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## ISIS Analysis of IAEA Iran Safeguards Report

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The International Atomic Energy Agency (IAEA) released on May 22, 2013 its [latest report](#) on the implementation of NPT safeguards in Iran and the status of Iran's compliance with Security Council resolutions.

### Key Findings:

- 1) Number of installed IR-1 centrifuges at Natanz Fuel Enrichment Plant (FEP) continues to increase, but at a slower rate than the last few reporting periods;
- 2) The IR-40 heavy water reactor at Arak appears to be nearing completion with operation expected in the second half of 2014; continued construction of the IR-40 reactor is in violation of United Nations Security Council resolutions;
- 3) New IR-2m advanced centrifuges continue to be installed at the Natanz FEP; both the number and preparatory work for future installation increased significantly; however, when they will start enriching or how well they will operate remains unknown;
- 4) Number of cascades producing near 20-percent low-enriched uranium (LEU) is constant;
- 5) Iran has less than enough 19.75-percent low-enriched uranium hexafluoride for one nuclear weapon if further enriched to weapon-grade, but its stock of near 20 percent LEU hexafluoride continues to grow;
- 6) Almost all of the cascades at the Fordow Fuel Enrichment Plant (FFEP) are now vacuum tested and likely ready for enrichment;
- 7) Iran continues converting near 20 percent LEU hexafluoride to oxide form, but not at a sufficient rate to reduce its stock of near 20 percent LEU hexafluoride. Nonetheless, Iran continues producing fuel for the Tehran Research Reactor (TRR);

8) Iran is using a Zero Power Reactor near Esfahan and the Tehran Research Reactor to test IR-40 Arak prototype reactor fuel; and

9) No progress on "structured approach" to resolve outstanding questions about military dimensions and no access to Parchin military site, which Iran continues to sanitize. The Parchin site is [now being asphalted](#).

## **LEU production and centrifuge levels at Natanz Fuel Enrichment Plant (FEP)**

**Iran's total 3.5 percent low enriched uranium (LEU) production at the FEP through May 4, 2013 is reported to be 8,960 kilograms (kg), including 689 kg estimated by Iran to have been produced since February 4, 2013.** 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 is enriching uranium up to the 20 percent level, is discussed below.

**The average production of 3.5 percent LEU at the FEP has remained consistent for the past few reporting periods at approximately 233 kg per month of LEU hexafluoride.**

As of May 15, Iran had 79 IR-1 centrifuge cascades fully installed and one additional cascade partially installed for a total of 13,555 IR-1 centrifuges. Iran has increased the number of IR-1 centrifuges installed at the FEP by 886 centrifuges since the end of the last reporting period. Iran has also maintained the same number of cascades enriching since the previous reporting period, for a total of 53 cascades or 8,992 centrifuges enriching. Iran fed 7,488 kg of natural uranium hexafluoride into the cascades at the FEP. This is consistent with the previous few reporting periods. Figures 1-5 illustrate these trends at Natanz.

Iran's centrifuge performance at the FEP can be evaluated in terms of 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 updated concentrations in this report, but these older numbers are used. Using standard idealized enrichment calculations, 689 kg of LEU translates to 1,694 kg of swu, or 19 kg swu/day. On an annualized basis, this is about 6,870 kg swu per year (see Figure 6). These numbers are consistent with the previous reporting period.

The average swu/centrifuge-year for this period remained at 0.76, which is consistent with performance at the FEP throughout 2012. However, 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). This consistently lower enrichment output likely indicates that Iran is continuing to have trouble with the IR-1 centrifuges installed at the FEP.

## **Installation of Advanced Centrifuges Continues at Natanz Fuel Enrichment Plant**

In a letter dated January 23, 2013, Iran informed the IAEA that its advanced, carbon-fiber-based centrifuge, designated the IR-2m, "will be used" in one of the modules of Production Hall A. This statement is being widely interpreted as Iran announcing that it intends to install about 3,000 IR-2m centrifuges, which is the normal deployment in a module. Information in this recent IAEA report

indicates that Iran actually does plan to install that number of centrifuges; whether it has the resources or wherewithal to do so is unclear.

On May 15, 2013, IAEA inspectors observed that Iran had fully installed four cascades and partially installed one cascade for a total of 689 IR-2m centrifuges and empty centrifuge casings. This represents an increase of 509 centrifuges and casings since the previous reporting period. The IAEA also reports that Iran has begun “preparatory installation work” for an additional 13 cascades of IR-2m centrifuges. As of this report, Iran had not begun enriching in any of the advanced centrifuge cascades. Figure 7 tracks the IR-2m installation at the FEP.

No information is given in the IAEA report about the number of installed IR-2m centrifuges containing rotor assemblies, which is the true measure of the number installed. Thus, the information about the number of actual installed IR-2m centrifuges is highly incomplete.

### **Advanced Centrifuges at Natanz Pilot Fuel Enrichment Plant (PFEP)**

Since the last IAEA report, Iran has installed one new type of centrifuge, the IR-5 centrifuge, at the Natanz Pilot Fuel Enrichment Plant. No specifications of this centrifuge were provided.

Four out of six cascades at the pilot plant are dedicated to research and development (R&D), cascades 2, 3, 4 and 5. As of May 14, 2013, there were 19 (down from 29 on February 19, 2013) IR-4 centrifuges, 14 (up from six) IR-6 centrifuges, three (up from two) IR-6s centrifuges, and one IR-5 centrifuge installed in cascade 2, 19 IR-s centrifuges (up from 2) and three (down from nine) IR-2m centrifuges installed in cascade 3, 164 IR-4 centrifuges installed in cascade 4, and 162 IR-2m centrifuges installed in cascade 5. The numbers of centrifuges in cascades 4 and 5 remained the same as on February 19, 2013.

Iran has fed intermittently natural uranium hexafluoride into IR-2m and IR-4 centrifuges, into single machines and sometimes into cascades of various sizes. It continues to recombine the enriched product and depleted tails.

In a new development, Iran did not start to withdraw enriched uranium and tails from cascades 4 and 5, as it told the IAEA it would do as of the February 2013 report. It continued to recombine the product and tails, stating that the “experimental activities over cascades 4 and 5 have been postponed.” The implications of this statement for the start of enrichment in the IR-2m centrifuges deployed in the underground FEP are unclear.

