INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

REPORT

# Analysis of IAEA Iran Verification and Monitoring Report - February 2023

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## Background

- This report summarizes and assesses information in the International Atomic Energy Agency's (IAEA) quarterly report for February 28, 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 advanced centrifuge cascades and half of its existing stock of 60 percent enriched uranium. This breakout could be difficult for inspectors to detect promptly, if Iran took steps to delay inspectors' access.
- Using its remaining stock of 60 percent enriched uranium and its stock of near 20 percent enriched uranium, Iran could produce enough weapon-grade uranium for an additional four nuclear weapons in a month. During the next two months, Iran could produce two more weapons' worth of weapon-grade uranium from its stock of less than five percent enriched uranium, meaning that Iran could produce enough weapon-grade uranium for five nuclear weapons in one month and seven in three months.
- The IAEA detected uranium particles enriched to 83.7 percent from environmental sampling taken during a monthly interim verification (IIV) at the Fordow Fuel Enrichment Plant (FFEP) on January 22. Iran's answers about this anomaly did not satisfy the IAEA, which has continued probing Iran for more credible answers.
- The IAEA took the environmental samples that detected the presence of near-84 percent enriched uranium a day after inspectors detected an undeclared interconnection between two IR-6 cascades at Fordow, which Iran should have informed the IAEA about under its safeguards obligations. That change likely led the IAEA to take environmental samples at the product sampling point.
- This development amplifies concerns that Iran is undertaking covert experiments that add to its ability to more rapidly break out. Worrisome possibilities include that Iran tested a

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way to produce near weapon-grade uranium without IAEA detection, or to syphon off a small amount of near 84 percent enriched uranium.

- If the high enrichment level was unintentional, as Iran claims, Iran should have reported the unprecedented enrichment level following the interconnection of the two IR-6 cascades, in line with its reporting of previous fluctuations in the enrichment levels encountered by Iran with the advanced centrifuge cascades dedicated to enriching to 60 percent at the pilot plant. If Iran did not know that the enrichment level reached almost 84 percent, it appears to be operating cascades in a dangerous way, somewhat oblivious to criticality concerns.
- The IAEA seeks increased access to the FFEP. It reports, "At a technical meeting between senior officials in Tehran on 23 February 2023, Iran confirmed that it would facilitate the notified further increase of the frequency and intensity of Agency verification activities at FFEP."
- As of February 12, Iran had a stock of 87.5 kg (an increase of 25.2 kg) (in uranium mass or U mass) of 60 percent enriched uranium in uranium hexafluoride ($UF_6$) form, or 129.4 kg (in hexafluoride mass or hex mass). Adding to concerns about the purpose of this enriched uranium, Iran has converted only 2 kg of 60 percent highly enriched uranium (HEU) (U mass) into a chemical form typically used in civilian nuclear programs and none has been converted since March 2022. Iran keeps the majority (80 percent) of its stock of 60 percent HEU at the Esfahan site, where it maintains a capability to make enriched uranium metal.
- Iran's average production rate of 60 percent enriched uranium has doubled to 8 kg per month (U mass) since Iran began on November 22, 2022 to enrich uranium to near 60 percent in two IR-6 centrifuge cascades at the FFEP, in addition to the two cascades, one containing IR-6 centrifuges and the other IR-4 centrifuges, at the Natanz Pilot Fuel Enrichment Plant (PFEP). In both cases, Iran uses up to 5 percent low enriched uranium (LEU) as feed.
- The average production rate of 20 percent enriched uranium at the FFEP decreased by half from 26.8 kg (U mass) or 39.6 kg (hex mass) per month, to 13 kg (U mass) or 19.2 kg (hex mass) per month.
- As of February 12, 2023, Iran had an IAEA-estimated stock of 434.7 kg of 20 percent enriched uranium (U mass and in the form of $UF_6$), equivalent to 643 kg (hex mass). Iran also had a stock of 37.7 kg (U mass) of 20 percent uranium in other chemical forms.
- At the Natanz Fuel Enrichment Plant (FEP), Iran added seven cascades of advanced centrifuges during the last reporting period, for a total installed of 36 cascades of IR-1 centrifuges, 21 cascades of IR-2m centrifuges (up by six), four cascades of IR-4 centrifuges (up by one), and three cascades of IR-6 centrifuges.
- During the last six months, Iran installed 15 IR-2m centrifuge cascades at the FEP, or roughly 3,650 centrifuges. It is not clear whether these are newly made centrifuges or those taken from storage.
- Iran's current, total operating enrichment capability is estimated to be about 18,700 separative work units (SWU) per year, higher than the 16,300 SWU per year at the end of the last reporting period. As of the end of this reporting period, Iran was not yet using its fully installed enrichment capacity at the FEP, which, as noted above, has grown substantially.

