INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

REPORT

Analysis of IAEA Iran Verification and Monitoring Report

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This report assesses information in the International Atomic Energy Agency's (IAEA's) quarterly safeguards report for February 23, 2021, *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*)*.

The IAEA issued its report to member states on the day that Iran pledged to stop implementing the Additional Protocol (AP) to its comprehensive safeguards agreement (CSA), a further step in nuclear advances it has been taking since Iran passed new legislation in December. The legislation mandates augmentations to Iran's nuclear program and reduced IAEA inspections, absent the United States dropping all sanctions on Iran, a step that the Biden administration has refused to take. On February 23, 2021, Iran suspended the AP and voluntary monitoring measures under the JCPOA, as mandated by the legislation. A few days earlier, during a weekend visit to Tehran by IAEA Director General Rafael M. Grossi, Iran agreed to continue implementing a limited number of verification and monitoring activities for three months and abide by its CSA, the latter being the fundamental IAEA inspection arrangement, including for IAEA access to any site in Iran.

Summary and Breakout Estimate

1) Iran started to produce near 20 percent enriched uranium on January 4, 2021, in 1044 IR-1 centrifuges located at the Fordow Fuel Enrichment Plant (FFEP).

2) Iran produced 3.6 grams of uranium metal from natural uranium tetrafluoride (UF_4) at the Fuel Plate Fabrication Plant (FPFP) at Esfahan, testing the process in preparation for a scaled up enriched uranium metal production line at the FPFP.

3) Iran's low enriched uranium (LEU) stock far exceeds the limit set by the JCPOA. As of February 16, 2021, Iran had a stockpile of about 4390.2 kilograms (kg) of LEU (hexafluoride mass), almost all enriched below 5 percent, or 2967.8 kg (uranium mass).

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4) Of the 2967.8 kg LEU (uranium mass), 1025.5 kg are enriched to up to 2 percent, 1890 kg are enriched to more than 2 but less than 5 percent, and 17.6 kg are enriched to up to 20 percent. The remainder, 34.7 kg, is uranium not in the form of uranium hexafluoride (UF_6), and its enrichment level is not specified. In past reports, the subcategories of enriched uranium added up to match the total amount of enriched uranium listed. However, this time, there was a discrepancy of 34.7 kg.

5) Monthly LEU production of up to 5 percent LEU (excluding near 20 percent enrichment and enriched uranium not in the form of UF_6) has increased from 146.7 kg/month (uranium mass) in the previous reporting period (Aug. 2020 – Nov. 2020) to 205.5 kg/month during this reporting period (Nov. 2020 – Feb. 2021). The increase affected mostly the below 2 percent LEU production, which had dropped during the previous reporting period before reaching 144.7 kg/month this reporting period. The monthly average production of 2 to 5 percent LEU increased slightly to 154.3 kg/month.

6) Iran's estimated breakout time, as of late February 2021, is as short as 3.1 months. Iran now has sufficient LEU enriched below five percent to produce enough weapon-grade uranium (WGU) for a second nuclear weapon, where the second one would be produced more quickly than the first, requiring, in total, as little as five months to produce enough WGU for two nuclear weapons.

7) Iran's total estimated enrichment capacity at Natanz and Fordow has increased from 6963 separated work units (SWU)/yr to 8258 SWU/yr in currently enriching centrifuges; an increase of nearly 20 percent. (This value, while indicative of Iran's total enrichment output, should not be used in breakout estimates).

8) The current enrichment capacity at the Natanz Fuel Enrichment Plant (FEP) and Fordow plant, ignoring the Natanz Pilot Fuel Enrichment Plant (PFEP), is 6744 SWU per year. If Iran installs all cascades of advanced centrifuges it is currently installing and firmly planning (a total of six), the total capacity increases to almost 12,900 SWU per year. This enrichment capacity is almost three times larger than allowed under the JCPOA.

9) Iran's stock of heavy water as of February 15, 2021 was 131.4 metric tonnes, above the JCPOA's limit of 130 metric tonnes. Iran also shipped out 5.4 metric tonnes.