### **19.75 percent LEU production at the Natanz pilot plant**

Iran has designated two, tandem cascades at the smaller, above-ground Pilot Fuel Enrichment Plant for the production of LEU enriched to nearly 20 percent uranium-235, ostensibly for the Tehran Research Reactor. 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 and outputs roughly 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 13, 2013 and May 10, 2013, 88.6 kg of 3.5 percent low enriched uranium in the form of uranium hexafluoride was introduced into the two, interconnected cascades. Iran withdrew

from the tandem cascades a total of 12.9 kg of nearly 20 percent LEU hexafluoride during this reporting period. This rate, approximately 4.5 kg per month, is consistent with previous reporting periods. **In total, Iran has fed 1,354 kg of 3.5% LEU to produce 163 kg of 19.75% uranium since the beginning of operations in February 2010.**

### **Fordow Fuel Enrichment Plant (FFEP)**

The Fordow site has two enrichment halls, Units 1 and 2, which are currently each designed to hold 8 cascades of 174 IR-1 centrifuges. Iran is continuing to operate the four cascades of 174 IR-1 centrifuges each in two, tandem sets to produce 19.75 percent LEU in a total of 696 enriching centrifuges, the same number of centrifuges enriching as was reported in the February 2013 as well as the November, August, and May 2012 safeguards reports. **Thus, Iran has not increased the number of centrifuge cascades producing 20 percent LEU at either Fordow or Natanz.**

**Iran appears to have nearly fully outfitted the facility with centrifuges, despite not expanding the number of centrifuges at the facility producing 19.75 percent enriched uranium in four reporting periods.** Based on Iran's patterns of installation, it may be that it plans to orient all of the cascades at the Fordow facility as tandem cascades. Figure 11 displays the number of centrifuges enriching and installed at the FFEP graphically.

Between February 11, 2013 and May 10, 2013, the two sets of tandem cascades produced approximately 31.7 kg of 19.75 percent enriched uranium at a combined average rate of 11 kg of 19.75 percent LEU hexafluoride per month. This is consistent with Iran's performance in the previous reporting period.

### **Production of Uranium Oxide**

Iran reported in the August 2012 report that it began feeding its 19.75 percent uranium hexafluoride into the Fuel Plate Fabrication Plant at Esfahan. As of May 6, 2013, Iran had fed a total of 141 kg 19.75 percent enriched uranium hexafluoride into the process at Esfahan to produce  $U_3O_8$  containing about 63 kg of enriched uranium (uranium mass). The 141 kg of near 20 percent LEU hexafluoride contains about 93 kg of enriched uranium (uranium mass). Thus, approximately 30 kg of enriched uranium remain held up in the process or in different forms. Thus, Iran still seems to be experiencing problems in its conversion process.

The IAEA also reports that as of May 7, 2013, Iran had produced 16 fuel assemblies for the Tehran Research Reactor (TRR). The report implies but does not explicitly state that these assemblies contained near 20 percent. The report indicates that six assemblies were transferred to the TRR; it also states that as of May 7, 2013, three indigenously produced assemblies containing 3.5 percent LEU and near 20 percent LEU were in the core of TRR. If others had been irradiated briefly and removed is unknown. But it appears that Iran is irradiating only a fraction of its indigenously produced fuel assemblies for the TRR.

### **Taking Stock**

Iran has produced a total of 8,960 kilograms of 3.5 percent LEU hexafluoride. About 2,550 kilograms have been used to make the 19.75 percent LEU hexafluoride. Across its three centrifuge facilities, it has installed 16,593 IR-1 centrifuges. Figure 8 shows cumulative centrifuge trends in Iran.

**Combined, the PFEP at Natanz and the FFEP have produced 325 kg of 19.75 percent uranium.** Figure 7 represents the cumulative production of 19.75 percent enriched uranium in Iran. The total average monthly production of 19.75 percent LEU hexafluoride during the most recent period remains consistent at an average of 15.5 kilograms per month of 19.75 percent LEU hexafluoride. If Iran begins enriching in the additional deployed cascades, this rate could triple.

Even as such, the current rate of production of 20 percent LEU far exceeds Iran's need for enriched uranium for the Tehran Research Reactor.

Of the 325 kg of near 20 percent LEU, according to the IAEA's May 2012 report, Iran had down blended 1.6 kilograms of 19.75 percent LEU hexafluoride into LEU enriched to less than five percent. Between December 17, 2011 and May 6, 2013 the IAEA reported that Iran fed into the process line at the Fuel Plate Fabrication Plant at Esfahan 141 kilograms of uranium hexafluoride enriched up to 20 percent uranium-235, and it produced 63 kilograms of near 20 percent enriched uranium in the form of  $U_3O_8$  powder. Using this material, Iran has manufactured 16 TRR fuel assemblies and one experimental fuel assembly. In total, Iran had a stock of 182 kg of near 20 percent LEU hexafluoride, up 15 kg from the last IAEA report. **Table 2 summarizes these findings.**

Iran has achieved varying rates of separative work in the IR-1 centrifuge at its enrichment plants. Although Iran continues to install and enrich in additional centrifuges at the FEP, the enrichment output measured in swu/centrifuge-year at this plant has varied and declined overall. The separative work achieved at both the PFEP and FFEP indicates that Iran has been using tandem cascades to enrich to 19.75 percent comparably and effectively. During this reporting period, the FFEP achieved 1.06 swu/centrifuge-year, consistent with the previous reporting period's 1.1 swu/centrifuge-year, and the PFEP cascades achieved 0.91 swu/centrifuge-year, consistent with Iran's progress throughout much of 2012. Table 3 compares the enrichment output at the FEP, PFEP, and FFEP.

## **Arak IR-40 Reactor Start-up Delayed**

The IAEA reports that start-up of the IR-40 heavy water-moderated reactor at Arak is delayed until the third quarter of 2014. Iran earlier indicated the reactor would start up in the first quarter of 2014. The IAEA observed during a Design Inventory Verification (DIV) that the reactor vessel had been received at the site but not yet installed. It observed that "a number of other major components had yet to be installed, including the control room equipment, the refueling machine and reactor cooling pumps." Iran told the IAEA that pre-commissioning of the reactor using dummy fuel assemblies and light water will begin in the fourth quarter of 2013 and commissioning using real fuel assemblies and heavy water would begin in the first quarter of 2014, with the start-up planned for third quarter 2014.

