INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

Analysis of IAEA Iran Verification and Monitoring Report - May 2023

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Background

- This report summarizes and assesses information in the International Atomic Energy Agency's (IAEA's) quarterly report for May 31, 2023, *Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015)*, including Iran's compliance with the Joint Comprehensive Plan of Action (JCPOA).

Findings

- Iran can now break out and produce enough weapon-grade enriched uranium for a nuclear weapon in 12 days, using only three or four of its advanced centrifuge cascades and little more than one-third of its existing stock of 60 percent enriched uranium. This breakout could be difficult for the IAEA to detect promptly, if Iran took steps to delay inspectors' access.
- Using more of its remaining stock of 60 percent enriched uranium in the same three or four cascades and much of its stock of near 20 percent enriched uranium in the vast bulk of its production-scale cascades, Iran could produce enough weapon-grade uranium (WGU) for an additional four nuclear weapons within the first month of a breakout.
- In the second month, using its further remaining stocks of 20 and 60 percent material and part of its stock of less than 5 percent low enriched uranium (LEU), Iran could produce enough WGU for another two weapons. Using its residual stock of less than 5 percent low-enriched uranium (LEU), Iran could produce enough WGU for an eighth weapon by the end of the third month.
- In summary, Iran could produce enough WGU for five nuclear weapons in one month, seven in two months, and a total of eight in three months.
- Iran's stockpile of 60 percent highly enriched uranium (HEU) was 114.1 kg (Uranium mass, or U mass) or 168.8 kg uranium hexafluoride mass (hex mass) as of May 13. With a monthly average production rate of 9 kg (U mass) per month, Iran could amass enough 60 percent HEU for three nuclear weapons by mid-June.
- Iran is producing 60 percent HEU from 5 percent LEU feed in advanced centrifuge cascades at the above-ground Pilot Fuel Enrichment Plant (PFEP) and the below-ground Fordow Fuel

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Enrichment Plant (FFEP); the latter includes an IR-6 centrifuge cascade that is easily modifiable to change operations. This cascade was at the center of an IAEA-detected undeclared mode of operation in January 2023, interconnected with another IR-6 cascade to produce HEU, and subsequently, the IAEA detected the presence of near-84 percent HEU particles at the cascade's product sampling point.

- The IAEA assessed that Iran's explanation for its production of 83.7 percent enriched uranium — which Iran claimed was the result of "unintended fluctuations'' — was "not inconsistent" with "additional information and supporting operational data" Iran provided during meetings with the IAEA and "had no further questions on the matter at that stage."
- The IAEA did not provide any details of its findings, or report whether it checked if any of Iran's information was falsified, but notes that it did investigate the information's consistency. The IAEA has used the more mathematical double negative "not inconsistent," rather than "consistent," in the past to express a finding for which it has a lower confidence level because of insufficient basis to confirm information made available by the state. As such, the IAEA may revisit a "not inconsistent" finding. Nonetheless, this episode has left an indelible impression that Iran can quickly and perhaps secretly produce 90 percent enriched uranium, if it chooses to do so.
- The IAEA has been seeking increased access and intensification of verification activities at the FFEP. In its separate report on Iran's compliance with the Nuclear Non-Proliferation Treaty (NPT), the IAEA reported that it installed enrichment monitoring devices (EMD) at both the FFEP and at the PFEP to "monitor the enrichment level of the HEU being produced by Iran." These monitors are not JCPOA-related but are installed pursuant to Iran's comprehensive safeguards agreement (CSA) with the agency. IAEA Director General Rafael Grossi confirmed in a press conference that the EMD data will notify the IAEA of "another oscillation or otherwise" in the enrichment level in "real-time."
- Iran continues to keep the majority (60 percent) of its stock of 60 percent HEU at the Esfahan site, where it maintains a capability to make enriched uranium metal.
- As of May 13, 2023, Iran had an IAEA-estimated stock of 470.9 kg of 20 percent enriched uranium (U mass and in the form of UF_6), equivalent to 696.6 kg (hex mass). Iran also had a stock of 38.8 kg (U mass) of 20 percent uranium in other chemical forms.
- The average production rate of 20 percent enriched uranium at the FFEP remained steady at 12.2 kg (U mass) or 18 kg (hex mass) per month.
- At the Natanz Fuel Enrichment Plant (FEP), Iran has a total of 36 cascades of IR-1 centrifuges, 21 cascades of IR-2m centrifuges, four cascades of IR-4 centrifuges, and three cascades of IR-6 centrifuges installed. It did not install any additional centrifuge cascades at the FEP during this reporting period, although it has additional eight IR-4 centrifuge cascades planned and the installation of one IR-4 cascade was ongoing.
- Iran did not install any additional advanced centrifuge cascades at the FFEP, where it is currently operating six IR-1 centrifuge cascades and two IR-6 centrifuge cascades, although it plans to install up to 14 additional IR-6 centrifuge cascades.
- Iran installed one IR-4 centrifuge cascade at the PFEP since the last reporting period. It is unclear why Iran has not installed additional centrifuge cascades per its announced plans, especially following a spike in advanced centrifuge deployment from August 2022 to February 2023. It is unclear whether this means Iran produced fewer centrifuges than

expected, implying possible manufacturing difficulties, or is keeping newly produced machines in storage instead.

- Iran's current, total operating enrichment capability is estimated to be about 19,100 separative work units (SWU) per year, a slight increase over the end of the last reporting period, largely due to the added cascade at the PFEP. As of this reporting period, Iran was not yet using its fully installed enrichment capacity at the FEP.
- Iran's stockpile of near 5 percent LEU was 1340.2 kg (U mass) or 1982.5 kg (hex mass). Average production of near 5 percent LEU at the FEP decreased, but despite large amounts of 5 percent LEU being used as feedstock for 20 and 60 percent uranium production, Iran's overall near 5 percent LEU stock increased slightly.
- Despite the increase during this reporting period in the amount of uranium enriched between two and five percent, Iran has not prioritized stockpiling this material over the past two years. In addition, it has not made planned progress on the Enriched Uranium Powder Plant, a key civil facility to convert less than five percent enriched uranium hexafluoride into a uranium oxide powder for use in nuclear power reactor fuel. These two choices are at odds with Iran's contention that its primary goal is to accumulate 4-5 percent enriched uranium for use in nuclear power reactor fuel. Instead, Iran has used this stock extensively to produce near 20 percent and 60 percent enriched uranium, far beyond any of Iran's civilian needs.
- Iran's overall reported stockpile of enriched uranium increased by 983.7 kg (U mass), largely due to an increase in uranium enriched to less than 2 percent.
- The IAEA reported unsatisfactory progress by Iran on resolving a discrepancy in Iran's natural uranium inventory at the Uranium Conversion Facility (UCF). It reported a shortfall in Iran's declaration, which may indicate that Iran mixed into the UCF inventory undeclared uranium it used in the past at the Lavisan-Shian site during its early-2000s nuclear weapons program.
- The IAEA reports that Iran provided an updated design information questionnaire (DIQ) for the Arak reactor indicating that it is reorienting the reactor consistent with the conceptual design set out in the JCPOA. The reactor will have a power of 20 MW(th). Iran informed the IAEA that it expects to commission the reactor in 2023 and start operations in 2024, although the reported status of the reactor construction raises doubts about whether these milestones will be reached.
- The IAEA underscores that "for two and a quarter years Iran has not provided updated declarations and the Agency has not been able to conduct any complementary access under the Additional Protocol to any sites and locations in Iran."
- The IAEA reports that in line with an IAEA/Iran Joint Statement from March 2023, in May, "the Agency installed surveillance cameras at workshops in Esfahan where centrifuge rotor tubes and bellows are manufactured." However, despite reinstalling surveillance cameras, Iran is still not turning over the video footage to the IAEA, nor has Iran provided past footage from nuclear-related sites from February 2021 to June 2022. Moreover, there remain other Iranian centrifuge manufacturing and assembly facilities where Iran has still not permitted the IAEA to reinstall cameras.
- The IAEA urges Iran to hasten its cooperation. It writes, "The process of implementing the activities set out in the Joint Statement needs to be sustained and uninterrupted in order

that all of the commitments contained therein are fulfilled. In addition, the Agency has informed Iran that for these activities to be effective the Agency needs to re-establish a satisfactory understanding of Iran's inventory of centrifuge rotor tubes and bellows, including those in assembled centrifuges."