- Average production of near 5 percent LEU at the FEP decreased, but for the second time in a row since early 2021, Iran's near 5 percent LEU stock increased from one reporting period to the next, reaching 1324.5 kg (U mass).
- Despite the increase, during this reporting period, in the amount of uranium enriched between two and five percent, Iran has not prioritized stockpiling of this material, during the last two years. This is at odds with its 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 87.1 kg (U mass).
- The IAEA discussed a discrepancy in Iran's natural uranium inventory at the Uranium Conversion Facility (UCF). *The Wall Street Journal* reported that the discrepancy may be related to inspectors' efforts to locate undeclared uranium Iran used during its early-2000s nuclear weapons program, in which case the IAEA's upcoming Nuclear Non-Proliferation Treaty (NPT) safeguards report may contain more relevant information.
- The IAEA reports that it can no longer reestablish continuity of knowledge about Iran's activities under a revived JCPOA, such as production of advanced centrifuges and heavy water, due to Iran's decision in February 2021 to deny the IAEA access to data from key JCPOA-related monitoring and surveillance equipment and Iran's decision in June 2022 to remove all such equipment, including video cameras and online enrichment monitors. The IAEA says it would need to establish a new baseline altogether and would require access to extensive records. It reports, "Any future baseline for [JCPOA] verification and monitoring activities would take a considerable time to establish and would have a significant degree of uncertainty."
- 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 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.
- The IAEA concludes 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."
- 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.
- Concern about Iran's installation of advanced centrifuges at an undeclared site is magnified as its 60 percent HEU stocks grow. Such a scenario becomes more worrisome and viable, since it requires a relatively small number of advanced centrifuge cascades to rapidly

enrich the 60 percent material to weapon-grade. This hybrid strategy involves the diversion of safeguarded HEU and the secret manufacture and deployment of only two or three 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.

## Part 1: Enriched Uranium Stocks

At the Natanz FEP, Iran produced approximately 1657.4 kg of $UF_6$ enriched up to 5 percent U-235 during the reporting period, which spanned 112 days from October 22, 2022 to February 11, 2023. 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 would be 1120.4 kilograms, for a monthly average production rate of 300 kg U mass and a daily average production rate of 10 kg U mass.[2] These average production rates decreased from 415 kg U mass per month, or 13.8 kg U mass per day, during the previous reporting period, consistent with the lower average amount of 2 percent LEU reportedly used as feed in this reporting period, which allows for the quicker production of 5 percent LEU. Of the 1967 kg near 2 percent LEU (hex mass) used as feed, 60 kg (hex mass) were dumped, representing 3 percent of the feed, down from 7.5 percent dumped during the previous reporting period.

At the FFEP, during the last reporting period, which spanned October 22, 2022 to February 11, 2023, Iran produced 18.9 kg (hex mass) of near 60 percent enriched uranium, or 12.8 kg U mass. Taking into account that 60 percent enriched uranium production did not start until November 22, 2022, daily average production was 0.16 kg (U mass), for a monthly average of 4.7 kg (U mass). Iran also produced 71.7 kg of $UF_6$ (hex mass) enriched up to 20 percent enriched uranium, or 48.4 kg U mass. It produced 879.7 kg of $UF_6$ hex mass (or 594.6 kg U mass) of up to 2 percent enriched uranium in tails.