The IAEA reports that Iran continues to test prototype natural uranium fuel rods and fuel assemblies and to produce fuel pellets using natural  $UO_2$  for the IR-40 reactor. In March 2013, Iran informed the IAEA that it plans to produce 55 fuel assemblies for the reactor by August 2013. At the Fuel Manufacturing Plant at Esfahan, in April 2013, the IAEA verified 36 prototype natural uranium fuel assemblies before Iran transferred them to the Heavy Water Zero Power Reactor near Esfahan for testing. This zero power reactor creates limited amounts of fission for testing purposes. The purpose of this testing was not stated. Earlier, one prototype IR-40 natural uranium fuel assembly was transferred to the Tehran Research Reactor for testing.

In May 2013, the IAEA carried out a DIV at the Fuel Manufacturing Plant which also confirmed that manufacture of fuel assemblies using nuclear material for the IR-40 reactor had not yet begun. Only dummy assemblies had been produced.

Iran has failed to provide the IAEA with an updated Design Inventory Questionnaire (DIQ) on the IR-40 reactor since 2006. The IAEA notes that “this lack of up to date design information is having an increasingly adverse impact on the Agency’s ability....to implement an effective safeguards approach.”

## **Iran Laying Asphalt at the Suspect Parchin Site**

Iran continues to conduct activities at the suspect Parchin site that will further complicate the verification work of the IAEA. According to the IAEA’s report, “Iran has conducted further spreading, levelling and compacting of material over most of the site, a significant proportion of which it has also asphalted.” ISIS’s [satellite imagery brief](#) released today illuminates Iran’s work at the site and appears to confirm these paving and asphaltting activities.

The Parchin site is the location of a test chamber that is suspected of being used for containing high explosives tests related to nuclear weapons development. Iran began altering the buildings at this site and the site itself during the spring of 2012, shortly after the IAEA requested access to this site. The IAEA in this latest safeguards report states that “satellite imagery available to the Agency [IAEA] for the period from February 2005 to January 2012 shows virtually no activity at or near the building housing the containment vessel (chamber building). Since the Agency’s first request for access to this location, however, satellite imagery shows that extensive activities and resultant changes have taken place at this location.”

Iran on multiple occasions has refused the IAEA’s legitimate requests for access to this site. Iran may now be attempting to further complicate the taking of environmental samples at the site. By doing so, Iran may seek to further erode the IAEA’s ability to determine whether nuclear weapons development work happened at this site, as IAEA evidence supports.

## **New Nuclear Facility Sites Being Selected**

The IAEA states that Iran informed it in a letter dated May 1, 2013 that the construction of four new research reactors “are in preliminary site selection phase,” “that certain locations were ‘under evaluation’” and that more information would be provided after site approval. Iran announced to the media on April 25, 2013 that it was producing 20 percent enriched uranium to provide fuel for the Tehran Research Reactor (TRR) and for “four other reactors in four different parts of Iran which are under construction.”

Iran announced on February 23, 2013 that it has identified 16 sites for the construction of nuclear power plants. In a letter to the Iran dated March 6, 2013, the IAEA stated that Iran should provide relevant design information and schedules of the plants’ construction. In a response, Iran stated that it had suspended its implementation of modified Code 3.1 of its subsidiary arrangements to its safeguards agreement and thus is not obliged to inform the IAEA of these details, but would inform it “in due time.” The IAEA says that Iran legally cannot stop implementing these arrangements.

Iran has also not provided information about the construction of ten additional enrichment plants, of which it claims site selection for five plants has been decided. The construction of a third enrichment plant is increasingly suspected.

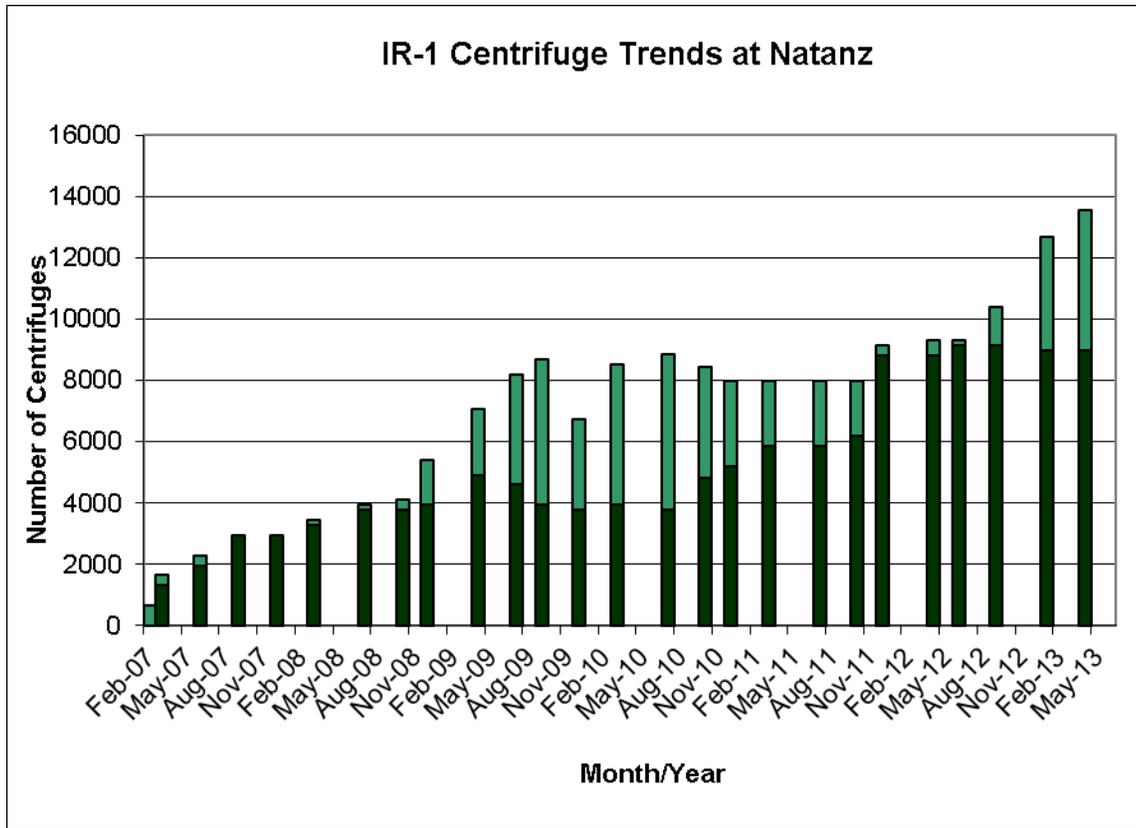
### **Still No Progress on “Structured Approach”**

The IAEA reports that it held an additional round of talks with Iran on May 15, 2013 following nine rounds of failed talks aimed at agreeing on a “structured approach” to resolve outstanding issues with Iran, including those relating to possible military dimensions to Iran’s nuclear program.

