



Update on Iran's Stocks of 3.5 Percent Low Enriched Uranium

Blocking unjustified exemptions to the 300 kilogram cap

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The Joint Comprehensive Plan of Action (JCPOA) signed by the P5+1 and Iran imposes a series of restrictions on Iran's stockpile of up to 3.67 percent low enriched uranium (LEU). One restriction imposes a cap on the amount of uranium that is allowed in Iran. The agreement allows for exemptions to this cap but these exemptions are intended to be applied to future fuel fabrication efforts. Iran may now be trying to obtain an exemption for pre-existing LEU that was expected to have been removed from the country or blended down to natural uranium by Implementation Day (January 16, 2016). The United States and its P5+1 partners should refuse to grant this exemption. One recent action is that Iran down blended 12 kilograms of up to 3.67 percent LEU to natural uranium.

3.5 Percent LEU Exported from Iran

According to the JCPOA, "Iran will maintain a total enriched uranium stockpile of no more than 300 kg of up to 3.67% enriched uranium hexafluoride (or the equivalent in different chemical forms) for 15 years." This 300 kilogram (kg) hexafluoride (UF₆) is equivalent to approximately 200 kg if only the uranium mass is measured. The rest of the mass is fluorine. According to the International Atomic Energy Agency (IAEA), on Implementation Day, Iran was abiding by the cap.

In order to comply with the cap Iran was required to export a large amount of LEU. On December 28, 2015, Iran reportedly exported over 25,000 pounds of low enriched uranium materials to Russia to comply with the 300 kg cap requirement.¹ Exact values were not provided publicly. Russia later provided a detailed breakdown of the exports to the members of the Nuclear Suppliers Group, so the values are not classified or safeguards confidential and should be publicly released. This removal also included tens of kilograms, perhaps over 100 kilograms, of near 20 percent LEU. (This stock will be addressed in a separate report when more details about the size of this stock becomes known).

¹ John Kerry, "An Update on Progress Toward Implementation Day of the JCPOA," Press Statement, December 28, 2015, <http://www.state.gov/secretary/remarks/2015/12/250876.htm>.

The amount of 3.5 percent LEU exported by Iran can be estimated using data on Iran's total production at its Natanz and Fordow enrichment plants provided in the IAEA's earlier safeguards reports, where it routinely reported more detailed information. As of November 2015, the date of the last IAEA report containing detailed LEU data, Iran had produced 16,142 kilograms of 3.5 percent LEU hexafluoride. It produced approximately 200 kg more between this date and Implementation Day.² Of its cumulative LEU stockpile, about 3,490 kg of LEU hexafluoride were used to make near 20 percent LEU and for research. Another 4,334 kg of LEU hexafluoride were fed into the Enriched UO₂ Powder Plant (EUPP) for conversion into oxide form. Thus, prior to Implementation Day, Iran had a stock of about 8,518 kg of LEU hexafluoride (or 5,707 kg if only the uranium mass were measured) and another stock equivalent to 4,334 kg of LEU hexafluoride (2,904 kg in uranium mass) at the EUPP. These values equal the equivalent of 12,852 kg of LEU hexafluoride, or 8,610 kg of LEU (uranium mass) and are detailed further in Table 1.

Based on the IAEA data from November 2015, of the total amount fed into the EUPP, about 2,676 kg (uranium mass) ended up in oxide form as LEUO₂ (equivalent to about 3,994 kg LEU hexafluoride) and 228 kg LEU (uranium mass), the equivalent of about 340 kg LEU hexafluoride, were in various intermediate chemical forms in the process lines of the EUPP.

Between September 2015 and January 2016, Iran focused on emptying the EUPP of LEU. However, not all the LEU was removed from the processing lines and associated equipment. Although the precise amount is unknown, an estimated 100 to 200 kg of LEU (uranium mass) were still held up at the EUPP as of Implementation Day. The value may be closer to 100 kg than 200 kg. This LEU was a major fraction -- perhaps almost all -- of the LEU that remained in Iran on Implementation Day. Some unknown but smaller amount of LEU also remained at Natanz and Fordow in the cascades and feed and withdrawal equipment. This amount would likely not be reflected in table 1.

² IAEA Director General, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2015/65, November 18 2015. <http://isis-online.org/uploads/isis-reports/documents/gov-2015-65.pdf>. On November 15, 2015, according to this detailed report, Iran was enriching uranium at Natanz with the same number of centrifuges as before. It is legitimate to assume that Iran continued enriching uranium with this same number of centrifuges until mid-December 2015, producing an average of about 200 kg of LEU hexafluoride during this period. We assume that Iran interrupted its enrichment efforts between mid-December 2015 and mid-January 2016 because of the centrifuge dismantlement efforts required to meet the Implementation Day obligations.