- The absence of monitoring and surveillance equipment, particularly since June 2022, has caused the IAEA to doubt its ability to ascertain whether Iran has diverted or may divert advanced centrifuges. A risk is that Iran could accumulate a secret stock of advanced centrifuges, deployable in the future at a clandestine enrichment plant or during a breakout at declared sites. Another risk is that Iran will establish additional centrifuge manufacturing sites unknown to the IAEA. Iran has proven its ability of moving manufacturing equipment to new, undeclared sites, further complicating any future verification effort and contributing to uncertainty about where Iran manufactures centrifuges.
- The IAEA concluded previously that "Iran's decision to remove all of the Agency's equipment previously installed in Iran for surveillance and monitoring activities in relation to the JCPOA has [had] detrimental implications for the Agency's ability to provide assurance of the peaceful nature of Iran's nuclear programme."
- Concern about Iran's installation of advanced centrifuges at an undeclared site increases as its 60 percent HEU stocks grow. Such a scenario is becoming more worrisome and viable, since a relatively small number of advanced centrifuge cascades would suffice for the rapid enrichment of the 60 percent enriched material to weapon-grade. This hybrid strategy involves the diversion of safeguarded HEU and the secret manufacture and deployment of only three or four cascades of advanced centrifuges. With greater uncertainty about the number of advanced centrifuges Iran is making, there is a greater chance of Iran hiding away the requisite number of advanced centrifuges to realize this scenario.
- Combined with Iran's refusal to resolve outstanding safeguards violations, the IAEA has a significantly reduced ability to monitor Iran's complex and growing nuclear program, which notably has unresolved nuclear weapons dimensions. The IAEA's ability to detect diversion of nuclear materials, equipment, and other capabilities to undeclared facilities remains greatly diminished.

Part 1: Enriched Uranium Stocks

At the Natanz FEP, Iran produced approximately 1219.2 kg of UF_6 enriched up to 5 percent U-235 during the reporting period, which spanned 89 days from February 12, 2023 to May 12, 2023.[2] The report discusses this amount as kilograms of UF_6 in units of UF_6 mass, which the authors refer to as hex mass. The total uranium mass, ignoring the fluorine elements, is 824.2 kilograms, for a monthly average production rate of 278 kg U mass and a daily average production rate of 9.3 kg U

[2] That production values are reported in uranium hexafluoride mass can be discerned only by comparing the production values to the differences in stockpile from one reporting period to the next. The differences in stockpile are consistently two-thirds of the given produced quantity, showing that the former is in uranium mass and the latter is in uranium hexafluoride mass.

mass. These average production rates decreased slightly from 300 kg U mass per month, or 10 kg U mass per day, during the previous reporting period, consistent with the fact that only natural uranium was used as feed during this reporting period, rather than Iran using also 2 percent LEU as feed, which allows for the quicker production of 5 percent LEU.

At the FFEP, during the last reporting period, which spanned February 12, 2023 to May 12, 2023, Iran produced 22.9 kg (hex mass) of near 60 percent enriched uranium, or 15.5 kg U mass. The daily average production rate was 0.17 kg (U mass), resulting in a monthly average of 5.2 kg (U mass), slightly above the average production during the last reporting period, where it was 4.7 kg (U mass). Annually, Iran could produce 94 kg (hex mass) or 63.5 kg (U mass) at this rate.

Iran also produced 53.6 kg of UF_6 (hex mass) enriched up to 20 percent enriched uranium, or 36.2 kg U mass. Average production of 20 percent enriched uranium at the FFEP was comparable to the last reporting period, at 0.6 kg (hex mass) or 0.4 kg (U mass), a decrease from earlier reporting periods. At this rate, Iran could produce 18 kg of near 20 percent enriched uranium per month (hex mass) or 12.2 kg (U mass) per month. Annually, Iran could produce 219.8 kg (hex mass) or 148.6 kg (U mass).

From its production of 60 and 20 percent enriched uranium at the FFEP, Iran accumulated 697.9 kg (hex mass) or 471.7 kg (U mass) of up to 2 percent enriched uranium in tails.

At the PFEP, Iran continued to produce 2 percent enriched uranium and up to 60 percent enriched uranium stock during the reporting period. Production of up to 5 percent LEU decreased significantly as the respective line underwent "refurbishment activities" and was not operating for most of the time. Between February 12, 2023 and May 12, 2023, the PFEP produced 16.6 kg (hex mass) of near 60 percent enriched uranium (equivalent to 11.2 kg in U mass); 2.6 kg (hex mass) of up to 5 percent LEU (1.8 kg U mass); and 237.8 kg (hex mass) of uranium enriched up to 2 percent U-235 (160.8 kg U mass).

The 60 percent enriched uranium production rate at the PFEP during this reporting period was 16.6 kg (hex mass) or 11.2 kg (U mass) over 89 days, resulting in a monthly average production rate of 5.6 kg (hex mass) or 3.8 kg (U mass) per month, or a daily average production rate of 0.19 kg (hex mass) or 0.13 kg (U mass) per day. This rate is slightly up from the previous reporting period's monthly average production rate, which was 4.6 kg (hex mass) or 3.1 kg (U mass) per month. Annually, using only the two advanced production-scale centrifuge cascades at the PFEP, Iran could produce 68 kg (hex mass) or 46 kg (U mass) of 60 percent enriched uranium. Together with production at the FFEP, Iran could produce 110 kg (U mass) or 162 kg (hex mass) of near 60 percent enriched uranium per year.

Of the 2 percent LEU, Iran produced 237.8 kg (hex mass) (or 160.7 kg U mass) in PFEP lines 1, 2, and 3, and 403.9 kilograms (hex mass) (or 273 kg U mass) enriched up to 2 percent as tails in line 5.

Estimates of additional amounts of LEU in oxides and intermediate products, fuel assemblies and rods, and scrap, add up to 359.7 kg (U mass), an amount only slightly larger than during the

previous reporting period. The report specifies that of the 359.7 kg enriched to unspecified levels (U mass), 38.8. kg are up to 20 percent enriched uranium and 2 kg are up to 60 percent HEU. Of the 38.8 kg (U mass) near 20 percent enriched uranium, 32.7 kg (U mass) are specified to be in the form of fuel assemblies. This includes an import during a previous reporting period of 2.7 kg of 20 percent enriched uranium for Tehran Research Reactor (TRR) fuel production from Russia, and 1.1 kg of 20 percent enriched uranium in a fuel assembly irradiated to less than the limit established by the JCPOA under which the irradiated uranium would no longer be included in the enriched uranium stockpile.

Of its near 5 percent LEU stock, Iran fed 775 kg hex mass (or 523.9 kg U mass) into the cascades at Fordow, for an average feed rate of about 8.7 kg per day hex mass, or 5.9 kg U mass, more than during the previous reporting period. (In this report, there is no indication that natural uranium was used as feed for the two IR-6 cascades to produce direct feed for one set of IR-1 centrifuges enriching to 20 percent enriched uranium.) Iran dumped 0.7 kg of near 5 percent LEU feed at the FFEP (hex mass), or about 0.5 kg in uranium mass, less than one-tenth of the amount dumped during the previous reporting period. Iran also fed 423.2 kg of near 5 percent hex mass (286 kg U mass) into PFEP R&D lines 4, 5, and 6, for a daily average feed rate of 4.8 kg (hex mass) or 3.2 kg U mass per day, similar to the previous reporting period.