### **Note on Legal Mandate and Completeness**

The IAEA underlines that while it continues to verify the non-diversion of declared nuclear material in Iran, “it is unable to provide 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.” The IAEA writes in footnote 56 of the report that the Board has on numerous occasions, since as early as 1992, confirmed that under Article 2 of Iran’s comprehensive safeguards agreement the IAEA is authorized and required to “seek to verify both the non-diversion of nuclear material from declared activities (i.e. correctness) and the absence of undeclared nuclear activities in the State (i.e. completeness).” It is imperative that Iran not delay further in answering the IAEA’s questions about the alleged past and possibly on-going military dimensions of its nuclear programs, especially given the current state of heightened international tensions over this issue.

**Figure 1: IR-1 Centrifuge Trends at Natanz\*\***



\*\* The dark green bar represents the number of IR-1 centrifuges enriching, while the light green represents the number of IR-1 centrifuges installed but not enriching. The sum of the two represent the total number of IR-1 centrifuges installed at the FEP.

**Figure 2: Uranium Hexafluoride Feed at the Natanz FEP**

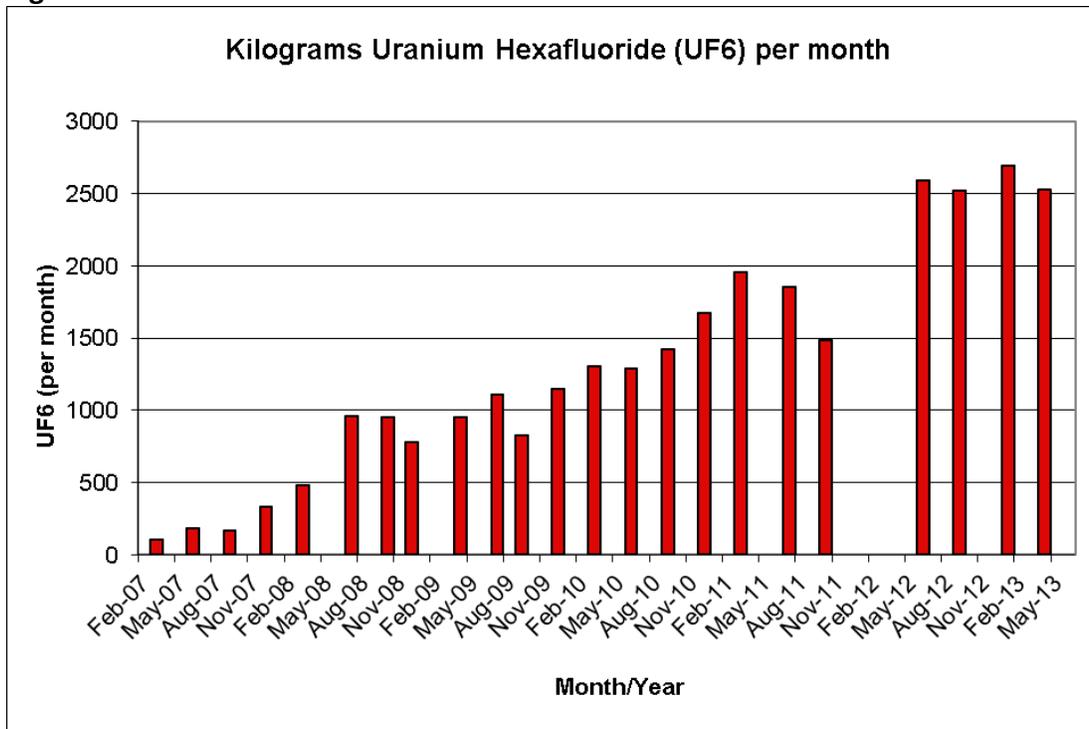


Figure 3: LEU Production (kilograms uranium hexafluoride per month) at Natanz

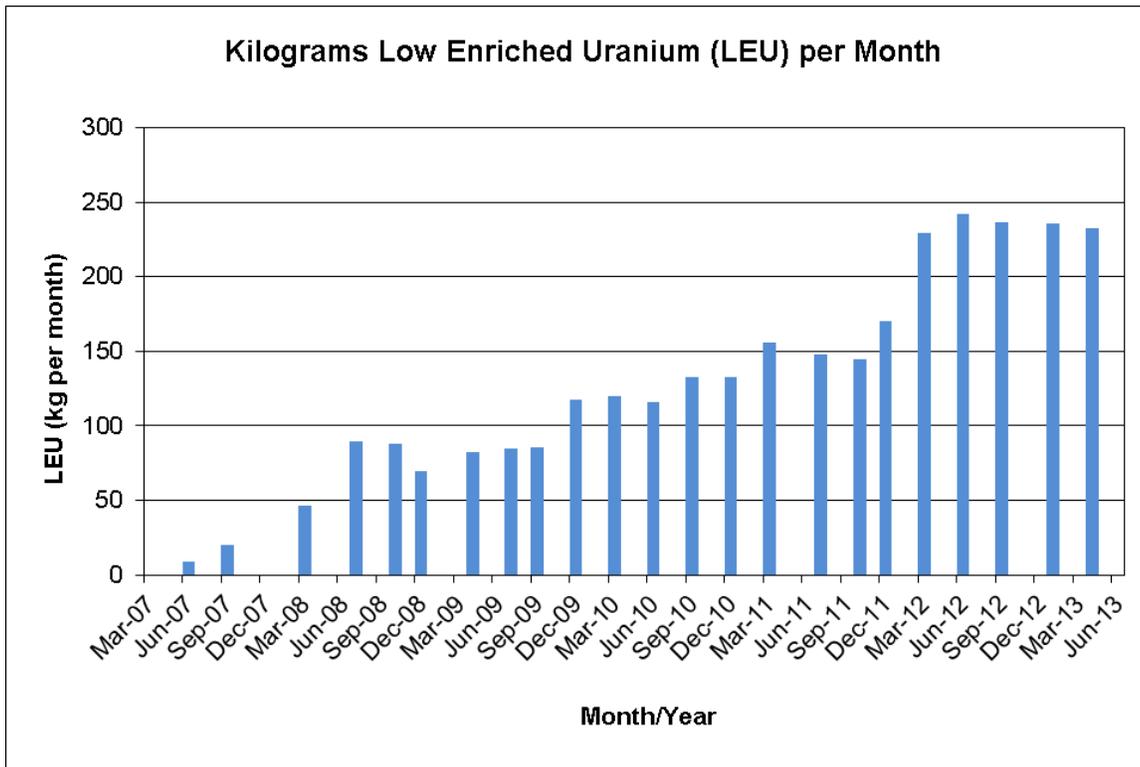
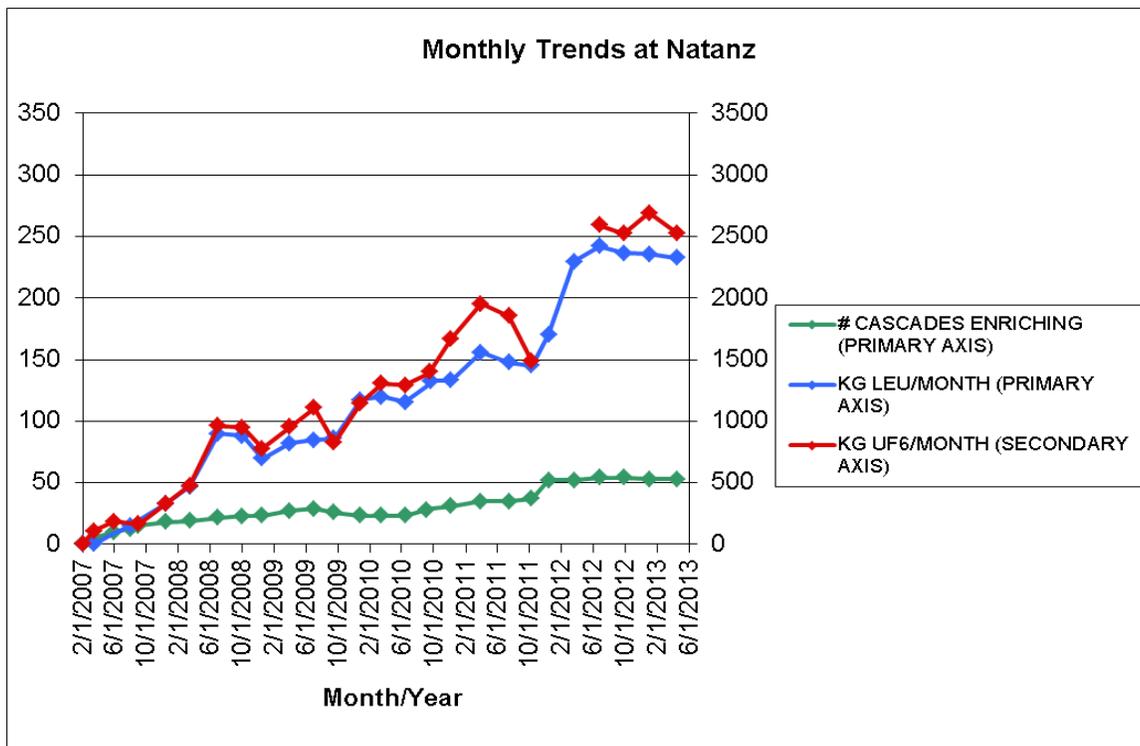
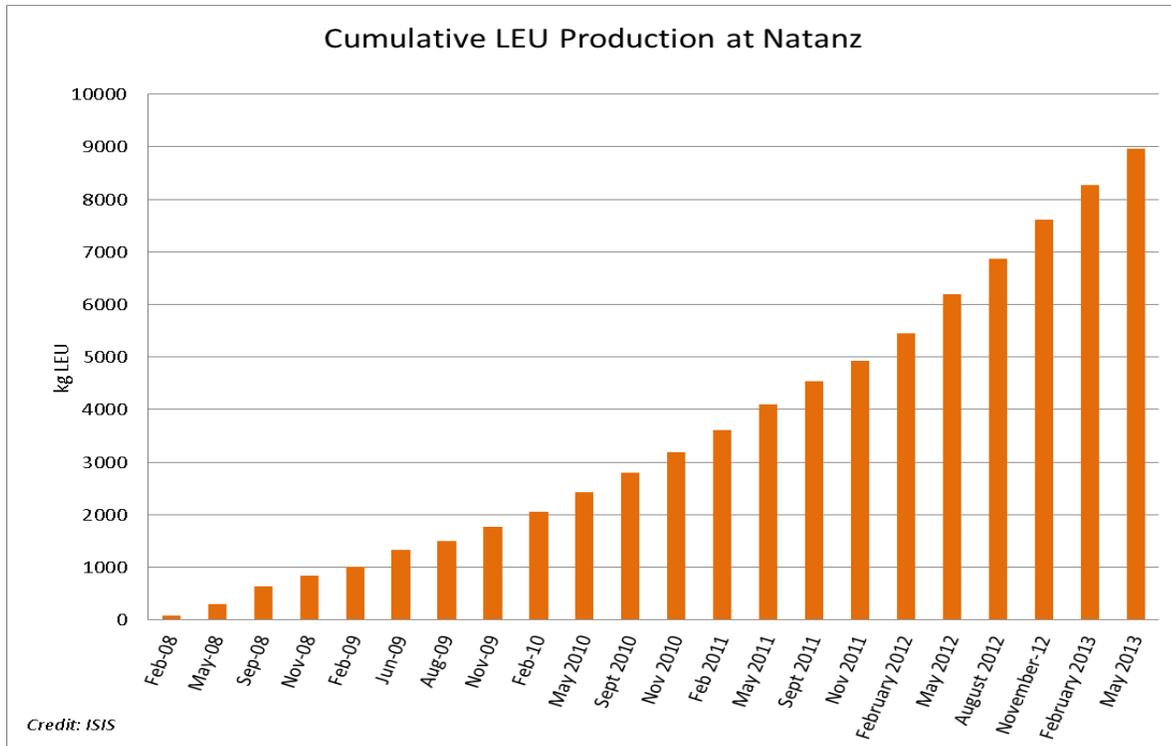


