the last reporting period we noted it was 133 kg of LEU hexafluoride). This monthly rate is the highest level that Iran has ever achieved. The current average represents a 17 percent increase from the last reporting period, and an over 30 percent increase in monthly LEU output since the summer of 2010 when Stuxnet was discovered.[1]

As of May 14, 2011, Iran was enriching in 35 cascades, containing a total of 5,860 IR-1 centrifuges. The IAEA noted that some of these centrifuges "were possibly not being fed" with uranium hexafluoride. At the end of the last reporting period, Iran was enriching in 31 cascades, containing a total of 5,184 IR-1 centrifuges. So, it has increased the number of enriching centrifuges by 676 centrifuges, or by 13 percent. Some 2,100 centrifuges are installed but not being fed with uranium hexafluoride, according to this report. The total number of centrifuges installed is given as about 8,000 centrifuges, the same as in the last report. Uranium hexafluoride feed rates are not given. Figures 1-4 illustrate these trends at Natanz.

The average monthly LEU production value provides some insight into the FEP's performance. At the end of the previous reporting period, the average value was 0.026 kg of LEU hexafluoride per month per centrifuge. At the end of the current reporting period, the average is about 0.027 kg LEU hexafluoride per month per centrifuge. This represents a four percent increase. It is important to note that the number of centrifuges declared as enriching increased by 13 percent since the last reporting period. The IAEA repeats in this report that not all these centrifuges are likely fed with uranium hexafluoride. Overall, the results suggest that the older centrifuges in modules 24 and 26, or roughly 4,000 centrifuges, operate better than the centrifuges that have started to enrich in the last three reporting periods. Or, roughly 1,800 IR-1 may operate less than the older centrifuges.

This situation can also be understood by using an equivalent method that is easier to compare to historical enrichment output at the FEP, namely the output measured in separative work units (swu). ISIS derives this value from the declared LEU production. In the most recent reporting period, the LEU value is used with an assumption that the material is 3.5 percent enriched and the waste has a tails assay of 0.4 percent. The IAEA did not provide these updated numbers in this report, but these numbers are consistent with data in earlier reports. Using standard enrichment calculators, 499 kg LEU translates to 1,228 kg of separative work units (swu), or 12.8 kg swu/day. On an annualized basis, this is 4,670 swu per year (see Figure 5). The number of centrifuges declared as enriching was 5,860 at the end of this period and 5,184 centrifuges at the beginning. Thus the possible range of averaged values is 0.8 kg U swu per year per centrifuge at the end of the reporting period and 0.90 kg U swu per year per centrifuge at its beginning. For most of 2010, this value was about 0.9 kg U swu per year per centrifuge (see Table 1, which lists these values on a quarterly basis since the FEP started operation, and Figure 5, which displays this data graphically). These numbers again imply that there could be a problem affecting these newer 1,800 centrifuges. Some fraction of them may not have enriched during the latest reporting period, or they may be enriching inefficiently or sporadically.

[1] The IAEA uses different reporting period dates for LEU production in its latest reports, which can cause a discrepancy in monthly LEU output if one is not careful. In the May 24, 2011 IAEA report, cumulative LEU production from October 18, 2010 to May 13, 2011 is reported. In the February 25, 2011 IAEA report, the LEU production is reported from November 1, 2010. In this ISIS report, the monthly LEU production is derived by subtracting the total LEU values reported in the May and February IAEA reports, 4,105 kg and 3,606 kg, respectively. The subtraction gives 499 kg.

No Deployment of Advanced Centrifuges at Pilot Fuel Enrichment Plant (PFEP), 20 Percent Enrichment Continues

Iran has designated two cascades at the smaller, above-ground pilot fuel enrichment plant for the production of LEU enriched to nearly 20 percent uranium-235 for the Tehran Research Reactor (TRR). One of these cascades enriches from 3.5 percent LEU to almost 20 percent LEU, while the second one takes the tails from the first one and outputs about 10 percent LEU and a tails of natural uranium. The ten percent material is fed into the first cascade in addition to 3.5 percent LEU. This process allows Iran to more efficiently use its 3.5 percent LEU stock.