Based on this information, Iran's new stockpile of near 5 percent LEU in uranium mass should be the sum of 1324.5 kg U mass from the last reporting period, 824.2 kg from the FEP, and 1.8 kg from the PFEP, with the feed of 810 kg subtracted. Adding back the 0.5 kg (U mass) feed dumped at the FFEP, this total becomes 1340.9 kg (before rounding of addends), close to the 1340.2 kg U mass of near 5 percent LEU in UF_6 form that the IAEA reported.

The net overall enriched uranium stock, including all levels of enrichment and all chemical forms, increased by 983.7 kg from 3760.8 kg to 4744.5 kg (see Table 1). For the first time since August 2022, this represents a large increase in uranium enriched up to 2 percent, which accounts for 904.3 kg of the overall increase. The near 5 percent LEU stock in the form of UF_6 increased by 15.7 kg, down from an increase of 294.6 kg during the previous reporting period, as Iran kept producing 20 percent enriched uranium and 60 percent enriched uranium; both processes use large amounts of 5 percent LEU as feedstock. The near 20 percent enriched uranium stock increased by 36.2 kg from 434.7 kg to 470.9 (U mass), and the near 60 percent enriched uranium stock increased by 26.6 kg from 87.5 kg to 114.1 kg (U mass).

At the PFEP, Iran continued to use a combination of R&D lines 4, 5, and 6 to feed 5 percent LEU into the interconnected cascades in lines 4 and 6 and produce 60 percent enriched uranium. As line 5 underwent changes during this reporting period, it was "only shortly" in operation to produce up to 5 percent LEU, using tails produced in lines 4 and 6 as feed. During this reporting period, spanning February 12, 2023 to May 12, 2023, of the 423.2 kg (hex mass) of 5 percent LEU fed into lines 4 and 6, Iran turned 16.6 kg (hex mass) (3.9 percent) into 60 percent enriched uranium and 2.6 kg (hex mass) back into 5 percent enriched uranium (less than one percent, due to line 5 not operating most of the time). 409.3 kg (hex mass) (96.7 percent) remained as tails enriched up to 2 percent.

Table 1. Enriched Uranium Quantities,* including less than 5 %, up to 20 %, and up to 60 % enriched uranium (all quantities in uranium mass)

Chemical Form	May 15, 2022	August 21, 2022	October 22, 2022	February 12, 2023	May 13, 2023
UF6 (kg)	3491.8	3621.3	3323.1	3402	4384.8
Uranium oxides and their intermediate products (kg)	238.9	252.3	241.6	215.3	207.5
Uranium in fuel assemblies and rods (kg)	48.1	48.2	49.3	58.4	59.5
Uranium in liquid and solid scrap (kg)	30.6	19.1	59.7	85.1	92.7
Enrichment Level Subtotals					
Uranium enriched up to 5 percent (kg) but more than 2 percent	1055.9	713.9	1029.9	1324.5	1340.2
Uranium enriched up to 2 percent (kg)	2154.4	2519.9	1844.5	1555.3	2459.6
Uranium enriched up to 20 percent (kg)	238.4	331.9	386.4	434.7	470.9
Uranium enriched up to 60 percent (kg)	43.1	55.6	62.3	87.5	114.1
Uranium in chemical forms other than UF6 with unspecified enrichment level (kg) (including 38.8 kg up to 20 % LEU and 2 kg up to 60 % HEU)	317.6	319.6	350.6	358.8	359.7
Totals of Enriched Uranium in UF6 , <5 % (kg)	3210.3	3233.8	2874.4	2879.8	3799.8
Totals of Enriched Uranium in UF6, including near 20 % and near 60 % (kg)	3491.8	3621.3	3323.1	3402	4384.8
Totals of Enriched Uranium in all chemical forms , <5 % <20 % and <60 % enriched	**3809.4**	**3940.9**	**3673.7**	**3760.8**	**4744.5**

*These totals do not include undisclosed stocks of enriched uranium exempted by the JCPOA Joint Commission.

Part 2: Enrichment Capacity

Natanz Fuel Enrichment Plant

Installed Centrifuges. As of May 23, 2023, Iran had installed at the Natanz FEP 36 cascades of IR-1 centrifuges,[3] 21 cascades of IR-2m centrifuges, four cascades of IR-4 centrifuges, and three cascades of IR-6 centrifuges. Iran has plans to install an additional eight cascades of IR-4 centrifuges, and the installation of one IR-4 cascade was on-going, but no full cascades were added to the FEP during this most recent reporting period. Iran now has an estimated total of 4872 advanced centrifuges installed at the FEP, of which 3654 are IR-2m centrifuges.

Enriching Centrifuges. As of May 23, 2023, the IAEA reports that at the FEP, in total, 36 cascades of IR-1 centrifuges, nine cascades of IR-2m centrifuges, two cascades of IR-4 centrifuges, and three cascades of IR-6 centrifuges were being fed with natural UF_6 to produce UF_6 enriched up to 5 percent. During the previous reporting period, 36 IR-1 cascades, eight IR-2m cascades, three IR-4 cascades, and three IR-6 cascades were being fed, also with natural UF_6 or with uranium enriched up to 2 percent. Overall, the enrichment capacity in enriching centrifuges remains significantly below that of installed centrifuges, as a total of 12 IR-2m cascades and two IR-4 cascades are installed but not enriching at the FEP.

The quantity of IR-1 centrifuges Iran withdrew from JCPOA-mandated storage continues to be unavailable for this reporting period because of Iran's refusal since February 2021 to provide the IAEA with access to data and recordings collected by agency equipment, and since June 2022, to continue collecting such data. In general, these centrifuges are believed to be coming from stocks of IR-1 centrifuges dismantled before JCPOA Implementation Day in January 2016 rather than being newly built.

It is unclear whether the IR-2m cascades installed during the last few reporting periods contain newly produced machines or if they were drawn from a secret storage site. The number installed far exceeds the amount Iran stored under monitoring during the implementation of the JCPOA and subsequently redeployed in early 2021. The total number of IR-2m centrifuges installed is three times the quantity Iran had installed prior to the JCPOA and even exceeds the quantity Iran had declared prior to the JCPOA it planned to install at the FEP but declared, perhaps falsely, that it had not built.

Fordow Fuel Enrichment Plant

At the FFEP, Iran currently has 1044 IR-1 centrifuges installed in three sets of two interconnected cascades, and two interconnected cascades of 166 IR-6 centrifuges. Iran has not installed any additional IR-6 or IR-1 centrifuges toward its plans of adding up to 14 additional cascades to the FFEP. Iran removed a single IR-1 centrifuge and associated "temporary set-up" installed for stable

[3] In August 2022, Iran had announced its intention to reconfigure some of the IR-1 cascades to include additional centrifuges, and in December 2022, this process was completed with 120 total IR-1 centrifuges added.

isotope production R&D, a further indication that it has no plans to return to the JCPOA's aspired conversion of the FFEP away from uranium enrichment and towards stable isotope production.

Iran also did not make progress in installing infrastructure for enrichment in building B1000, currently used to store excess IR-1 centrifuges, but which Iran announced in November 2022 would be commissioned for enrichment. Building B1000 contains eight enrichment units, where each can hold 18 cascades (same general design as Building A1000), but Iran has not specified how many centrifuges and what type it plans to install there.