Figure 4: Overall Trends at Natanz



**Figure 5: Cumulative LEU Production at the Natanz Fuel Enrichment Plant**



**Figure 6: Annualized SWU at Natanz**

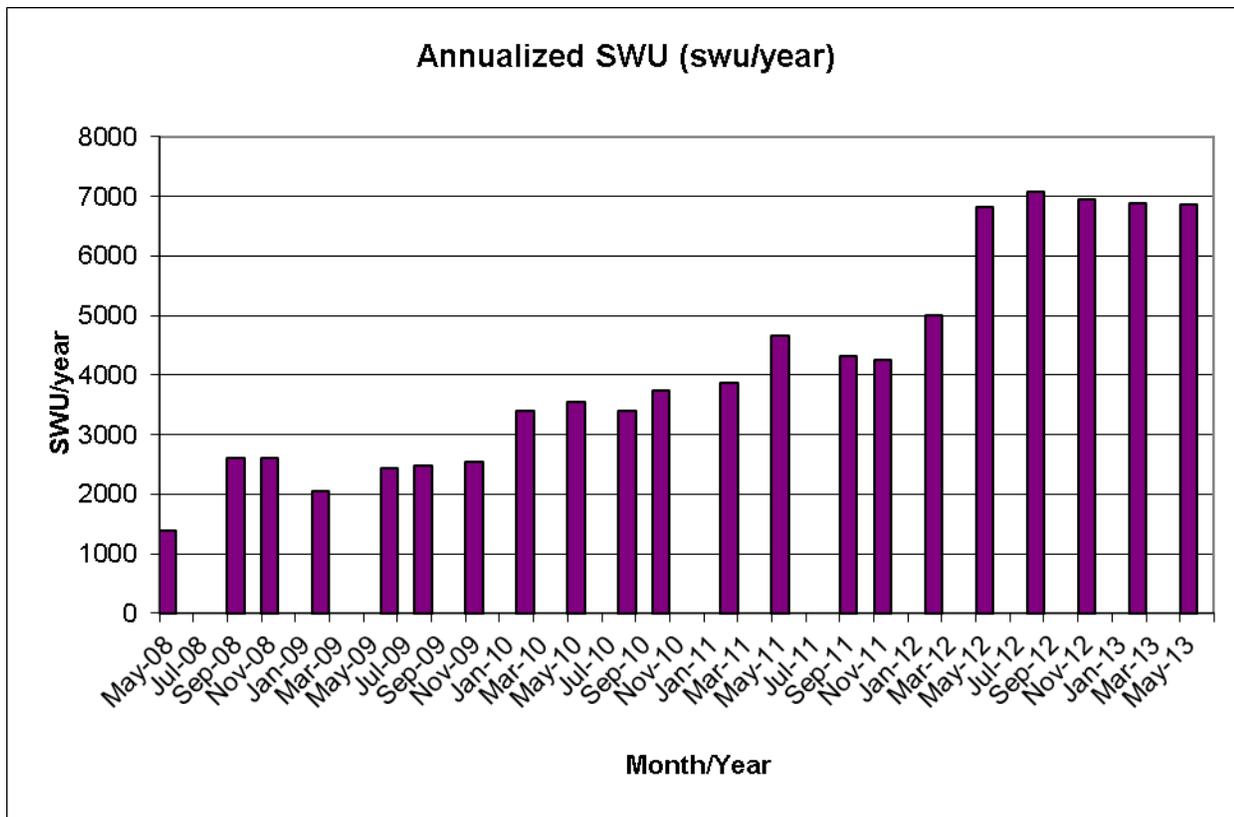


Figure 7: IR-2m Progress at the FEP

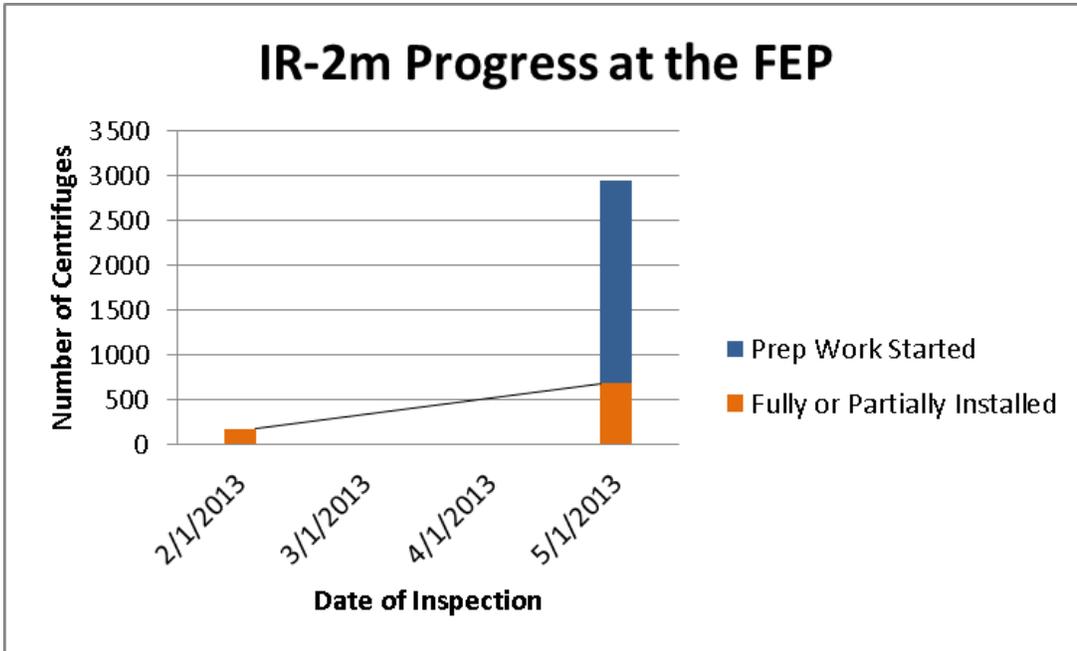