Average production of 20 percent enriched uranium at the FFEP decreased by half to 0.6 kg (hex mass) or 0.4 kg (U mass) since the previous reporting period, when it was 1.3 kg (hex mass) or 0.89 kg (U mass). At this rate, Iran could produce 19.2 kg of near 20 percent enriched uranium per month (hex mass) or 13 kg (U mass) per month. Annually, Iran could produce 233.7 kg (hex mass) or 160 kg (U mass). This lower value is expected since Iran stopped producing 20 percent enriched uranium in the IR-6 cascades; however, it is also about one-third lower than the 29.4 kg (hex mass) Iran produced at the FFEP on average before it started using the IR-6 centrifuge cascades, and could reflect inefficiencies in producing 20 percent enriched uranium from natural uranium.

[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.

At the PFEP, Iran produced 2 percent enriched uranium, up to 5 percent enriched uranium, and up to 60 percent enriched uranium stock during the reporting period. Between October 22, 2022 and February 11, 2023, the PFEP produced 17.1 kg (hex mass) of near 60 percent enriched uranium (equivalent to 11.6 kg) (U mass); 103.3 kg (hex mass) of up to 5 percent LEU (69.8 kg U mass); and 598.5 kg (hex mass) of uranium enriched up to 2 percent U-235 (404.6 kg U mass).

The 60 percent enriched uranium production rate at the PFEP during this reporting period was 17.1 kg (hex mass) or 11.6 kg (U mass) over 112 days, resulting in a monthly average production rate of 4.6 kg (hex mass) or 3.1 kg (U mass), or a daily average production rate of 0.15 kg (hex mass) or 0.1 kg (U mass). This rate is slightly below the previous reporting period's monthly average production rate, which was 4.9 kg (hex mass) or 3.3 kg (U mass). Annually, using only the two advanced production-scale centrifuge cascades at the PFEP, Iran could produce 55.7 kg (hex mass) or 37.7 kg (U mass) of 60 percent enriched uranium. Together with production at the FFEP, Iran could produce 95 kg (U mass) or 141 kg (hex mass) of near 60 percent enriched uranium annually.

Of the 2 percent LEU, Iran produced 201.6 kg (hex mass) (or 136.3 kg U mass) in PFEP lines 1, 2, and 3 and 396.9 kilograms (hex mass) (or 268.3 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 358.8 kg (U mass), an amount larger than during the previous reporting period. The report specifies that of the 358.8 kg enriched to unspecified levels (U mass), 37.7 kg are up to 20 percent HEU and 2 kg are up to 60 percent HEU. Of the 37.7 kg (U mass) near 20 percent enriched uranium, 31.6 kg (U mass) are specified to be in the form of fuel assemblies. A footnote specifies that Iran received from Russia 2.7 kg of 20 percent enriched uranium "in the form of fuel meats." The increase of 2.7 kg from the last reporting period amount of 28.9 kg indicates that the Russian imports were added to the stock.