Iran continues to use the three sets of two interconnected IR-1 cascades to produce 20 percent enriched uranium from up to 5 percent LEU. Two interconnected IR-6 cascades have produced 60 percent HEU from 5 percent LEU feed. In late January 2023, the IAEA detected near-84 percent enriched HEU at the product sampling point, suggesting that the enrichment level temporarily rose above 60 percent (see below).

60 Percent Production at the FFEP. The IAEA confirmed that on November 22, 2022, Iran started using the two cascades of IR-6 centrifuges to produce UF_6 enriched up to 60 percent from near 5 percent LEU feed "by operating the two IR-6 cascades as one set of two interconnected cascades." In a footnote, the IAEA specified that the declared mode of interconnection used the IR-6 cascade without modified sub-headers for the last stage of enrichment to 60 percent, and this mode appears to have been used through January 16, 2023.

At some point after an unannounced inspection (UI) on January 16, 2023, Iran made an undeclared change to the operation, where the IR-6 cascade with modified sub-headers was used for the last stage of enrichment. This change was detected by the IAEA during another unannounced inspection on January 21, 2023. The IAEA reported the undeclared change of operation as a breach of Iran's safeguards obligations. Further, inspectors decided to collect environmental samples at the product sampling point during the monthly interim verification (IIV) the next day.

Near-84 Percent Production at the FFEP. On January 22, 2023, the IAEA detected uranium particles enriched to 83.7 percent from environmental sampling taken during a monthly IIV on January 22. Iran's answers about this anomaly did not satisfy the IAEA, and it asked Iran for more credible answers. One month later, the IAEA took destructive analysis samples from the cylinder Iran had been using to collect the 60 percent HEU product, but did not identify an anomaly in the overall enrichment level of the product collected in that cylinder. In its earlier reporting, the IAEA tied the detection of near-84 percent enriched uranium particles directly to its closer examination of the area following the change in the IR-6 cascade configuration discussed above.

On February 20, 2023, Iran informed the Agency that "unintended fluctuations in enrichment levels may have occurred during the transition period at the time of commissioning the process of [60 percent] product (November 2022) or while replacing the feed cylinder." In February and March, the IAEA and Iran had several meetings at the facility and in Tehran, where Iran provided additional information, including supporting operational data, with regards to the particles enriched up to 83.7 percent. The IAEA checked the consistency of the new information. On March

30, 2023, the IAEA indicated in a letter to Iran that, based on its evaluation, it "assessed that the information provided was not inconsistent with Iran's explanation for the origin of these particles and that the Agency had no further questions on the matter at that stage." The IAEA repeated that it also found no indication of the accumulation and collection of nuclear material enriched above 60 percent, but it will be able to confirm that no diversion of nuclear material took place once it completes an annual physical inventory verification (PIV). That annual PIV was "successfully carried out at the end of April – beginning of May 2023, the evaluation of which is still ongoing."

The IAEA report does not contain any details of the agency's findings, nor does the IAEA report on whether it checked if any of Iran's information was falsified, but the IAEA does indicate it checked the information's consistency. The IAEA's judgment that the information supplied by Iran was "not inconsistent" with Iran's explanation is notable. Historically, the IAEA uses the mathematical logical formulation of "not inconsistent," a double negative, instead of "consistent," to express that a finding has a lower confidence level because of insufficient basis to confirm information made available by a state. However, the IAEA also does not have credible information contradicting the statements made by the state.[4] As such, the IAEA may revisit a "not inconsistent" finding. Nonetheless, it is apparent from the description that Iran's production of the 83.7 percent HEU was probably a one-off occurrence, but the episode has left an indelible impression that Iran can produce 90 percent enriched uranium quickly and perhaps secretly if it chooses to do so.

Pilot Fuel Enrichment Plant

New Underground PFEP. Since the previous report, Iran has made "some further progress" with plans to transfer its enrichment research and development activities to "a segregated area of Building A1000 at the FEP, to create a new area of the PFEP." On April 24, 2023, Iran provided the IAEA with an updated design information questionnaire (DIQ) for Building A1000, stating it intends to commission there six of the 18 R&D lines (A-F), consisting of "up to 174 IR-4 or IR-6 centrifuges, or various configurations of smaller cascades and single machines." It further declared that it may accumulate enriched uranium product of up to 5 percent LEU from enrichment activities in that area. Iran has begun installing centrifuges in two of the lines, lines A and B, where line A consists of five IR-4 centrifuges, and line B consists of 20 IR-6s centrifuges. On May 23, 2023, the IAEA verified that the installation of infrastructure for the overall 18 cascades was progressing, but the installation of feed and withdrawal equipment had not begun.
The report does not provide an anticipated start date for this new area. Given that this new R&D area represents a three-fold increase from the six lines in the above-ground PFEP, and each could hold a full production-scale cascade of Iran's advanced centrifuges, one must ask if this area could

[4] From an earlier IAEA safeguards report, "By 'consistent', the Agency means that the information made available to it by the State is internally consistent and consistent with the Agency's findings and all information available to it. The Agency uses the term 'not inconsistent' to refer to instances where there is insufficient information available to confirm the information made available by the State (for example, if the events took place many years in the past). The confidence level in the second instance is therefore lower, but the Agency has no credible information contradicting the statements made by the State."

be devoted to production-scale enrichment in case of a surge in enriched uranium production or a breakout.

60 Percent Enriched Uranium Production in Lines 4, 5, and 6. The IAEA reported no changes to the deployment of centrifuges in production lines 4 and 6 which are used for the production of 60 percent enriched uranium. Since 60 percent enriched uranium production started on April 17, 2021, Iran has changed the mode of production several times, described in previous IAEA reports.

On May 23, 2023, the IAEA verified that Iran was continuing to feed up to 5 percent LEU into the two interconnected cascades in lines 4 and 6, comprising up to 164 IR-4 and up to 164 IR-6 centrifuges, respectively, and producing up to 60 percent enriched uranium. Line 5 is used to re-enrich tails from lines 4 and 6 to near 5 percent LEU, but was undergoing "refurbishment activities" for most of the recent reporting period. The assay of the tails is likely about 2-3 percent. In a footnote, the IAEA confirms that the tails from lines 4 and 6 that were not re-enriched in line 5 were accounted for as part of the stockpile enriched up to 5 percent, rather than the stockpile enriched up to 2 percent. As of May 18, the previously installed 30 IR-5 and 29 IR-6s centrifuges had been removed and line 5 was enriching tails from lines 4 and 6 in a cascade of 166 IR-4 and three IR-6 centrifuges.

The IR-4 cascade in line 4 and the IR-6 cascade in line 6 have similar estimated production-scale enrichment outputs of about 600 SWU per year each, where the enrichment outputs for these two centrifuge types in a production-scale cascade are taken from separate Institute reports.[5] The IR-6 centrifuge cascade has a production-scale enrichment output that is lower than expected. The two lines together have an estimated output of 1200 SWU per year, or the equivalent of about 1330 IR-1 centrifuges.

Lines 2 and 3. On May 23, 2023, the IAEA verified that lines 2 and 3 continued to accumulate uranium enriched up to 2 percent through feeding of natural UF_6. The IAEA verified that Iran had been using for this purpose small and intermediate cascades of up to: 7 IR-2m centrifuges; 20 IR-4 centrifuges; six IR-5 centrifuges and 18 IR-5 centrifuges; ten IR-6 centrifuges and 19 IR-6 centrifuges; and 20 IR-6s centrifuges. Iran has not redeployed any IR-s centrifuges, which had previously been installed in lines 2 and 3. The IR-s is a shorter centrifuge with a relatively high theoretical enrichment output, suggesting that it uses a carbon fiber rotor tube and is designed to operate at higher speeds than other Iranian advanced centrifuges, as discussed in an earlier Institute report.[6] Perhaps, Iran acquired enough information from a multi-year testing

[5] David Albright, Sarah Burkhard, and Spencer Faragasso, "A Comprehensive Survey of Iran's Advanced Centrifuges," *Institute for Science and International Security*, December 2, 2021, https://isis-online.org/isis-reports/detail/a-comprehensive-survey-of-irans-advanced-centrifuges. The enrichment output for the IR-6 is further adjusted based on: David Albright and Sarah Burkhard, "The IR-6 Centrifuge Needs Further Development," *Institute for Science and International Security,* September 9, 2022, https://isis-online.org/isis-reports/detail/the-ir-6-centrifuge-needs-further-development/.