10) Iran has not pursued the construction of the Arak heavy water research reactor (IR-40 Reactor) based on its original design. It also has not produced or tested natural uranium pellets, fuel pins or fuel assemblies for the original reactor design.

Part 1: Low Enriched Uranium Stocks

The IAEA reports that Iran exceeds by over fourteen fold the JCPOA's cap of 300 kg of low enriched uranium (hexafluoride mass), or 202.8 kg (uranium mass). On July 1, 2019, the IAEA

first reported that Iran had surpassed the JCPOA's LEU stock limit by enriching 205.0 kg of LEU (uranium mass). Since then, Iran has added 2762.8 kg LEU (uranium mass) to its stockpile. Iran also continued, for well over a year, to enrich to 4.5 percent, in violation of the JCPOA's 3.67 percent enrichment limit. The IAEA first stated on July 8, 2019, that Iran was enriching up to a level of 4.5 percent. Since January 4, 2021, Iran has crossed another line by enriching and accumulating uranium enriched to near 20 percent. Iran's Supreme Leader tweeted on February 22, 2021, threatening to enrich up to 60 percent.[2]

On February 16, 2021, the IAEA's most recent verification date, Iran possessed a total stockpile of about 4390.2 kg of low enriched uranium (hexafluoride mass), or the equivalent of 2967.8 kg (uranium mass). Of that, 17.6 kg (uranium mass) are enriched to near 20 percent, produced in IR-1 centrifuges at Fordow, and 1025.5 kg (uranium mass) are enriched to less than 2 percent, produced in advanced centrifuges at the Natanz PFEP. 1890 kg (uranium mass) are enriched to less than 5 but more than 2 percent LEU, where most but not all of the material was produced at the Natanz and Fordow Fuel Enrichment Plants in already deployed IR-1 centrifuges and newly installed IR-2m centrifuges; an unstated amount was also produced in advanced centrifuges at the PFEP. The remainder of 34.7 kg is uranium not in the form of uranium hexafluoride, and its enrichment level is not specified.

Iran added 472.6 kg (uranium mass) to its less than 5 percent enriched uranium stockpile (excluding enriched uranium not in the form of uranium hexafluoride) during this reporting period, which spans November 3, 2020 to February 16, 2021, or a total of 106 days.

On January 4, 2021, Iran started producing near 20 percent enriched uranium by feeding enriched uranium hexafluoride into IR-1 centrifuges at Fordow. As of February 16, Iran had produced a total of 17.6 kg (uranium mass) or 26.04 kg (hexafluoride mass) of near 20 percent enriched uranium in six IR-1 cascades, organized as three sets of tandem cascades. During these 43 days, the average daily production was 0.606 kg per day, for an average monthly production of 18.2 kg (hexafluoride mass). This value is higher than the typical value of 15 kg per month (hexafluoride mass), achieved prior to the negotiation of the Joint Plan of Action in 2013. The new Iranian legislation mandates the production of 120 kg per year of near 20 percent enriched uranium, a goal which seems achievable at current rates of production.

In Table 1 below, a stockpile comparison from February 19, 2020 to February 16, 2021, shows how Iran has increased its production of LEU throughout the year, as measured only in uranium mass. The net increase in the total stock of LEU (excluding near 20 percent LEU and LEU in chemical forms other than UF_6), from February 2020 to February 2021, was 1894.6 kilograms LEU (uranium mass), at an overall average rate of about 158 kilograms (uranium mass) per month. Alternatively, these values convert to 2880 kg of LEU (hexafluoride mass), or an average of about 234 kg of LEU (hexafluoride mass) per month.