Figure 8: Total Number of Deployed IR-1 Centrifuges in Iran

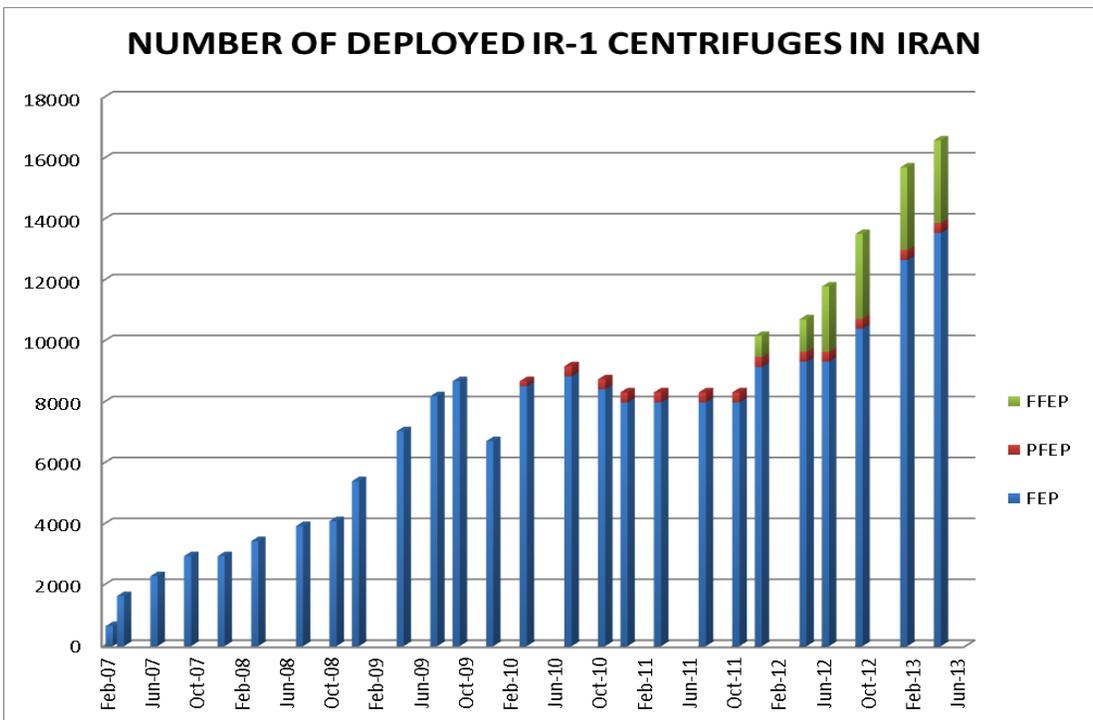


Figure 9: Cumulative 19.75 Percent Uranium Production in the PFEP and FFEP

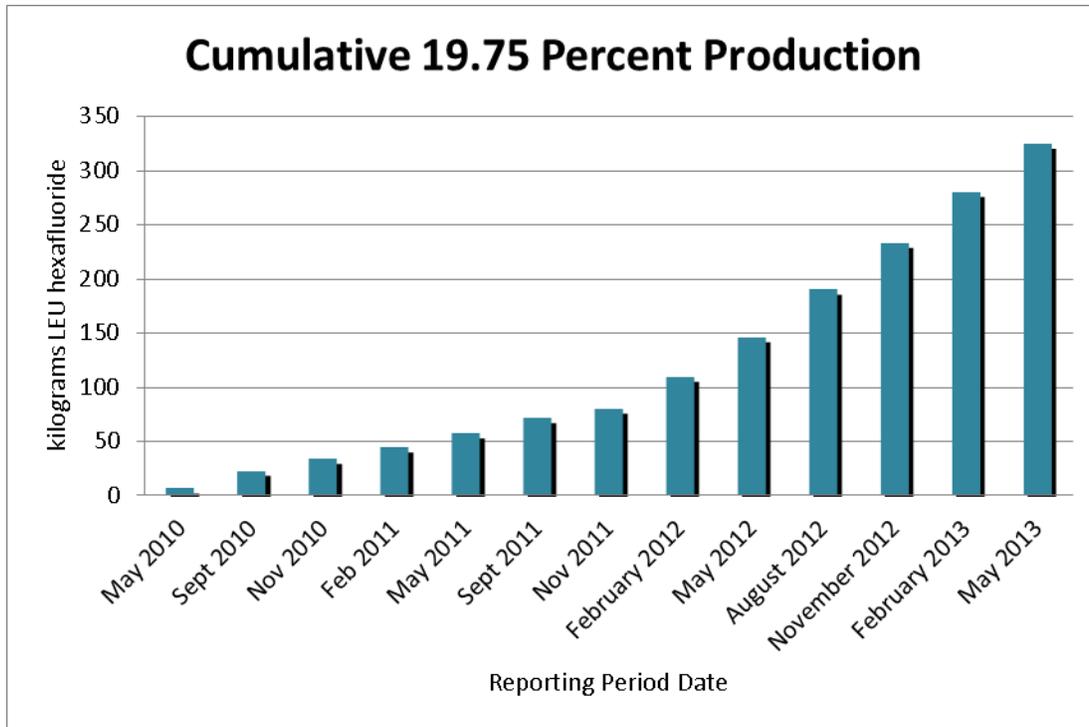


Figure 10: SWU/Centrifuge-year at the Fordow Fuel Enrichment Plant and Pilot Fuel Enrichment Plant