[6] David Albright, Sarah Burkhard, and Spencer Faragasso, "A Comprehensive Survey of Iran's Advanced Centrifuges," *Institute for Science and International Security*, December 2, 2021, https://isis-online.org/isis-reports/detail/a-comprehensive-survey-of-irans-advanced-centrifuges.

period, or just as likely, encountered a problem. Iran has had difficulty operating centrifuges at high speeds and the centrifuges may have broken and were not replaced.

The following single centrifuges were being tested with natural UF_6 but were not accumulating enriched uranium: five IR-2m centrifuges, six IR-4 centrifuges; one IR-5 centrifuge; five IR-6 centrifuges; one IR-7 centrifuge; one IR-8 centrifuge; one IR-8B centrifuge; and one IR-9 centrifuge. The single installed IR-6s centrifuge that was reportedly removed during the last quarterly report in February has not returned.

In 2021, Iran implemented a new mode of operation in line 2, feeding either 5 or near 20 percent enriched uranium into single advanced centrifuges, intermediate cascades of 10 advanced centrifuges, and intermediate cascades of 20 advanced centrifuges. For part of last year, only near 20 percent enriched uranium was used as feed, marking the first time Iran started feeding a cascade with uranium enriched higher than 5 percent at any of its enrichment plants. Although the product and tails streams were re-combined, with no product collected, the experience gained from this procedure was likely important, particularly in the production of HEU in key advanced centrifuges when using near 20 percent enriched uranium feedstock. It is possible, and perhaps the objective, that Iran achieved an enrichment level of 90 percent and measured it, prior to remixing with the tails, a measurement likely unavailable to the IAEA. In any case, Iran gained irreversible knowledge in the setup and use of feed equipment designed for smaller quantities and higher enriched uranium levels.

The IAEA reported that as of November 17, 2021, Iran had stopped feeding near 20 percent enriched uranium into line 2. It added that Iran had removed the associated temporary feed and withdrawal setup, a setup likely required because of the smaller quantities of enriched uranium and concerns about criticality of HEU product. The IAEA did not state where this setup is stored or how many such setups exist. These setups could be critically important in a breakout and allow for a more rapid conversion from producing LEU to producing HEU. As such, their use in line 2 represents the use of additional equipment and experience gained relevant to breakout.

Line 1. Iran was feeding natural UF_6 into an intermediate cascade of 18 IR-1 centrifuges and an intermediate cascade of 82 IR-2m centrifuges in line 1 to produce uranium enriched up to 2 percent U-235.

Capacity of Centrifuges Enriching Uranium

Table 2 lists the estimated enrichment capacity by facility for those centrifuges that are currently enriching (not including machines installed but not yet enriching), leading to a total of 19,160 SWU per year, or the equivalent of 21,297 IR-1 centrifuges. This total enrichment capacity of enriching centrifuges is slightly higher than the previous reporting period's 18,700 SWU per year, because Iran started to enrich uranium in a cascade of IR-4 centrifuges at the PFEP.

By contrast, including the installed but not yet enriching centrifuges results in an enrichment capacity of 29,650 SWU per year.

Of note, the total enrichment capacity used in breakout calculations is different since it also includes currently installed centrifuges. This difference is especially significant at the moment, because Iran has 14 additional advanced centrifuge cascades installed, which it was not using to enrich during the latest reporting period, but doing so will increase Iran's installed enrichment capacity dramatically. Also, the advanced centrifuges in the PFEP, except production-scale advanced cascades, would likely not contribute meaningfully to the quick production of enough WGU for a nuclear explosive, starting with up to five percent or near 20 percent enriched uranium.

Table 2. Quantity of enriching centrifuges and enrichment capacity

	Number of enriching centrifuges	Enrichment capacity in SWU/yr	IR-1 equivalent
Natanz FEP	8606	14465	16073
Fordow	1376	2135	2372
Natanz Above-Ground PFEP*	697	2563	2847
Lines 1, 2 & 3	See text		
Lines 4, 5 & 6	See text		
Natanz Below-Ground PFEP	25	89	98
Total	10679	19163	21297

*The values for lines 1, 2 and 3 of the PFEP are rough estimates based on the use of estimated and measured values for the separative output of these centrifuges in cascades, as drawn from IAEA and Iranian information.

Practicing Breakout by Producing Highly Enriched Uranium

During this reporting period, Iran continued to produce 60 percent enriched uranium, or HEU, and its stock now amounts to almost three significant quantities of HEU.[7] Thus, Iran continues to have enough nuclear explosive material to have assurance it can directly fashion a nuclear explosive device. Its recent production of an unspecified amount of 84 percent enriched uranium supports that Iran can reach even higher enrichments.

Sixty percent enrichment is a level associated with a key step in the traditional A.Q. Khan stepwise process of climbing from natural uranium to 90 percent enriched uranium. But 60 percent

[7] A significant quantity of 60 percent enriched uranium is 41.7 kg, and contains 25 kilograms of uranium-235, all in uranium mass.

enriched uranium can be used directly in nuclear weapons. About 40 kg (U mass) is more than enough to make a nuclear explosive, compared to 25 kg (U mass) of 90 percent enriched uranium the Institute uses as sufficient for Iran to manufacture a nuclear explosive.

Moreover, the way Iran has enriched to 60 percent in one step, starting from near 5 percent enriched material, is innovative, suggesting Iran gained valuable experience in producing HEU, and by extension, even WGU. Iran is practicing breakout under a civilian cover and also learning to reduce the number of steps that it would need to go from natural uranium to WGU.

Iran may have applied this one-step process to the production of small quantities of WGU from near 20 percent enriched uranium, despite not collecting this product, as discussed above. In November 2021, Iran fed an unspecified amount of its near 20 percent enriched uranium stock into a variety of advanced centrifuges at the PFEP. Since Iran was not accumulating enriched uranium, and was instead combining the product and tails, the levels of enriched uranium achieved are not included in the report and may also not be known to the IAEA. The levels reached may include 90 percent, or weapon-grade.

Although Iran's process of creating 60 percent enriched uranium is far from ideal, the Iranian process has demonstrated certain advantages, including being within its technical reach and recycling the tails down to the level of near two percent enriched or even natural uranium, while producing 5, 20, and 60 percent enriched uranium. More importantly, it is practicing multi-step enrichment arrangements that are key to breaking out. Moreover, the Iranians are experimenting with transferring enriched UF_6 as a gas from one step to the next, instead of having to solidify the intermediate product gas and turn it back into a gas in the next step. All this experimentation is leading Iran to be more capable of breaking out, if the leadership orders production of WGU or moves toward the construction of nuclear weapons. Meanwhile, Iran continues to accumulate 60 percent HEU, which can be used directly in a nuclear explosive or further enriched quickly to weapon-grade in relatively few advanced centrifuges. After all, 60 percent enriched uranium is 99 percent of the way to WGU.

Transfer of 60 Percent HEU from Natanz to Esfahan

During previous reporting periods, Iran transferred 60 percent HEU hexafluoride from the Natanz site to the Fuel Plate Fabrication Plant (FPFP), which it declared to be for the production of HEU targets for the TRR. However, almost none of this enriched uranium has been turned into targets.