[2] https://twitter.com/khamenei_ir/status/1363899581101129731?s=20

During this reporting period, covering November 2020 to February 2021, the average production rate was about 205 kg per month of enriched uranium up to 5 percent (uranium mass), or 304 kg per month of enriched uranium (hexafluoride mass). During this reporting period, compared to the previous one, overall average monthly production of enriched uranium increased slightly, where production of below 2 percent LEU increased from just 23 kg/month during the previous reporting period to 145 kg/month during this latest reporting period, and average monthly production of the 2 to 5 percent enriched stock increased slightly from 123 to 154 kg/month (uranium mass).

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

Chemical Form	**February 2020**	**May 2020**	**August 2020**	**November 2020**	**February 2021**
UF_6 (kg)	996.5	1546.7	2073.8	2408.5	2933.1
Uranium oxides and their intermediate products (kg)	9.7	9.7	15.2	15.5	13.3
Uranium in fuel assemblies and rods (kg)	7.7	7.7	8.2	8.2	10.5
Uranium in liquid and solid scrap (kg)	7	7.5	8.2	10.7	10.9
Enrichment Level Subtotals					
Uranium enriched to 3.67 % (kg)**	214.6	215.1	215.1	215.1	--
Uranium enriched up to 5 % (kg) but more than 2 %	537.8	873.4	1251.5	1535.1	1890
Uranium enriched up to 2 % (kg)	268.5	483.1	638.8	692.7	1025.5
Uranium enriched up to 20 % (kg)	0	0	0	0	17.6
Uranium in chemical forms other than UF_6, with unspecified enrichment level (kg)					34.7
Totals of Enriched Uranium in UF_6 form, <5 % (kg)					2915.5
Totals of Enriched Uranium in UF_6 form, including near 20 % (kg)					2933.1
Totals of Enriched Uranium in all chemical forms, <5 % and <20 % enriched	**1020.9**	**1571.6**	**2105.4**	**2442.9**	**2967.8**

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

** This stockpile is not listed as a separate quantity in this February 23, 2021, verification report. The report does not provide the amount of enriched uranium fed into Fordow to produce 20 percent LEU.

Part 2: Enrichment capacity

Natanz Fuel Enrichment Plant (FEP)

Centrifuge Deployments. At the Natanz Fuel Enrichment Plant, the IAEA reported that Iran operated 5060 IR-1 centrifuges in 30 cascades and approximately 338 IR-2m centrifuges installed in two cascades. Iran withdrew 97 IR-1 centrifuges from storage to replace broken ones in these cascades. During the previous reporting period, it withdrew 20 IR-1 centrifuges, and during the prior one, it withdrew 104 IR-1 centrifuges.

Advanced Centrifuges in the FEP. Iran has continued deploying advanced centrifuges in the FEP to produce up to 5 percent enriched uranium.

The first stage was the deployment of three cascades taken from lines 4, 5, and 6 of the PFEP. The first cascade comprised IR-2m centrifuges, operating since at least November 9, 2020. As of February 21, 2021, a cascade of IR-4 centrifuges had been installed but was not yet enriching uranium. As of that date, Iran was still installing a cascade of IR-6 centrifuges.

Iran announced in December 2020 that it intended to install three more IR-2m cascades in the FEP. It has completed the installation of two of these cascades, each containing 174 centrifuges. It started feeding one of them on January 30, 2021. As of February 21, it had not yet operated the second one. The installation of the third cascade was on-going.

On February 15, 2021, Iran announced that it planned to install two additional IR-2m cascades in the FEP. This announcement brings to six the total number of IR-2m cascades planned, being installed, or enriching.

Enrichment Output of Advanced Centrifuges at the FEP

The operation of these eight cascades, assuming they all work, will double the enrichment output of the FEP, as described below.

The production-level cascades of IR-2m and IR-4 centrifuges have been a priority to Iran, although the IR-4 centrifuges likely operate less reliably than the IR-2m centrifuges. Prior to the implementation of the JCPOA, when operated in a production-scale cascade, each IR-2m centrifuge, which includes two carbon fiber rotor tubes connected by a maraging steel bellows, had an enrichment capacity of about 3.7 SWU per year. The IR-4, which has two carbon fiber rotor tubes connected by a carbon fiber bellows, has a lower capacity than the IR-2m, estimated here as ten percent lower, or about 3.3 SWU per year per centrifuge.