Table 1 Iran's Stock of 3.5 percent LEU(a)

Prior to Implementation Day (January 16, 2016)

	Plant	Kg UF ₆	Kg U-mass
LEU produced	Fuel Enrichment Plant (FEP)	15,525	10,401.7
	Pilot Fuel Enrichment Plant (PFEP)	136.4	91.4
	Fordow Fuel Enrichment Plant (FFEP)	364.6	244.3
	Produced from ~20 percent downblending	115.6	77.4
	Produced between Nov.15-Dec.15, 2015	200	134
Subtotal		16,341.6	10,948.8
LEU Used	Fed into PFEP	- 1,630.8	-1,092.6
	FED into FFEP	- 1,806	-1,210
	Used for R&D at UCF	- 53	-35.51
	Fed into EUPP	-4,334	-2,903.7
	Subtotal	- 7,823.8	- 5,242
Total LEU in UF₆ Form		8,517.8(b)	5,707
LEU Oxide Produced at EUPP	Oxide	+3,994	+2,676
	Intermediate Forms	+340	+227.8
	Subtotal	4,334	2,903.8
TOTAL		12,851.8	8,610.7

- (a) The sources for this table are IAEA safeguards reports on Iran.
- (b) This number, based on step-by-step calculations, differs slightly from the amount given by the IAEA in its latest report, which is 8,305.6 kilograms, for a difference of 12.2 kilograms. This difference was also present in every report dating back to February 2014. The difference in the November 2013 report was 0.4 kilograms. The reason for the differences are unclear.

So, based on the values in table 1, 8,518 kg of LEU hexafluoride produced at Natanz and Fordow are believed to have been exported. With regard to the material stored at the EUPP, all of the 2,676 kg of enriched uranium in oxide form (uranium mass) are believed to have been shipped out of the country by Implementation Day. There were also likely smaller amounts of LEU from the EUPP that were shipped out. In total, the estimated amount, where we ignore the different units, is 11,194 kg, or 24,627 pounds of LEU. To this value should be added some amount of the 340 kg LEU hexafluoride (228 kg uranium mass) and an undisclosed amount of near 20 percent LEU. Adding these values could add 400 pounds to this estimate. In sum, this estimated value is consistent with the value of over 25,000 pounds quoted by Secretary Kerry.

With regards to Natanz, since Implementation Day, Iran has been reportedly producing very little new LEU and is engaging in a new enrichment variation using depleted uranium instead of natural uranium feed and enriching to the level of natural uranium. Enrichment up to the level of natural uranium is not included in the cap. Given that the EUPP may contain up to 200 kg of LEU (uranium mass), which is equivalent to 300 kg of LEU hexafluoride, Iran may not be able to produce much enriched uranium without violating the cap.

Since Implementation Day, Iran has embarked on further cleaning out the process lines at the EUPP (under IAEA supervision). The February 2016 IAEA report stated that Iran's stock of 3.67 percent LEU accounted for 20-40 kg of enriched uranium that "Iran has stated are recoverable from the process lines at the [EUPP]." ³ Unmentioned was the other LEU in-process, or an estimated 60-180 kg of LEU, assuming 100-200 kg of LEU remained on Implementation Day.

The recent IAEA report contains additional information on the recovered LEU. On April 23 and 24, 2016, the IAEA verified that the recovered quantity of uranium enriched up to 3.67% U-235 was 35.7 kg. ⁴ The report implied that there is more LEU slated for recovery. This LEU would have been removed from the recovery lines, leaving about 64.3-164.3 kilograms inside the process areas of the EUPP as of late April.

Iran has also recently down blended a small amount of its remaining LEU. Between March 5 and May 8, 2016, "the Agency verified that Iran downblended 6.1 kg of uranium in the form of UF₆ enriched up to 3.67% U-235 to the level of natural uranium and, between 16 and 24 May 2016, the Agency verified that Iran downblended 5.9 kg of uranium contained in liquid and solid scrap enriched up to 3.67% U-235 to the level of natural uranium."⁵ It is unclear if any of this material was considered part of the in-process inventory of the EUPP. In addition, it is possible that the 6.1 kg of LEU hexafluoride could have been newly produced enriched material that was downblended to stay below the cap.

Neither the IAEA nor Iran provided a definition of what constitutes recoverable LEU. Its definition matters in the context of the JCPOA and should not be left to the IAEA or Iran.