Of its near 5 percent LEU stock, Iran fed 816 kg hex mass (or 551.6 kg U mass) into the cascades at Fordow, for an average feed rate of about 7.3 kg per day hex mass, or 4.9 kg U mass, less than the previous reporting period. (In a footnote, the IAEA reports that natural uranium was used as feed as well, which reflects that for some of the reporting period, the two IR-6 cascades were fed with natural uranium to produce direct feed for one set of IR-1 centrifuges enriching to 20 percent enriched uranium.) Iran dumped 8.9 kg of near 5 percent LEU feed at the FFEP (hex mass), or about 6 kg in uranium mass, or 1 percent of the total LEU feed. Iran also fed 517.4 kg of near 5 percent hex mass (349.8 kg U mass) into PFEP R&D lines 4, 5, and 6, for a daily average feed rate of 4.6 kg (hex mass) or 3.2 kg U mass per day, less than during 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 1029.9 kg U mass from the last reporting period, 1120.4 kg from the FEP, and 69.8 kg from the PFEP, with the feed of 901.4 kg subtracted, resulting in 1318.7 kg. Adding back the 6 kg (U mass) feed dumped at the FFEP, this total becomes 1324.7 kg, close to the 1324.5 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 87.1 kg from 3673.7 to 3760.8 kg (see Table 1). For the first time since February 2021, this represents an increase in the overall enriched uranium stock that is due to an increase in uranium enriched to up to 5 percent, instead of uranium enriched up to 2 percent. The near 5 percent LEU stock in the form of $UF_6$ increased by 294.6 kg, while Iran kept producing 20 percent enriched uranium and increased its production of 60 percent enriched uranium; both processes use large amounts of 5 percent LEU as feedstock. Iran's near 2 percent LEU stock decreased by 289.2 kg from 1844.5 kg to 1555.3 kg (U mass). The near 20 percent enriched uranium stock increased by 48.3 kg from 386.4 kg to 434.7 kg (U mass), and the near 60 percent enriched uranium stock increased by 25.2 kg from 62.3 kg to 87.5 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, while feeding the tails into line 5 to produce up to 5 percent LEU. During this reporting period, spanning October 22, 2022 to February 11, 2023, of the 517.4 kg (hex mass) of 5 percent LEU fed into lines 4 and 6, Iran turned 17.1 kg (hex mass) (3.3 percent) into 60 percent enriched uranium, 103.3 kg (hex mass) back into 5 percent enriched uranium (20 percent), and 396.9 kg (hex mass) (77 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 | March 3, 2022 | May 15, 2022 | August 21, 2022 | October 22, 2022 | February 12, 2023 |
|---|---|---|---|---|---|
| | | | | | |
| $UF_6$ (kg) | 2883.2 | 3491.8 | 3621.3 | 3323.1 | 3402 |
| Uranium oxides and their intermediate products (kg) | 249.5 | 238.9 | 252.3 | 241.6 | 215.3 |
| | | | | | |
| Uranium in fuel assemblies and rods (kg) | 37.8 | 48.1 | 48.2 | 49.3 | 58.4 |
| Uranium in liquid and solid scrap (kg) | 26.6 | 30.6 | 19.1 | 59.7 | 85.1 |
| | | | | | |
| **Enrichment Level Subtotals** | | | | | |
| Uranium enriched up to 5 percent (kg) but more than 2 percent | 1277.9 | 1055.9 | 713.9 | 1029.9 | 1324.5 |
| Uranium enriched up to 2 percent (kg) | 1390 | 2154.4 | 2519.9 | 1844.5 | 1555.3 |
| Uranium enriched up to 20 percent (kg) | 182.1 | 238.4 | 331.9 | 386.4 | 434.7 |
| Uranium enriched up to 60 percent (kg) | 33.2 | 43.1 | 55.6 | 62.3 | 87.5 |
| | | | | | |
| Uranium in chemical forms other than $UF_6$ with unspecified enrichment level (kg) (including 37.7 kg up to 20 % LEU and 2 kg up to 60 % HEU) | 313.9 | 317.6 | 319.6 | 350.6 | 358.8 |
| | | | | | |
| **Totals of Enriched Uranium in $UF_6$, <5 % (kg)** | 2667.9 | 3210.3 | 3233.8 | 2874.4 | 2879.8 |
| **Totals of Enriched Uranium in $UF_6$, including near 20 % and near 60 % (kg)** | 2883.2 | 3491.8 | 3621.3 | 3323.1 | 3402 |
| **Totals of Enriched Uranium in all chemical forms , <5 % <20 % and <60 % enriched** | **3197.1** | **3809.4** | **3940.9** | **3673.7** | **3760.8** |

*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 February 21, 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. Since the last IAEA quarterly reporting in November 2022, Iran has installed six IR-2m centrifuge cascades and completed installation of a fourth cascade of IR-4 centrifuges. Iran has plans to install an additional eight cascades of IR-4 centrifuges, but installation had yet to begin. It now has an estimated total of 4872 advanced centrifuges installed at the FEP, of which 3654 are IR-2m centrifuges.