Between February 12, 2011 and May 21, 2011, 86.9 kg of 3.5 percent low enriched uranium in the form of uranium hexafluoride was introduced into the two, interconnected cascades, and Iran withdrew a total of 13.1 kg of nearly 20 percent LEU hexafluoride. During the reporting period, Iran produced 19.75 percent enriched uranium at a rate of 3.91 kg/month, a slight increase from the average rate of 3.69 kg per month since February 9, 2010. In total, Iran has fed 574.1 kg of 3.5% LEU to produce 56.7 kg 19.75% uranium.

Iran has not installed two cascades of advanced centrifuges at the PFEP as it said it would. In January 2011, as reported previously by the IAEA, Iran indicated it would install two additional 164-centrifuge cascades, Cascades 4 and 5, in the R&D area at the PFEP. One would contain the IR-2m centrifuges and the other the IR-4 centrifuges. The IAEA reports that installation work of Cascades 4 and 5 is ongoing but no advanced centrifuges have yet been installed. This may imply that Iran is having trouble manufacturing these more advanced centrifuges.

Little information is publicly available about the IR-2m or IR-4 centrifuges, but they are both assessed as significantly more advanced than the IR-1 centrifuge and should have a significantly higher enrichment output and a lower failure rate than the IR-1 centrifuge. The two cascades would be fed with natural uranium hexafluoride, not 3.5 percent LEU. The purpose of operating these cascades is likely to demonstrate performance prior to installation of such cascades at Natanz or other enrichment sites.

Knowledge about Enrichment Activities Diminishing, Construction of Secret Sites Possible

The IAEA reports that its knowledge overall about Iran's enrichment activities "continues to diminish," which ISIS believes raises questions about whether Iran could again be building enrichment sites in secret. The IAEA reports that Iran has not yet provided any information about its plans to construct ten additional enrichment sites (even though Iran indicates it has chosen sites for five of these). It has not provided information about its deployment of advanced centrifuges or information about the locations of centrifuge manufacturing facilities.

The Agency reports that it has no information about whether construction of an additional enrichment plant has started. Iran announced earlier that it planned to start construction as soon as early spring 2011. Uncertainty about another secret enrichment site should be of concern to the international community. Iran kept the Fordow site hidden until Western intelligence publicly

revealed it and has indicated it will not provide the IAEA with information about additional enrichment sites until six months prior to the introduction of nuclear material.

No centrifuges yet installed at the Fordow Enrichment Site

Iran has still not installed any centrifuges at the Fordow site near Qom. Iran claimed in February 2011 to the IAEA that it planned to begin feeding nuclear material into cascades "by this summer."

The available information continues to support assessments that after its discovery by Western intelligence, Iran downgraded the role of the Fordow plant as a centrifuge facility. Iran has declared that the plant will hold only twelve cascades of IR-1 centrifuges. The other part of the plant will be devoted to research and development of more advanced centrifuges.

The delay in installing centrifuges and reduction in the planned number of IR-1 centrifuges at Fordow suggests that Iran could be de-emphasizing the site following its discovery and will concentrate on constructing new secret sites. Although Iran says it will eventually declare those sites to the IAEA, doubts remain. In several cases, including with Natanz, Kalaye Electric, Lavizan Shian, and now the Fordow site, Iran only declared the formerly secret sites after their discovery by other nations and groups. The new developments at Fordow also contradict speculation that Iran wants to build and operate many centrifuge plants at once, as opposed to what it now appears to be doing—building multiple facilities that will not be outfitted with large numbers of centrifuges unless they can remain secret sites that could be used in a breakout.

The IAEA reports that it still "cannot confirm the chronology of the design and construction of the FFEP [Fordow Fuel Enrichment Plant] or its original purpose" and that Iran has told the Agency it is "not mandated to raise questions that are beyond its Safeguards Agreement." The IAEA notes that it considers the questions it has raised about Fordow to be "within the terms of the Safeguards Agreement, in that the information requested is essential for the Agency to confirm that the declarations of Iran are correct and complete."