The IR-6 centrifuge, which includes two wider carbon fiber rotor tubes and a carbon fiber bellows, has a single machine estimated capacity of 6.8 SWU per year. No recent data are available publicly on its performance in a cascade. Assuming that the cascade value would be about 90 percent of the capacity achieved by an IR-6 centrifuge operating by itself, the

estimated value in a cascade is 6.12 SWU per year per machine. There has been suspicion that the IR-6, as well as several other centrifuge types, have operational problems caused by their use of carbon fiber bellows. Adding to this suspicion is a statement in the IAEA report that Iran had started manufacturing metal bellows, likely maraging steel bellows, for IR-6 centrifuges as part of a testing program. These metal bellows would be reinforced with carbon fiber, a standard procedure used in other centrifuge programs, to allow the maraging steel part to spin more rapidly.

The six cascades of IR-2m centrifuges have a total estimated capacity of about 3830 SWU per year. Two of these cascades were enriching as of the end of this reporting period, generating about 1250 SWU/year. The IR-4 and IR-6 cascades, when operational, would generate an estimated 540 and 1000 SWU/year, respectively. Some uncertainty stems from the report not stating in all cases the number of centrifuges in each cascade, where 164 is used in calculations unless otherwise specified in the report.

The IR-1 centrifuges at the FEP total 5060, for an estimated output of 4554 SWU/year, where each IR-1 is assumed to have a capacity of 0.9 SWU per year per when operating in a production-scale cascade. The two operating IR-2m cascades increase the total FEP output to about 5800 SWU/year. When all eight cascades operate, the total enrichment output will be about 9924 SWU per year.

Fordow Fuel Enrichment Plant (FFEP)

The IAEA reported that since January 4, 2021, the Fordow plant was enriching a feedstock of less than 5 percent enriched uranium up to 20 percent, in three sets of interconnected cascades, containing 1044 IR-1 centrifuges, in one wing or unit of the plant, called Unit 2. Of the IR-1 centrifuges dedicated to research and development activities related to stable isotope separation, only one IR-1 centrifuge remained; an additional dozen IR-1 centrifuges were "dismantled to create space" on January 23, 2021, for two cascades of IR-6 centrifuges. As of February 21, 2021, Iran had finished installing the sub-headers for the IR-6 cascades.

Iran declared on February 1, 2021, that these two advanced IR-6 centrifuge cascades would produce the less than 5 percent LEU feed for the tandem IR-1 centrifuge cascades, enriching it further to 20 percent, providing a two-step enrichment process from natural uranium to near 20 percent enriched uranium. Later, Iran could add additional steps going to higher enrichment levels. The next step would typically take near 20 percent enriched uranium up to 60 percent, the enrichment level specified by the Supreme Leader.

These two IR-6 cascades, assuming 164 centrifuges per cascade, would have an enrichment output of about 2000 SWU per year, bringing the total to 2940 SWU/year.

Advanced Centrifuges in the Pilot Fuel Enrichment Plant

The following summarizes the deployment of advanced centrifuges in the six lines at the Natanz PFEP, their enrichment status, and their enrichment capacity, if known, as of the end of the last IAEA reporting period.

Iran has begun to "transfer a part" of the PFEP to "building A1000," which houses the production hall at the FEP, aiming to concentrate all enrichment research and development in this underground area. As of February 7, 2021, Iran had "completed installation of sub-headers for 18 cascades for R&D activities in this new area of the PFEP."

At the PFEP, Iran is no longer uniformly remixing the product and tails (waste) from advanced centrifuges, but collecting it separately, meaning that Iran is accumulating enriched uranium at the PFEP. As of February 16, 2021, a total of 1025.5 kilograms (uranium mass) of uranium enriched up to two percent (ignoring LEU not in the form of UF_6) had been collected from lines 2, 3, and 5 at the PFEP; 332.8 kilograms were added during this reporting period. The IAEA does not provide the average enrichment of this material, although it can be safely assumed that it varies from just above natural uranium (0.71 percent uranium 235) up to 2 percent uranium 235. This average value matters because the amount of separative work to make, for example, a quantity of two percent enriched uranium, is several times the amount needed to make the same quantity of one percent enriched uranium.