These values represent a significant boost in the number of installed advanced centrifuge cascades since the end of the previous reporting period.[4] This impacts the breakout calculation discussed below and also affects breakout timelines.

**Enriching Centrifuges.** As of February 21, 2023, the IAEA reports that in total, 36 cascades of IR-1 centrifuges, eight cascades of IR-2m centrifuges, three cascades of IR-4 centrifuges, and three cascades of IR-6 centrifuges were being fed with natural $UF_6$ and $UF_6$ enriched up to 2 percent to produce $UF_6$ enriched up to 5 percent. During the previous reporting period, 34 IR-1 cascades, six IR-2m cascades, two IR-4 cascades, and three IR-6 cascades were being fed, also with natural $UF_6$ or with uranium enriched up to 2 percent.

The quantity of IR-1 or IR-2m centrifuges Iran withdrew from JCPOA-mandated storage continue 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, it is unclear whether the newly installed IR-1 and IR-2m cascades contain newly produced machines or those stored during implementation of the JCPOA, although the total number of IR-2m centrifuges installed is three times the quantity Iran had installed prior to the JCPOA and exceeds the quantity Iran had planned to install prior to the JCPOA.

### Fordow Fuel Enrichment Plant

At the FFEP, Iran currently has 1044 IR-1 centrifuges installed in three sets of interconnected cascades, two cascades of 166 IR-6 centrifuges, and one IR-1 centrifuge in a separate position. Iran has not announced any new plans to deploy additional centrifuges at the FFEP.

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[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.

[4] David Albright, Sarah Burkhard, Spencer Faragasso, and Andrea Stricker, "Analysis of IAEA Iran Verification and Monitoring Report - November 2022," *Institute for Science and International Security*, November 16, 2022, https://isis-online.org/isis-reports/detail/analysis-of-iaea-iran-verification-and-monitoring-report-november-2022/8.

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. With respect to the IR-6 cascades, it is assumed that up until November 22, 2022, Iran used the method of operation that began on October 2, 2022, namely using the two cascades of IR-6 centrifuges to produce $UF_6$ enriched up to 5 percent from natural uranium feed, to directly feed one set of IR-1 cascades to produce $UF_6$ enriched up to 20 percent enriched uranium. For most of the reporting period, however, as Iran announced on November 20 and started on November 22, the two IR-6 cascades 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.

**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.** 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. The IAEA reports 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. The IAEA adds a note to the end of its report to galvanize faith in its ability to detect Iran's undeclared advances at enrichment facilities. It writes, "Regarding the origin of the particles enriched above 60% U-235, identified after the implementation of the new cascade configuration at FFEP, discussions with Iran are still continuing. These events clearly indicate the capability of the Agency to detect and report in a timely manner changes in the operation of nuclear facilities in Iran." In this summary, the IAEA appears to tie the detection of near 84 percent enriched uranium particles directly to the change in IR-6 cascade configuration.

**Pilot Fuel Enrichment Plant**

Since the previous report, Iran has made "little 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 February 7, 2023, the IAEA verified that preparation activities for the planned installation of a new feed and withdrawal area for the new enrichment R&D activities had

been completed. On February 21, it verified that "installation of the infrastructure for 18 cascades [...] was progressing."

The report does not provide an anticipated start date for this new area. Given that this new R&D area is a three-fold increase from the six lines in the above-ground PFEP, one must ask if this area could 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. Per the most recent quarterly report, line 5, used to re-enrich tails from lines 4 and 6 to near 5 percent LEU, is undergoing "maintenance activities [...] involving the relocation of IR-5 centrifuges and the installation of IR-4 and IR-6 centrifuges."