Bushehr Nuclear Power Reactor Has Reached Criticality, Earthquake Warnings Ignored

The IAEA reports that Iran informed it on May 10 that the Bushehr nuclear power plant reached criticality. The Agency conducted a physical inventory verification (PIV) on April 15-16 and verified all nuclear material present and the completeness of the loading of fuel assemblies into the core. In February, Iran had unloaded fuel assemblies from the core of the reactor due to a broken pump that spread metal shards into the reactor core.

The media obtained a secret report written by Iranian scientists which warned of the possibility of earthquakes causing a serious accident at the Bushehr nuclear plant on the scale of the Fukushima nuclear plant crisis in Japan. The *Telegraph* quotes a senior Western official who said "Iranian officials have raised a number of serious issues highlighting the dangers earthquakes pose to the Bushehr plant, but the government has just ignored them." This report raises questions about the safety of the Bushehr reactor and Iran's wisdom in continuing with plans to build additional reactors given concerns about active seismic dangers in the country.

No Progress on Addressing Military Dimensions, IAEA has New Information about Iran's Undisclosed Activities

The IAEA reports that Iran has still refused to clarify and the Agency remains concerned about "the possible existence in Iran of past or current undisclosed nuclear related activities involving military related organizations, including activities related to the development of a nuclear payload for a missile." The IAEA notes, moreover, that since its last report in February, it has "received further information" related to these undisclosed nuclear related activities, which it is currently assessing.

Since the Agency first raised these concerns with Iran in August 2008, Iran has not provided access to locations, personnel, and information the Agency seeks in order to investigate these issues. Pursuant to resolving these outstanding issues and making progress on the "verification of the correctness and completeness of Iran's declarations," on May 6, 2011, IAEA Director General Amano sent a letter to newly appointed Vice President of Iran/head of Iran's Atomic Energy Organization, Fereydoun Abbasi, asking for "prompt access to relevant locations, equipment, documentation, and persons."

The IAEA lays out again very clearly in this report its lack of progress on investigating Iran's military related research and development by expanding on the list of areas over which it has concerns from its February report. It gives explicit definitions to the following areas it previously listed (quoted directly from pages 7-8):

- Neutron generator and associated diagnostics: experiments involving the explosive compression of uranium deuteride to produce a short burst of neutrons.
- Uranium conversion and metallurgy: producing uranium metal from fluoride compounds and its manufacture into components relevant to a nuclear device.
- High explosives manufacture and testing: developing, manufacturing and testing of explosive components suitable for the initiation of high explosives in a converging spherical geometry.
- Exploding bridgewire (EBW) detonator studies, particularly involving applications necessitating high simultaneity: possible nuclear significance of the use of EBW detonators.
- Multipoint explosive initiation and hemispherical detonation studies involving highly instrumented experiments: integrating EBW detonators in the development of a system to initiate hemispherical high explosive charges and conducting full scale experiments, work which may have benefitted from the assistance of foreign expertise.
- High voltage firing equipment and instrumentation for explosives testing over long distances and possibly underground: conducting tests to confirm that high voltage firing equipment is suitable for the reliable firing of EBW detonators over long distances.
- Missile re-entry vehicle redesign activities for a new payload assessed as being nuclear in nature: conducting design work and modeling studies involving the removal of the conventional high explosive payload from the warhead of the Shahab-3 missile and replacing it with a spherical nuclear payload.