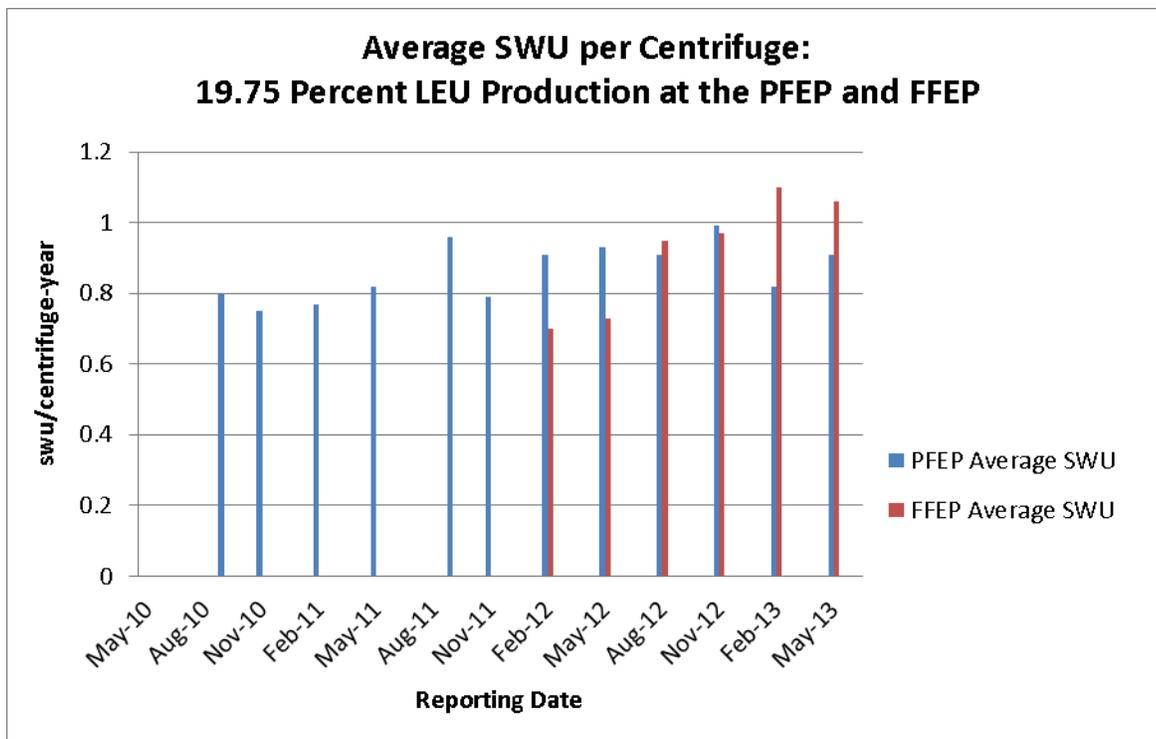
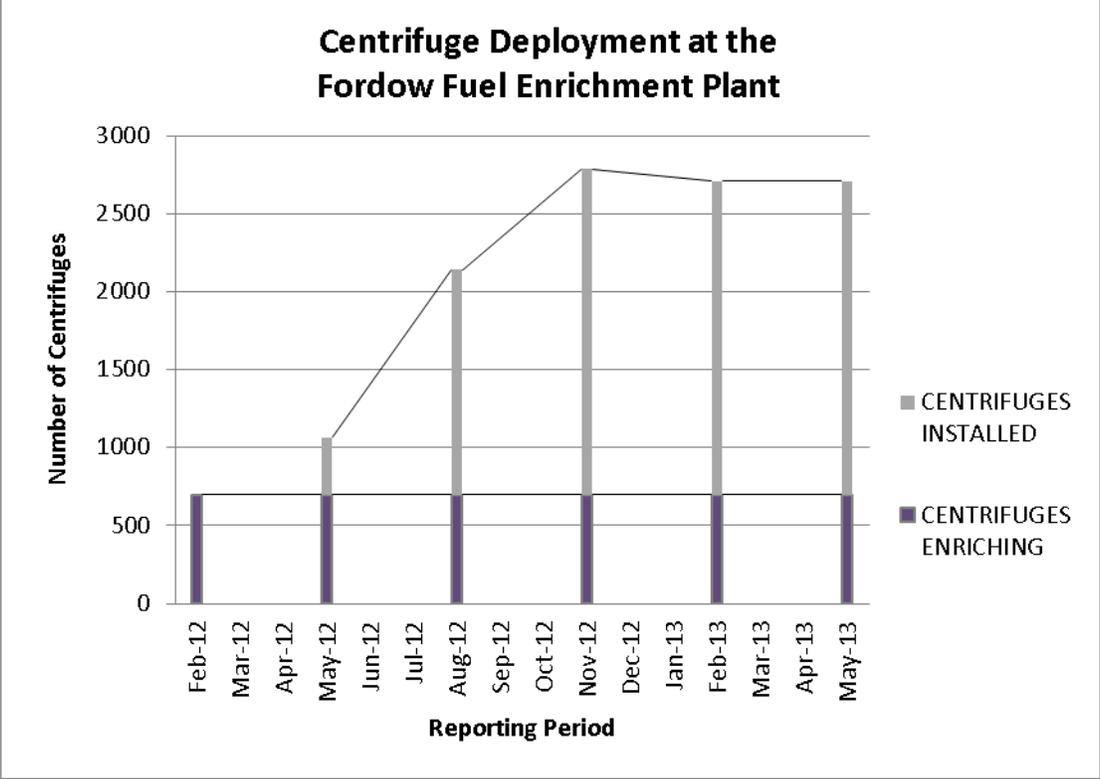


Figure 11: IR-1 Centrifuges Enriching and Installed at the Fordow Fuel Enrichment Plant



**Table 1: Minimal Average Separative Capacity of an IR-1 Centrifuge at the FEP**

**(kg U swu/year-centrifuge)**

<i>Period</i>	<i>Start of Period</i>	<i>End of Period</i>
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
05/14/2011 – 08/13/2011	0.74	0.74
08/14/2011 – 11/01/2011	0.73	0.68
11/02/2011 – 02/04/2012	0.76	0.53 (Note: Iran began enriching in approximately 2,600 additional centrifuges during this period. Therefore, these data are likely skewed.)
02/05/2012 – 05/11/2012	0.77	0.77
05/12/2012 – 08/06/2012	0.77	0.77
08/07/2012 – 11/9/2012	0.77	0.76
11/10/2012 – 02/03/2013	0.75	0.76
02/04/2013 – 05/04/2013	0.76	0.76

**Table 2: CUMULATIVE TOTALS OF NATURAL AND ENRICHED URANIUM FEED AND 3.5 AND 19.75 PERCENT LEU HEXAFLUORIDE PRODUCT IN IRAN**

<b>LOCATION</b>	<b>0.711 percent feed</b>	<b>3.5 percent LEU product</b>	<b>3.5 percent LEU feed</b>	<b>19.75 percent LEU product</b>
FEP	102,238 kg	8,960 kg	N/A	N/A
PFEP	N/A	N/A	1,354 kg	163 kg
FFEP	N/A	N/A	1,196 kg	162 kg
<b>GROSS TOTAL</b>	102,238 kg	8,960 kg	2,550 kg	325 kg
<b>NET TOTAL</b>	94,750 kg	6,357 kg*	2,550 kg	182 kg**

\*Number is less 3.5 percent enriched uranium hexafluoride used as feedstock at the PFEP and FFEP as well as 53 kg 3.5 percent LEU hexafluoride converted to uranium oxide.

\*\*Number is less 141 kg of 19.75 percent LEU hexafluoride fed into the process at the Fuel Plate Fabrication Plant near Esfahan and 1.6 kg 19.75 percent LEU hexafluoride down blended.

**Table 3: COMPARATIVE SWU Rate\* IN IR-1 CENTRIFUGES AT IRAN'S ENRICHMENT FACILITIES**

<b>LOCATION</b>	<b>IR-1 centrifuges producing 3.5 percent enriched uranium</b>	<b>IR-1 centrifuges producing 19.75 percent enriched uranium</b>
FEP	0.76 swu/cent-year	N/A
PFEP	N/A	0.91 swu/cent-year
FFEP	N/A	1.06 swu/cent-year

\*SWU rate represents an average of the SWU/centrifuge-year calculated using the number of centrifuges at both the beginning and the end of the reporting period.