On February 22, 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. The IAEA reports that as of February 22, 2023, tails from line 6 were "fed into the cascades of IR-3, IR-5, IR-6, and IR-6s centrifuges" to produce up to 5 percent enriched uranium, but it did not specify quantities of each centrifuge type or the total number of centrifuges in the cascades. The assay of the tails is likely about 2-3 percent. In a footnote, the IAEA confirms that at least some of the tails from line 4 and 6 were not re-enriched in line 5 but were accounted for as part of the stockpile enriched to up to 5 percent.

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 February 22, 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: 14 IR-2m centrifuges; 20 IR-4 centrifuges and six IR-4 centrifuges; six IR-5 centrifuges and five IR-5 centrifuges; ten IR-6 centrifuges, and 19 IR-6 centrifuges. Iran has not redeployed any IR-s

[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/.

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 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, one IR-4 centrifuge; one IR-5 centrifuges; five IR-6 centrifuge; one IR-7 centrifuge; one IR-8 centrifuge; one IR-8B centrifuge; and one IR-9 centrifuge. The single installed IR-6s centrifuge was removed.

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 76 IR-2m centrifuges in line 1 to produce uranium enriched up to 2 percent U-235.

[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.

**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 18,700 SWU per year, or the equivalent of 20,766 IR-1 centrifuges. This total enrichment capacity of enriching centrifuges is higher than the previous reporting period's 16,270 SWU per year, because Iran started to enrich uranium in an additional two IR-1 cascades, two IR-2m cascades, and one IR-4 cascade at the FEP.

By contrast, including the installed but not yet enriching centrifuges results in an enrichment capacity of 29,146 SWU per year.

Of note, centrifuge quantities for PFEP line 5 are taken from the November 2021 report, as they are not specified in more recent reports. 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 this increases 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 weapon-grade uranium (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 PFEP*** | 561 | 2099 | 2332 |
| **Lines 2 & 3** | See text | | |
| **Lines 1, 4, 5, 6** | See text | | |
| | | | |
| **Total** | **10543** | **18699** | **20776** |

*The values for lines 1, 2, 3, and 5 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 over two significant quantities of HEU. 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 is experimenting with even higher enrichments, while avoiding reaching the 90 percent or weapon-grade level, a clear Western political redline.

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 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 proceeded to enrich up 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. It 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. 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 Tehran Research Reactor (TRR). 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 (produced and irradiated in the TRR in March 2022) 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. Given a total stock of 87.5 kg (U mass), about 80 percent of this stock was in storage at Esfahan in the form of uranium hexafluoride as of the end of the last reporting period. Given that Esfahan holds Iran's capabilities to turn enriched uranium hexafluoride into metal, this transfer raises additional proliferation concerns.[7] No additional transfer or production of mini-plates (targets) has been reported since.

## Part 3: Current Breakout Estimates

During this reporting period, Iran's installed centrifuge capacity continued to grow substantially due to the installation of additional IR-2m cascades. This shortens breakout timelines, in particular speeding up the production of successive quantities of weapon-grade uranium, all of which depends on initially installed centrifuge enrichment capacity as well as enriched uranium stocks.

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.[8] If Iran wanted to further enrich all its 60 percent HEU up to weapon-grade, it could do so in about 23 days utilizing only three of its advanced IR-6 centrifuge cascades, all of which are already configured to make HEU.[9] It could produce enough WGU for its first nuclear explosive in slightly less than 12 days after starting a breakout.

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[7] 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.

[8] According to the IAEA, Iran has 87.5 kg of 60 percent enriched uranium (uranium mass) in the form of uranium hexafluoride, more than two 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."

[9] 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.

In parallel to further enriching 60 percent material, Iran could further enrich its near 20 percent enriched uranium stock to weapon-grade uranium. Using the Institute breakout calculator, and assuming a setup time of two weeks, Iran is estimated to be able to accumulate, in one month, enough weapon-grade uranium for three nuclear weapons from its stock of near 20 percent enriched uranium.