Figure 1: Centrifuge Trends at Natanz

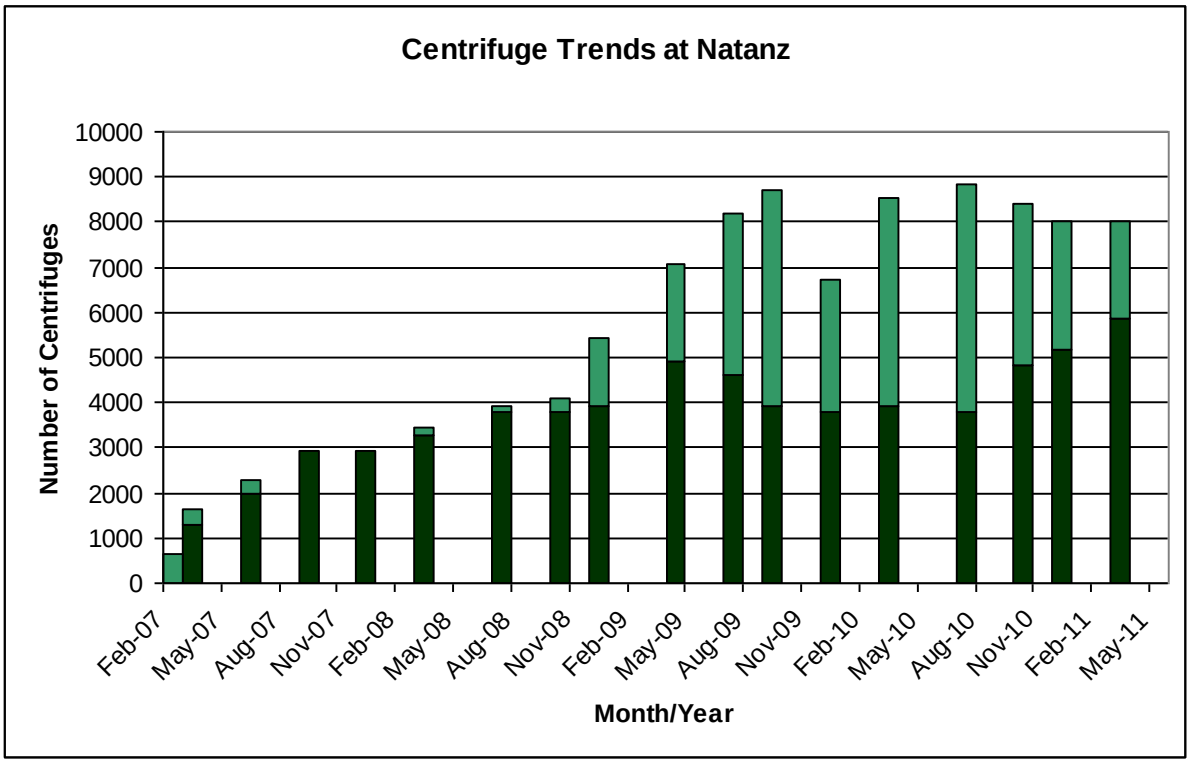

Figure 2: Uranium Hexaflouride Feed at Natanz

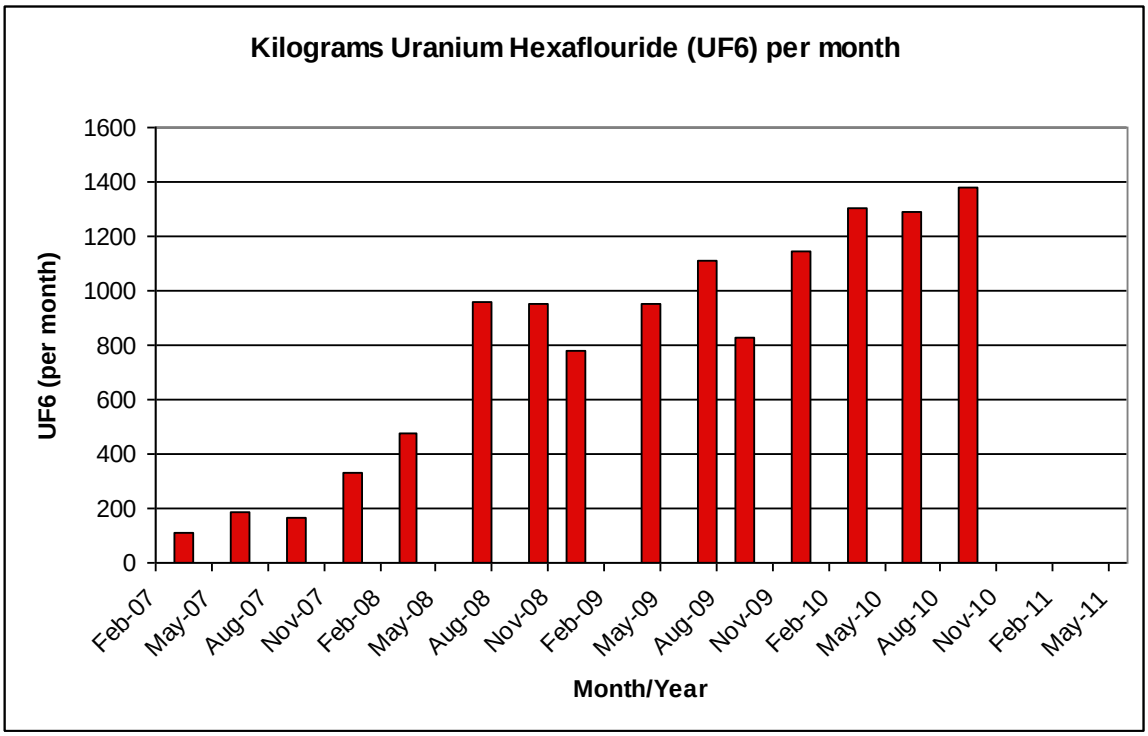

Figure 3: LEU Production (per month) at Natanz

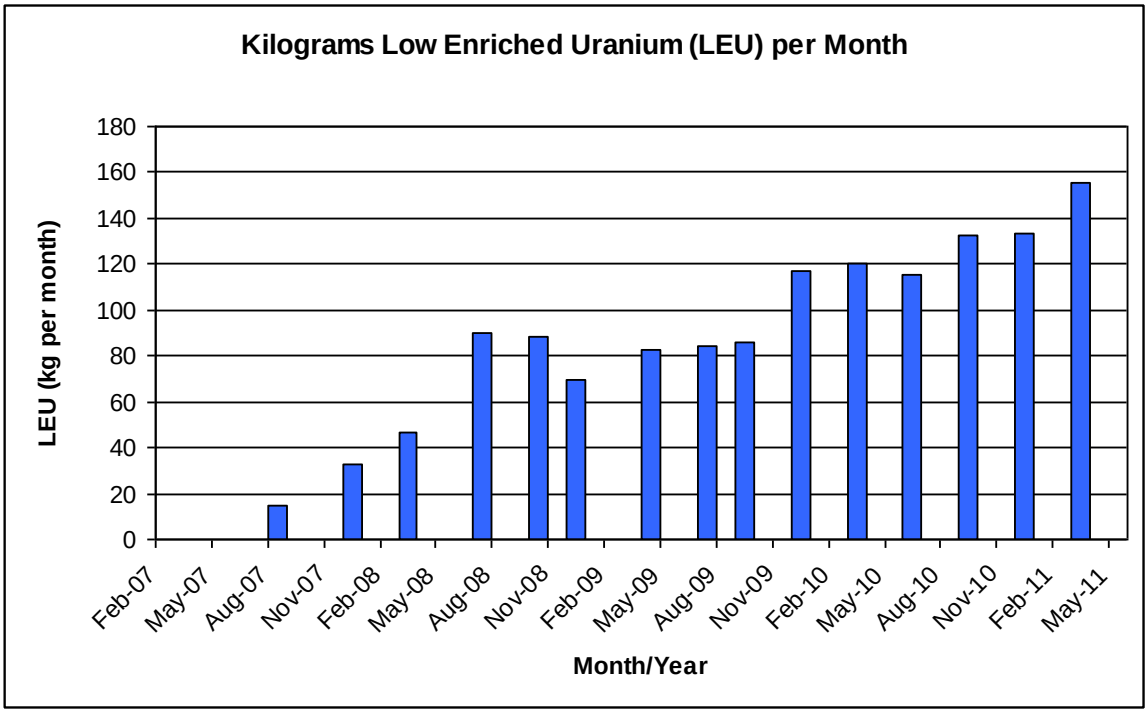