LEU Exemptions

Iran may seek to exempt some of the LEU at the EUPP from the 300 kg cap under the exemption language in the JCPOA, in essence allowing Iran to possess more than 300 kg of LEU enriched less than 3.67 percent. There is a risk that the United States will be willing to allow this with some of the LEU at the EUPP. This is in contrast to last summer, when US officials fully expected Iran to empty the EUPP of LEU, based on discussions with members of our Institute.

Although the JCPOA has exceptions to the 300 kg cap, exempting any remaining LEU in the EUPP appears to be unjustified. According to the JCPOA, "All enriched uranium hexafluoride in excess of 300 kg of up to 3.67% enriched UF₆ (or the equivalent in different chemical forms) will be down blended to natural uranium level or be sold on the international market and delivered to the international buyer in return for natural uranium delivered to Iran."

The JCPOA envisions that Iran may make LEU fuel domestically in the future. To that end, the JCPOA states: "The Joint Commission will establish a Technical Working Group with the goal of

³ IAEA Director General, *Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)*, GOV/2016/8, February 26, 2016. http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_February_26_2016.pdf

⁴ IAEA Director General, *Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)*, GOV/2016/23, May 27, 2016.

⁵ Ibid

enabling fuel to be fabricated in Iran while adhering to the agreed stockpile parameters (300 kg of up to 3.67 % enriched UF₆ or the equivalent in different chemical forms).” However, the exemptions specified in the JCPOA are intended for future fuel fabrication, and are not applicable to LEU processed in the EUPP prior to Implementation Day. The JCPOA intended that existing LEU enriched up to 3.67 percent would be subject to the 300 kg cap and not exempted.

This case motivates a discussion of what are legitimate exemptions if Iran were to start making LEU fuel. At least, LEU in intermediate products in uranium conversion plants such as the EUPP should not be exempted. Separating LEU from its chemical constituents in such products is typically straightforward.

With regard to domestic fuel fabrication, the JCPOA states: “Enriched uranium in fabricated fuel assemblies and its intermediate products manufactured in Iran and certified to meet international standards, including those for the modernised Arak research reactor, will not count against the 300 kg UF₆ stockpile limit provided the Technical Working Group of the Joint Commission approves that such fuel assemblies and their intermediate products cannot be readily reconverted into UF₆. This could for instance be achieved through impurities (e.g. burnable poisons or otherwise) contained in fuels or through the fuel being in a chemical form such that direct conversion back to UF₆ would be technically difficult without dissolution and purification. The objective technical criteria will guide the approval process of the Technical Working Group. The IAEA will monitor the fuel fabrication process for any fuel produced in Iran to verify that the fuel and intermediate products comport with the fuel fabrication process that was approved by the Technical Working Group.”

The JCPOA also states that the Joint Commission will establish this Technical Working Group, which is charged to “within one year, work to develop objective technical criteria for assessing whether fabricated fuel and its intermediate products can be readily converted to UF₆.”

These conditions imply that the LEU in the fuel should be very difficult to use in a breakout, or for the crash production of highly enriched uranium for nuclear weapons. While Iran may view the LEU as non-recoverable, that view does not appear to be a sufficient standard to meet the JCPOA conditions. Although an operator at the EUPP focused on economic issues may look at the material as unrecoverable, a country intent on breaking out and making highly enriched uranium as a national priority may make an entirely different calculation about the LEU’s worth.

The soundest path forward, and the one consistent with the JCPOA, is that any uranium in the EUPP should be counted as part of the 300 kg (hexafluoride mass) cap. Exempting part of this LEU appears to be inconsistent with the JCPOA, as this LEU stock was not intended to be subject to exemptions.

Given the low economic value of the LEU remaining in the EUPP, why does Iran not simply seek to ship it out or downblend more of it? By exporting or downblending it, Tehran could avoid the need to store it. That Iran wants to keep it signifies that it thinks it still has value.

If exemptions were somehow granted for the LEU in the EUPP, they could become dangerous precedents for future exemptions to the 300 kg cap. Future exemptions may involve considerably more LEU than this case and could undermine any hope of maintaining a one-year breakout time.

Conclusion

That almost all LEU was removed from Natanz, Fordow, and the EUPP is a positive accomplishment and places Iran under the 300 kg cap. The best strategy is to gather any remaining LEU in the EUPP and ship it out of Iran or downblend it to natural uranium. Until this is done, any uranium in or from the process lines at the EUPP should be counted toward the 300 kg cap, not just the amount estimated as recoverable by Iran. To do otherwise would undermine the fuel manufacturing exemption provision and risk creating precedents about in-process materials where only the relatively easily, recoverable amounts of LEU will be counted toward the cap while other forms will not.