Thus, in one month, using both its 20 and 60 percent stocks, Iran could produce enough weapon-grade uranium for five nuclear weapons, where each weapon is assigned 25 kg of weapon-grade uranium (U mass). Smaller amounts may be sufficient in each nuclear weapon, indicating that the breakout calculation is conservative.

Iran could also use its feedstock of less than five and above two percent (taken as 4.5 percent) enriched uranium, producing over 25 kg of WGU during each of months two and three after the start of a breakout.

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

When Iran ended its crash nuclear weapons program in 2003, called the Amad Plan, its biggest bottleneck was its lack of WGU; it still needed at least a few more years to accumulate enough WGU for a nuclear weapon.[10] 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.[11]

**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 not used, since to do so would require additional modifications of the

[10] 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).
[11] 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.

cascades to handle lower enrichments, likely significantly slowing or contributing only slightly, 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: Centrifuge Assembly, Manufacturing, Mechanical Testing, and Component Inventory

Iran has augmented centrifuge manufacturing and mechanical testing activities in violation of the JCPOA, while halting IAEA monitoring. Without any monitoring in place, the IAEA is uncertain about the total quantities of centrifuges Iran has manufactured during the last several months (see Part 7).

Since February 2021, Iran has not provided declarations about its production and inventory of centrifuge rotor tubes, bellows, and rotor assemblies or allowed IAEA verification, as specified in the JCPOA (see also Part 7). The IAEA has also been unable to access the data and recordings collected by its surveillance equipment up until June 2022, installed to monitor the manufacturing of rotor tubes and bellows, and consequently has had no ability to take inventory.

From June 9 to 11, 2022, Iran removed all such surveillance equipment, meaning that centrifuges manufactured after these dates were unmonitored, causing a high degree of uncertainty about the quantities manufactured, locations of their manufacture, and current locations. In particular, since June, the IAEA has been "unable to verify whether Iran has produced any IR-1 centrifuges, including IR-1 centrifuge rotor tubes, bellows or rotor assemblies to replace those that have been damaged or failed and has no information on the inventory of rotor tubes, bellows and rotor assemblies relevant to any type of Iranian centrifuge." Particularly concerning, the IAEA does not know how many advanced centrifuges Iran has made in several months, beyond those deployed at the three centrifuge plants.

There are indications that Iran has increased its production of centrifuges during this reporting period. On August 29, 2022, at Iran's request, the IAEA removed seals that had been attached in December 2021 to a flow-forming machine that had been used for the manufacture of centrifuge components in the past. This machine may have been at the TESA Karaj centrifuge manufacturing facility and subsequently moved to a new site due to that plant's closure.

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, both currently without any monitoring equipment. 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 larger, permanent advanced centrifuge assembly facility under a nearby mountain to the south of the Natanz enrichment plants.[12] The facility will replace the above-ground Iran Centrifuge Assembly Center (ICAC), destroyed in an attack in July 2020. The Institute assesses that this tunnel complex is likely to be more deeply buried than the Fordow enrichment plant and contains significant floor space.[13] However, construction progress has been slower than planned, and the facility may not open this year or possibly even next year.

## Part 5: Enriched Uranium Metal Production Remains Halted, Nuclear Material Discrepancy at Uranium Conversion Facility

During the last five 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 a 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, in violation of its JCPOA commitments. 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 and is producing it as a way 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.[14]

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[12] 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.

[13] 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.

[14] *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.

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 the 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 had "manufactured two fuel plates using uranium silicide." Subsequently, the two fuel plates were inserted into the TRR and on October 22, 2022, the IAEA observed that they were still being irradiated.