Figure 4: Overall Trends at Natanz

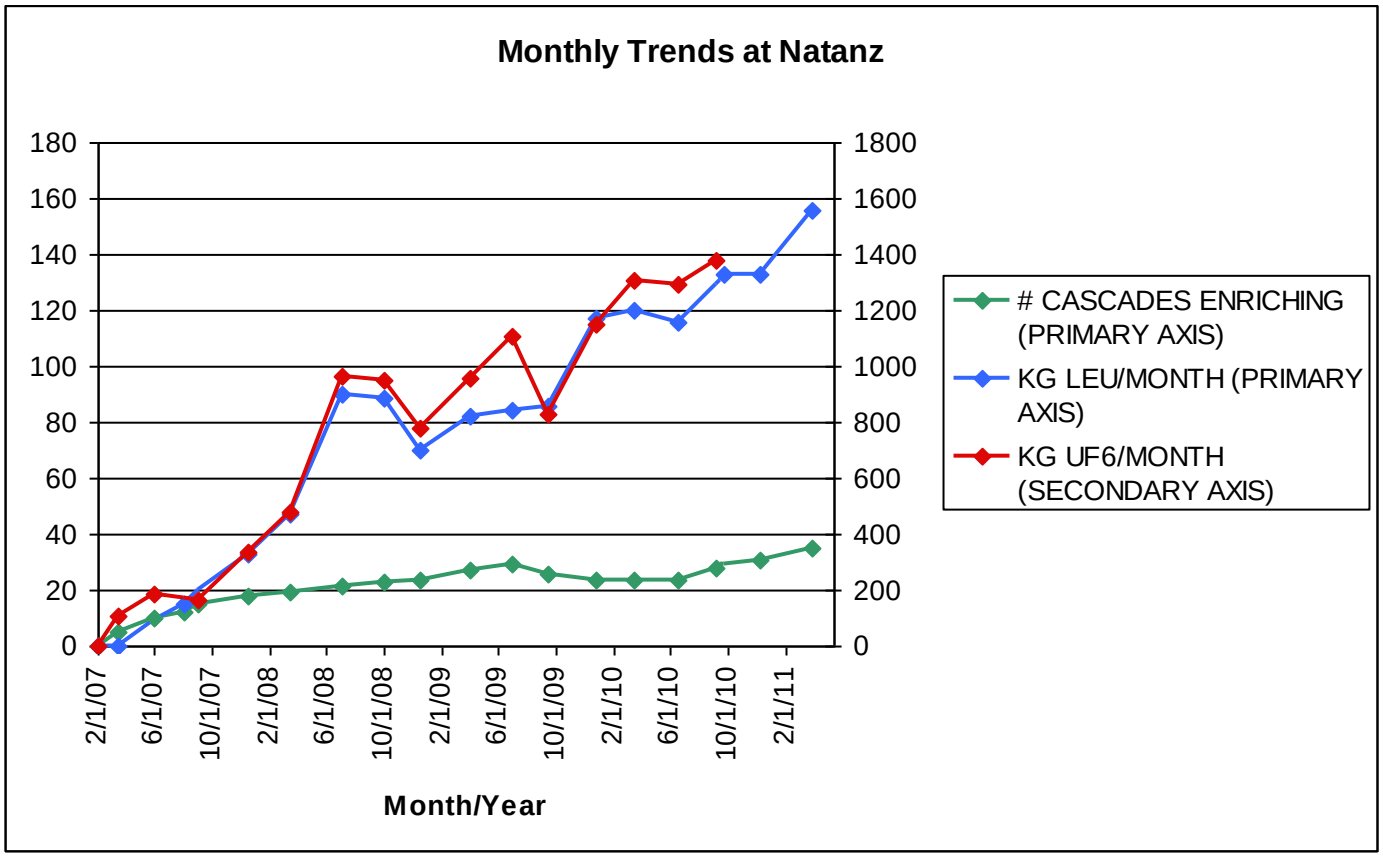

Figure 5: Annualized SWU at Natanz

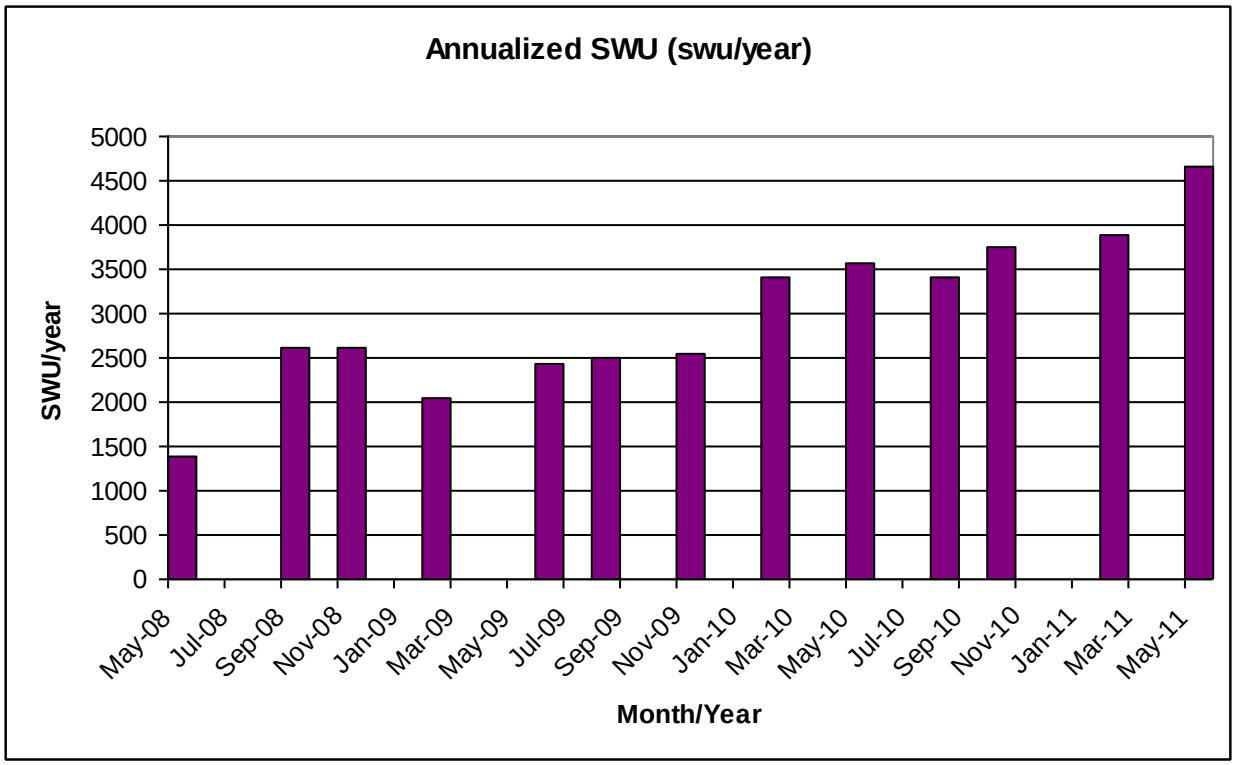

Table 1: Minimal Average Separative Capacity of an IR-1 Centrifuge at FEP (kg U swu/year-centrifuge)

Period	*Start of Period*	*End of Period*
12/13/2007 – 05/06/2008	0.47	0.43
05/07/2008 – 08/30/2008	0.80	0.69
08/31/2008 – 11/07/2008	0.69	0.69
11/08/2008 – 11/31/2009	0.55	0.52
02/01/2009 – 05/31/2009	0.62	0.49
06/01/2009 – 07/31/2009	0.51	0.54
08/01/2009 – 10/30/2009	0.55	0.64
11/23/2009 – 01/29/2010	0.88	0.92
01/30/2010 – 05/01/2010	0.92	0.90
05/02/2010 – 08/06/2010	0.90	0.92
08/07/2010 – 10/31/2010	0.99	0.78
10/18/2010 – 02/05/2011	0.75	0.81 (1.0 if 1,000 questionable centrifuges ignored)
02/06/2011 – 05/13/2011	0.90	0.80