In January 2022, Iran transferred 23.3 kg (U mass) of 60 percent material to the FPFP. On April 19, 2022, the IAEA verified the receipt of an additional quantity of 15.3 kg (U mass) 60 percent HEU, bringing the total to 38.6 kg (U mass). On September 11, 2022, the IAEA verified the receipt of 16.5 kg (U mass) of 60 percent enriched uranium, bringing the total to 55.1 kg. On October 24, 2022, the IAEA verified the presence of a total of 53 kg (U mass) 60 percent HEU at the "storage area" of FPFP. The difference of about 2 kg matches the amount of 60 percent HEU reported to be in forms other than uranium hexafluoride, specified to contain 1.6 kg (U mass) in mini-plates slated for irradiation in the TRR (see below), and 0.4 kg (U mass) in liquid and solid scrap.

On February 15, 2023, the IAEA verified the receipt at FPFP of 16.55 kg (U mass) of 60 percent enriched uranium in the form of uranium hexafluoride, bringing the total in the storage area to 69.55 kg (U mass) in the form of uranium hexafluoride. No additional transfer or production of mini-plates (targets) has been reported since the previous reporting period.

Given a total stock of 114.1 kg (U mass), about 60 percent of this stock was in storage at Esfahan in the form of uranium hexafluoride as of May 2023. This is a decrease from the total of 80 percent of this material stored at the FPFP at the end of the previous reporting period. Given that Esfahan holds Iran's capabilities to turn enriched uranium hexafluoride into metal, such transfers raise additional proliferation concerns.[8]

Part 3: Current Breakout Estimates

During this reporting period, Iran's installed centrifuge capacity used for breakout calculations did not grow. The reason for the halt to what had been a rapid growth in deployed advanced centrifuges is not explained. However, since Iran no longer allows the IAEA to monitor its manufacture and assembly of advanced centrifuges, it could be stockpiling such machines without the IAEA's knowledge.

Iran's breakout timeline remains at zero. It has significantly more than enough 60 percent enriched uranium, or HEU, to be assured it could directly fashion a nuclear explosive.[9] If Iran wanted to further enrich all its 60 percent HEU up to weapon-grade, obtaining almost 75 kg of weapon-grade uranium, it could do so in about 1.3 months, utilizing only three or four of its advanced IR-6 centrifuge cascades, all of which are already configured to make HEU.[10] It could produce enough WGU for its first nuclear explosive in about 12 days after starting a breakout, where a weapon is assigned 25 kg of weapon-grade uranium (U mass) (see below for a brief explanation for this choice).

In parallel to further enriching 60 percent material, Iran could enrich its near 20 percent enriched uranium stock to weapon-grade uranium in its production-scale cascades at the FEP and FFEP. Using the Institute's breakout calculator, and assuming a set-up time of two weeks, Iran is estimated to be able to accumulate, in slightly less than five weeks, more than enough weapon-grade uranium for three nuclear weapons from its total stock of near 20 percent enriched uranium.

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[8] David Albright, Sarah Burkhard, and Andrea Stricker, "Analysis of IAEA Iran Verification and Monitoring Report - May 2022," *Institute for Science and International Security*, June 6, 2022, https://isis-online.org/isis-reports/detail/analysis-of-iaea-iran-verification-and-monitoring-report-may-2022/8.

[9] According to the IAEA, Iran has 114.1 kg of 60 percent enriched uranium (uranium mass) in the form of uranium hexafluoride, almost three significant quantities, where the IAEA defines a significant quantity as the "approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive cannot be excluded."

[10] For background, see David Albright and Sarah Burkhard: "Entering Dangerous, Uncharted Waters: Iran's 60 Percent Highly Enriched Uranium," *Institute for Science and International Security,* April 11, 2022, https://isis-online.org/isis-reports/detail/entering-uncharted-waters-irans-60-percent-highly-enriched-uranium.

Looking at the issue differently, in one month, using portions of both 20 and 60 percent stocks, with a set-up time applied to the 20 percent enriched uranium, Iran could produce enough weapon-grade uranium for five nuclear weapons. Smaller amounts may be sufficient for each nuclear weapon, indicating that the breakout calculation is conservative. (If a setup time for 20 percent material is ignored, Iran could produce enough WGU for almost six nuclear weapons in one month).

In the second month, Iran could continue enriching to weapon-grade using its remaining feedstock of 60 and 20 percent, combined with some of its less than five and above two percent (taken as 4.5 percent) enriched uranium stock, producing enough weapon-grade uranium for two more nuclear weapons, or a cumulative total of seven. During the third month, there would be enough of the less than 5 percent enriched uranium to produce enough WGU for one more nuclear weapon.

Thus, Iran's enriched uranium stocks are sufficient to make enough weapon-grade uranium for five nuclear weapons in one month, seven nuclear weapons in two months, and eight in three months.

When Iran ended its crash nuclear weapons program in 2003, called the Amad Plan, its biggest bottleneck was the lack of WGU; it still needed at least a few more years to accumulate enough WGU for a nuclear weapon.[11] Under intense international pressure, Iran decided in 2003 to downsize and better camouflage its nuclear weapons effort, while pushing to establish a robust capability to enrich uranium. Today, that decision has borne fruit. While it could only aim for enough nuclear explosive material for five nuclear weapons in 2003, today it can have enough for those five weapons in one month. With its residual and covert nuclear weaponization capabilities, Iran could test a nuclear explosive underground or deploy a crude nuclear weapon in six months, or reestablish and complete its Amad Plan infrastructure in two years, before serially producing nuclear weapons for ballistic missiles.[12]

Breakout Calculator. The Institute's breakout calculator is used to estimate the breakout time, as in previous reports. The methodology is described in earlier Institute reports. The production of WGU from the 4.5, 20, and 60 percent enriched uranium stocks significantly reduces the timeline for the production of multiple quantities of 25 kg of WGU (U mass). The authors' benchmark reflects a reasonable, assured quantity of WGU for a variety of nuclear weapon designs available to Iran and the creation of a pipeline for production of multiple WGU cores. As before, the total enrichment contribution from small, non-production-scale cascades of advanced centrifuges installed at the PFEP is not included, as their use in a breakout would be complicated and likely would not contribute significantly to reducing breakout timelines. Stocks of less than 2 percent enriched uranium are also not used, since to do so would require additional modifications of the cascades to handle lower enrichments, likely significantly slowing or contributing only slightly,

[11] David Albright with Sarah Burkhard and the Good ISIS Team, *Iran's Perilous Pursuit of Nuclear Weapons* (Washington, DC: Institute for Science and International Security Press, 2021).

[12] David Albright, "Iran Building Nuclear Weapons," *Institute for Science and International Security,* December 5, 2022, https://isis-online.org/isis-reports/detail/iran-building-nuclear-weapons/8.

rather than speeding up, breakout timelines. Lastly, only enriched uranium hexafluoride stocks are used; Iran's chemical conversion of other stocks is assessed as too time consuming, and involving too little material, to significantly affect the breakout estimate.

The breakout timelines are credible, worst-case estimates, likely representing the shortest timelines to breakout, with longer timelines possible. Uncertainties include ongoing ones, such as the exact enrichment level of the uranium stock enriched between 2 and 5 percent and operational efficiencies of the advanced centrifuges, particularly the IR-4 and IR-6 cascades, although the calculations use a significantly lower estimated enrichment output for the IR-6 cascades than expected.