On February 21, 2022, the IAEA verified that the installation of equipment for the first stage of production of enriched $UF_4$ from enriched $UF_6$ at the FPFP, while almost complete, had progressed only slightly. The IAEA noted that on May 17, 2022, installation had been completed but had yet to undergo testing, and the IAEA observed the same as of February 25, 2023. No progress was observed on the remaining two stages of the process during this reporting period.

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. On February 12, 2023, the IAEA verified that no nuclear material had been introduced into the production area.

**Discrepancy at the Uranium Conversion Facility**

In this latest report, the IAEA for the first time discusses a small discrepancy in the inventory of natural uranium at the UCF. 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 the 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. This 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.

The IAEA does not discuss the significance of this discrepancy. However, JHL has figured prominently in past IAEA efforts to understand the fate of undeclared uranium metal discs dating to Amad Plan activities 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 an 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."[15]

## Part 6: 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 February 2023 report its assessment that the HWPP continued to operate during the reporting period.

The IAEA reports that as of February 8, 2023, Iran had not pursued construction of the Arak heavy water research reactor (IR-40 reactor), now called the Khondab Heavy Water Research Reactor (KHRR), based on its original design. Iran also had not produced or tested natural uranium pellets, fuel pins, or fuel assemblies for the reactor as originally designed. However, questions remain about the irreversibility of technical modifications carried out to date by Iran's partners in the JCPOA Arak reactor working group. Moreover, a wide range of "civil construction work" was ongoing at all floors of the reactor building.

## Part 7: Additional Protocol & JCPOA monitoring

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 of 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 can no longer carry out daily visits to Iran's enrichment facilities, receive updated declarations, or conduct "complementary access" to sites. It has not "had access to data gathered by on-line enrichment monitors and electronic seals, or access to recordings registered by its installed measurement devices." In addition to the centrifuge manufacturing limitations described in part 4, the IAEA also no longer receives data and

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

recordings of test stands for conducting quality control tests of advanced centrifuge rotor assemblies, prior to their installation at Natanz and Fordow enrichment plants. It also 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 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.[16]

**February 2021 Agreement Collapse and Issues with Re-establishing Continuity of Knowledge**

Between February 21, 2021 and June 8, 2022, as described, the IAEA and Iran had agreed that Iran would continue to collect safeguards information on agency monitoring and surveillance equipment per the terms of the JCPOA. This would allow the IAEA to "recover and re-establish the necessary continuity of knowledge." Yet following Iran's removal of IAEA monitoring equipment, the IAEA "has not been able to perform JCPOA verification and monitoring activities in relation to the production and inventory of centrifuges, rotors and bellows, heavy water and uranium ore concentrate (UOC) for two years, including the last nearly nine months when there has been no surveillance and monitoring equipment in operation following its removal in June last year." In a starker finding than the November 2022 report, the IAEA stated that this lack of verification and monitoring now prevents it from reestablishing an accurate baseline for these activities and it would need to establish a new baseline:

> *"...In the event of a full resumption of implementation by Iran of its nuclear-related commitments under the JCPOA, 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 above-mentioned JCPOA verification and monitoring activities. In doing so, the Agency would not be able to 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*

[16] 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/.

*been significantly higher than that previously observed by the Agency at the declared locations."*

The IAEA continues, "...Any future baseline for [JCPOA] verification and monitoring activities would take a considerable time to establish and would have a significant degree of uncertainty."

With regard to activities occurring between February 21, 2021 and June 8, 2022, the IAEA "would need to confirm the integrity, comprehensiveness and accuracy of the data recorded by its surveillance equipment" by comparing the data to the declarations provided by Iran. The IAEA added that Iran would need to provide it with all related records, "the consistency of which the IAEA would then need to confirm through the application of additional safeguards measures, including those available under the AP."

The IAEA would face severe challenges in verifying Iran's declared inventories after June 11, 2022, when the monitoring and surveillance equipment was removed. According to the February 2023 report, the IAEA would "face considerable challenges to confirm the consistency of Iran's related declarations since then, during which time no surveillance and monitoring equipment was operating."

The IAEA concludes, "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."