Lines 2, 3, and 5 contained a variety of centrifuge types and numbers, many accumulating enriched uranium. The following is a summary, as of the end of the last reporting period (February 17, 2021), of all the centrifuges installed in lines 2, 3, and 5, which amounted to about 73 in total that were accumulating enriched uranium (so far about 1025.5 kg, as mentioned above):

1. Up to 9 IR-1 centrifuges in a cascade;
2. Up to 11 IR-4 centrifuges in a cascade;
3. Up to 5 IR-5 centrifuges in a cascade;
4. Up to 29 IR-6 centrifuges, in two centrifuge cascades of 5 IR-6 centrifuges each and another one of 19 IR-6 centrifuges;
5. Up to 9 IR-6s centrifuges in cascades; and
6. Up to 10 IR-s centrifuges.

According to the IAEA report, as of February 17, 2021, Iran was testing the following single centrifuges with UF_6 in lines 2, 3, and 5 but not accumulating enriched uranium:

1. 19 IR-1 centrifuges;
2. Four IR-2m centrifuges;
3. Zero IR-3 centrifuges;
4. One IR-4 centrifuge;
5. Three IR-5 centrifuges;

6. Two IR-6 centrifuges;
7. Zero IR-6m centrifuges;
8. Two IR-6-s centrifuges;
9. Zero IR-6sm centrifuges;
10. Zero IR-7 centrifuges;
11. One IR-8 centrifuge;
12. Zero IR-8s centrifuges;
13. One IR-8B centrifuge;
14. One IR-s centrifuge; and
15. One IR-9 centrifuge

Iran also accumulated enriched uranium in lines 4 and 6, in one cascade of 119 IR-4 centrifuges and one cascade of 133 IR-6 centrifuges. The IAEA did not specify how much enriched uranium had been produced so far in lines 4 and 6, or its level of enrichment. This enriched uranium is likely included in the IAEA's aggregate, reported amount of uranium enriched to more than 2 percent and up to 5 percent.

Based on the above enrichment outputs of the IR-2m, IR-4, and IR-6 centrifuges, at its current number per cascade, line 4 has 119 IR-4 centrifuges with a separative output of 392.7 SWU per year, the equivalent of 436 IR-1 centrifuges. Line 6 at the PFEP held 133 IR-6 centrifuges in a single cascade (up from 110 during the last reporting period). It is unclear if Iran will increase the number of IR-6 centrifuges in line 6 to 164 centrifuges. 133 IR-6 centrifuges in cascade would have an output of about 814 SWU per year, and a cascade of 164 IR-6 would have total capacity of about 1,000 SWU per year, or the equivalent of about 1,115 IR-1 centrifuges.

Iran announced that it would replace the inoperable cascade of IR-1 centrifuges in Line 1 with IR-5 and IR-6s centrifuges in a full cascade of 172 centrifuges, or two intermediate cascades of 84 centrifuges. As of February 13, the IAEA verified that Iran had begun installing these centrifuges in line 1. This additional cascade could add an estimated 727 SWU per year to Iran's total enrichment capacity, or the equivalent of 807 IR-1 centrifuges.

According to the quarterly report, Tehran continued violating an additional JCPOA limitation by conducting mechanical testing of centrifuges at the Tehran Research Centre and at a workshop at Natanz. The report states, "On 17 February 2021, the Agency verified that Iran had conducted mechanical testing of three IR-4 centrifuges simultaneously for 90 days at the Tehran Research Centre in addition to two IR-4 centrifuges for six days at Natanz, and of three IR-6 centrifuges simultaneously for nine days at the Tehran Research Centre (para. 40). As of 24 January 2021, Iran had started using a new location (at a workshop at Natanz), beyond those specified in the JCPOA, for mechanical testing of centrifuges."