Part 4: Enriched Uranium Metal Production Remains Halted, Nuclear Material Discrepancy at Uranium Conversion Facility

During the last six reporting periods, Iran has not produced any uranium metal at the Fuel Plate Fabrication Plant (FPFP). On February 28, 2022, the IAEA verified that Iran had converted the remaining 900 grams of uranium in the form of uranium tetrafluoride (UF_4) enriched up to 20 percent, previously intended for production of uranium metal, into U_3O_8. However, its capability to produce uranium metal remains intact.

In December 2020, Iran informed the IAEA that it would begin producing uranium metal, including uranium metal enriched up to 20 percent, a step that alarmed many. Iran is using the uranium metal in civil applications, including to produce experimental fuel rods for the TRR. However, Iran has no pressing need to develop this fuel or to use this material for other civilian activities, lending weight to concern that Iran is installing the wherewithal to make uranium metal to increase its nuclear weapons capabilities, producing it to practice the manufacture of enriched uranium metal components of nuclear weapons. Prior to 2003, under the Amad Plan, Iran was constructing both pilot and large-scale uranium metallurgy facilities to make nuclear cores and was practicing with surrogate materials for WGU.[13]

On February 2, 2021, Iran began producing uranium metal using natural uranium in a laboratory experiment at the Esfahan FPFP. As of August 14, 2021, the IAEA verified that Iran had begun producing enriched uranium metal from 20 percent enriched UF_6. It produced 200 grams of enriched uranium metal, starting with 257 grams of enriched uranium in tetrafluoride form.

Iran stated this enriched uranium metal is for use in silicide fuel for the TRR. Iran produced "two batches of uranium silicide" containing 0.43 kg of uranium enriched to 20 percent. Assuming this is in uranium mass, the uranium silicide contains twice the amount of metal that was reported previously (430 grams compared to 200 grams). On November 2, 2021, the IAEA verified that Iran

[13] *Iran's Perilous Pursuit of Nuclear Weapons*; David Albright, Sarah Burkhard, and Frank Pabian, "Shahid Mahallati: 'Temporary' Plant for Manufacturing Nuclear Weapon Cores," *Institute for Science and International Security*, April 8, 2020, https://isis-online.org/isis-reports/detail/shahid-mahallati-temporary-plant-for-manufacturing-nuclear-weapon-cores/8.

had "manufactured two fuel plates using uranium silicide." Subsequently, the two fuel plates were inserted into the TRR. Iran has continued to make silicide fuel plates. As of May 20, 2023, three irradiated silicide fuel elements, containing 70 grams of 20 percent enriched uranium, were in the TRR spent fuel pond. As of that date, another two such fuel elements were being irradiated in the TRR.

On February 21, 2022, the IAEA verified that the installation of equipment for the first of three stages for the production of enriched UF_4 from enriched UF_6 at the FPFP, while almost complete, had progressed only slightly. Uranium tetrafluoride can be the intermediate product of uranium metal. The IAEA noted that on May 17, 2022, installation had been completed but Iran had not yet tested it with nuclear material, and the IAEA observed the same as of May 24, 2023. No progress was observed as of May 24 on the remaining two stages of this conversion process.

At the nearby Uranium Conversion Facility (or UCF) at Esfahan, in November 2021, Iran had finished installing equipment for producing uranium metal, and the facility was ready to operate with depleted or natural uranium. As of May 17, 2023, the IAEA verified that no nuclear material had been introduced into the production area.

Discrepancy at the Uranium Conversion Facility

The IAEA continued to report on a discrepancy in the inventory of natural uranium at the UCF, adding in this report Iran's lack of adequate cooperation to resolve the issue, despite an earlier promise to do so. On March 9, 2022, the IAEA verified the receipt at the UCF of 302.7 kg of natural uranium, as declared by Iran, in the form of solid waste and items of uranium metal from Jabar Ibn Hayan Multipurpose Laboratory (JHL). Later that same month, inspectors verified at the UCF Iran's dissolution of this nuclear material. The IAEA identified a discrepancy in the amount of nuclear material it had verified compared to the amount declared by Iran.
JHL has figured prominently in past IAEA efforts to understand the fate of undeclared uranium metal discs dating to Amad Plan activities undertaken at the secret Lavisan-Shian site in Tehran. There, uranium shavings taken from at least one metal disc were used in the production of uranium deuteride for neutron initiators being developed for use to start the chain reaction in the weapon-grade uranium core of a nuclear weapon. The *Wall Street Journal*, citing two senior diplomats familiar with Iran's activities, reported that the discrepancy was "connected to Iran's dissolution of a natural uranium metal disc the IAEA has been looking for as part of a probe into undeclared nuclear material found in Iran."[14]

Unlike the previous IAEA report, which did not report whether the discrepancy meant a surplus or a shortfall in Iran's declaration, the latest IAEA report specifies that there was a shortfall in Iran's declaration. This indicates that the IAEA did indeed verify the presence of more material than declared by Iran, and while not evidence, this is consistent with the media reporting that Iran may have mixed in undeclared nuclear material it used at Lavisan-Shian.

[14] Laurence Norman, "U.N. Agency Confirms Iran Produced Enriched Uranium Close to Weapons Grade," *The Wall Street Journal*, February 28, 2023.

The original discrepancy was acknowledged by Iran during a technical meeting between senior IAEA and Iranian officials in Tehran on February 23, 2023. Iran agreed to work with the IAEA to address this discrepancy. In April 2023, however, Iran provided the IAEA with revised nuclear material accountancy information for the UCF, but the IAEA stated these revisions "neither addressed the discrepancy nor satisfied the requirements stipulated under' its comprehensive safeguards report. The IAEA concluded that revisions are "not based on scientific grounds, and, therefore [are] not acceptable."

Part 5: Heavy Water and Arak Reactor

The IAEA reports that since February 2021, due to Iran's reductions in agency monitoring, it has not been able to ascertain the status of Iran's Heavy Water Production Plant (HWPP) nor the production and inventory of heavy water. Since June 11, 2022, when Iran removed Flow-rate Unattended Monitoring (FLUM) equipment at the HWPP, the IAEA has had no monitoring capabilities. Based on commercial satellite imagery, the IAEA included in its May 2023 report its assessment that the HWPP continued to operate during the reporting period.

The IAEA reports that as of May 17, 2023, Iran had not resorted to the original, pre-JCPOA design of the Arak heavy water research reactor (IR-40 reactor), now called the Khondab Heavy Water Research Reactor (KHRR). Iran also had not produced or tested natural uranium pellets, fuel pins, or fuel assemblies for the reactor as originally designed. The IAEA reports that Iran provided an updated DIQ for the Arak reactor, indicating "that the reactor power of 20 MW(th), the fuel enrichment and the preliminary core design are consistent with the 'Fundamental Principles' and 'Preliminary Characteristics' for the re-design of the research reactor" were consistent with the Arak conceptual design set out in Annex I of the JCPOA. Iran informed the IAEA that it expects to commission the reactor in 2023 and start operations in 2024. Iran also indicated that the primary circuit will be commissioned in the next 2-3 months and while using IR-20 dummy fuel assemblies. A wide range of "civil construction work was ongoing at all floors of the reactor building." It is questionable whether Iran can reach these milestones.

Part 6: Additional Protocol, Monitoring, and Transparency

Iran stopped implementing the Additional Protocol (AP) to its comprehensive safeguards agreement (CSA) and the JCPOA's additional monitoring arrangements on February 23, 2021, when it also stopped implementing modified Code 3.1 to the CSA. Iran agreed to continue operating IAEA monitoring and surveillance equipment installed for JCPOA monitoring purposes, but would keep footage and data in its custody until it received sanctions relief. These data would continue to be collected and stored "with the aim of enabling the Agency to recover and re-establish the necessary continuity of knowledge" at the affected nuclear sites. On June 8, 2022, following IAEA board censure over its failure to cooperate on the IAEA's separate safeguards probe, Iran notified the IAEA that it would remove the IAEA's JCPOA-related monitoring and surveillance equipment. From June 9 to 11, the IAEA removed, in total, 27 surveillance cameras,

the on-line enrichment monitor (OLEM) at the FEP, and the FLUM equipment installed at the HWPP. The equipment was placed in storage under IAEA seal. The IAEA notes, "This has seriously affected the Agency's verification and monitoring in relation to the JCPOA."

Due to Iran's refusal to implement the AP, the IAEA reports that "for two and a quarter years Iran has not provided updated declarations and the Agency has not been able to conduct any complementary access under the Additional Protocol to any sites and locations in Iran." The IAEA can no longer carry out daily visits to Iran's enrichment facilities. It has not "had access to data gathered by on-line enrichment monitors and electronic seals, or access to measurement recordings registered by its installed measurement devices." The IAEA also no longer receives data and recordings of test stands engaged in quality control tests of advanced centrifuge rotor assemblies, prior to their installation at Natanz and Fordow enrichment plants. It no longer has information about Iran's production of uranium ore concentrate (UOC) or its transfer to the Esfahan facility for conversion, or about UOC obtained from any other source. Annex I to the IAEA report describes these and other reduced provisions, many of which fall under JCPOA enhanced monitoring provisions.

The IAEA reports, "In the event of a full resumption of implementation by Iran of its nuclear-related commitments under the JCPOA, therefore, the Agency would not be able to re-establish continuity of knowledge in relation to the production and inventory of centrifuges, rotors and bellows, heavy water and UOC. Instead, the Agency would need to establish a new baseline for the abovementioned JCPOA verification and monitoring activities, and is aware that it would face major challenges in doing so and that any new baseline would involve a significant degree of uncertainty." The IAEA states that it would face "major challenges" even if Iran provided all records and access as required under the AP.

The IAEA adds that it could not "exclude the possibility that prior to the establishment of any new baseline Iran's production of centrifuges, rotors and bellows, heavy water and UOC had been significantly higher than that previously observed by the Agency at the declared locations. In order to address the gaps in continuity of knowledge, work is needed to develop specific arrangements with Iran, including for the provision of the declarations and additional records mentioned above, which would be indispensable in addressing this issue."

The IAEA reports that in line with an IAEA/Iran Joint Statement from March 2023, in May, "the Agency installed surveillance cameras at workshops in Esfahan where centrifuge rotor tubes and bellows are manufactured." However, despite reinstalling surveillance cameras, Iran is still not turning over the video footage to the IAEA, nor has Iran provided past footage from nuclear-related sites from February 2021 to June 2022. Moreover, there remain several other Iranian centrifuge manufacturing and assembly facilities where Iran has still not permitted the IAEA to reinstall cameras.

Iran has augmented centrifuge manufacturing, assembly, and mechanical testing activities in violation of the JCPOA, while halting IAEA monitoring. Without any monitoring in place, for more

than two years, the IAEA cannot ascertain the total quantities of centrifuges Iran has manufactured.

Iran's recent reinstallation of some cameras does not change the fundamental challenge of knowing how many centrifuges Iran has built. Although the IAEA can ascertain the number of centrifuges deployed at Fordow and Natanz, it cannot know how many more Iran has made but not deployed at its declared enrichment plants.

A risk is that Iran will accumulate a secret stock of advanced centrifuges, deployable in the future at a clandestine enrichment plant or during a breakout at declared sites. Another risk is that Iran will establish additional centrifuge manufacturing sites unknown to the IAEA. During the first six months of 2022, Iran established two new sites for manufacturing rotor tubes and bellows at Esfahan and Natanz. Iran is fully capable of moving manufacturing equipment to new undeclared sites, further complicating any future verification effort and contributing to uncertainty about where Iran manufactures centrifuges.

As noted in earlier reports, Iran continues building a large, advanced centrifuge assembly facility under a nearby mountain to the south of the Natanz enrichment plants.[15] The facility will replace the above-ground Iran Centrifuge Assembly Center (ICAC), destroyed in an explosion in July 2020. The Institute assesses that this new tunnel facility is likely to be more deeply buried than the enrichment halls of the Fordow enrichment plant, and its working areas would be buried from 80 to 145 meters below the mountain peak.[16] Moreover, its working areas are expected to contain a significant amount of floor space, significantly more than the floor space of the facility it replaces, The potential size of the underground halls and their depth suggests that, in addition to a centrifuge assembly facility, this facility could also house a small advanced centrifuge enrichment facility.[17] However, construction progress has been slower than planned, and the facility may not open this year or possibly even next year.

The IAEA reports in its separate NPT report that Iran permitted the installation of enrichment monitoring devices (EMDs) and the FFEP and PFEP. Iran has not reinstalled the OLEM at the FEP.

The IAEA urges Iran to hasten its cooperation. It writes, "The process of implementing the activities set out in the Joint Statement needs to be sustained and uninterrupted in order that all of the commitments contained therein are fulfilled. In addition, the Agency has informed Iran that for these activities to be effective the Agency needs to re-establish a satisfactory understanding of Iran's inventory of centrifuge rotor tubes and bellows, including those in assembled centrifuges."

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[15] David Albright, Sarah Burkhard, and John Hannah, "Iran's Natanz Tunnel Complex: Deeper, Larger than Expected," *Institute for Science and International Security*, January 13, 2022, https://isis-online.org/isis-reports/detail/irans-natanz-tunnel-complex-deeper-larger-than-expected/8.

[16] David Albright and Sarah Burkhard, "Imagery Update: Iran Continues to Harden its New Natanz Tunnel Complex," *Institute for Science and International Security,* May 5, 2022, https://isis-online.org/isis-reports/detail/imagery-update-iran-continues-to-harden-its-new-natanz-tunnel-complex-2022.

[17] "Imagery Update: Iran Continues to Harden its New Natanz Tunnel Complex,"

The IAEA continues, "In light of the prolonged period between February 2021 and June 2022 during which the data recorded by the cameras were not reviewed by the Agency, it is indispensable that the Agency and Iran should agree on an approach without delay that would provide the Agency with access to these data recordings and to those since 2-3 May 2023."

The IAEA concluded in previous reporting, but omits the sentence in its May 2023 report, "Iran's decision to remove all of the Agency's equipment previously installed in Iran for surveillance and monitoring activities in relation to the JCPOA has [had] detrimental implications for the Agency's ability to provide assurance of the peaceful nature of Iran's nuclear programme."

The IAEA also reports that it cannot verify Iran's JCPOA commitments under Sections D, E, S, and T. The Section T commitments relate to prohibited nuclear weapons development activities.

During the reporting period, the IAEA did not attend any meetings of the Procurement Working Group of the JCPOA Joint Commission, which oversees Iran's imports of nuclear-related equipment. Tehran is likely not complying with the JCPOA's procurement channel provisions, given evidence of illicit procurements.[18]

[18] Alleged illicit procurements occurred from 2018 to 2020, raising the possibility that Iran has not been complying all along with the JCPOA procurement channel provisions. See: Spencer Faragasso and Sarah Burkhard, "Iranian Illicit Procurement Scheme to Acquire Controlled Spectrometry Systems Busted," *Institute for Science and International Security*, September 14, 2021, https://isis-online.org/isis-reports/detail/iranian-illicit-procurement-scheme-to-acquire-controlled-spectrometers. Another set of illicit procurements occurred from 2015 to 2018. See: Simon Mairson and Valerie Lincy, "U.S. Targets Procurement Network Supplying Machine Tools to Iran," *Wisconsin Project on Nuclear Arms Control*, October 21, 2019, https://www.wisconsinproject.org/u-s-targets-procurement-network-supplying-machine-tools-to-iran/.