As can be seen, Iran is developing a large number of centrifuges simultaneously, an unusual practice. The centrifuges currently at the PFEP include: IR-1, IR-2m, IR-4, IR-5, IR-6, IR-6s, IR-8, IR-8B, IR-s, and IR-9. No information was provided in the IAEA report on how well these centrifuges work, their failure rates, or why so many of them are being developed. Typically, a

centrifuge program with such characteristics is likely failing at developing a commercially viable centrifuge, although several of these centrifuges could work adequately in a nuclear weapons program, where efficiency, low failure rates, and low cost are not priorities. With the deployments of the IR-2m and IR-4 centrifuges, and expected deployment of IR-6 cascades in the FEP and FFEP, more data may be forthcoming.

Table 2 summarizes the enrichment capacity by facility. Iran's enrichment capacity has increased from an estimated 6963 SWU/yr to 8258 SWU/yr during this reporting period, representing an increase of 19 percent. This total enrichment capacity represents the equivalent of 9176 IR-1 centrifuges. As will be noted below, this entire capacity cannot be used in a breakout capacity, since many advanced centrifuges at the PFEP are not properly organized to contribute meaningfully to a breakout.

Table 2. Number of enriching centrifuges and enrichment capacity

	Number of centrifuges	**Enrichment capacity in swu/yr**	**IR-1 equivalent (number)**
Natanz	5398	5804	6450
Fordow	1044	940	1044
Natanz PFEP (advanced)*	325	1514	1683
Lines 2, 3, 5	See text		
Lines 4 & 6	See text		
Total enriching	6767	8258	9176

**The value for lines 2, 3, and 5 of the PFEP is a rough estimate based on the use of estimated and measured values for the separative output of these centrifuges in cascades, drawn from IAEA information. The values for lines 4 and 6 of the PFEP are given in the text. All values used to make these estimates reflect historical enrichment output values obtained by Iran prior to the nuclear deal and do not reflect current values, which are not included in the IAEA's quarterly reports.

Part 3: Current Breakout Estimates

The Institute's breakout calculator is used to estimate current breakout times, based on Iranian LEU stocks and installed enrichment capacity, and using the above values.

In the breakout estimate, the following conditions are assumed:

- Enrichment capacity at both the Natanz and Fordow Fuel Enrichment Plants, as drawn from the latest IAEA report. The enrichment contribution from advanced centrifuges installed at the PFEP is not included, as their use in a breakout would be complicated and likely not contribute to reducing breakout timelines.
- Only LEU stocks above two percent enriched uranium are used. Stocks of less than two percent enriched uranium are not used, since to do so would require additional modifications of the cascades to handle the lower enrichments, likely significantly slowing or contributing only slightly, rather than speeding up breakout timelines; and
- Iran redeploys additional centrifuges during a breakout. In this estimate, only the eight centrifuge cascades slated for deployment, which include four more IR-2m cascades, one IR-4 cascade, and three IR-6 cascades, are considered, assuming that they would become operational during the breakout period. To simplify the estimate, it is assumed that Iran would add two IR-2m centrifuge cascades each month after breakout commences, over a period of four months. During this period, Iran would also be adding IR-1 centrifuge cascades, at the rate of two per month. Iran may deploy additional advanced centrifuges, but this effect is not included in the estimate, as none of the dozen advanced centrifuge types Iran is testing at the PFEP stands out as Iran's clear centrifuge of choice, and many are assessed as performing poorly.

Two basic cases are considered below.

First, if Iran's stock of uranium enriched up to 4.5 percent, but greater than 2 percent (2796 kg (hexafluoride mass)) is taken as all at 4.5 percent enriched, admittedly a worst case, then its current stock has grown sufficiently to support the production of enough weapon-grade uranium (WGU) for three nuclear weapons.[3] In this new situation, breakout for one nuclear weapon would be accomplished in as little as 2.7 months, utilizing only this stock of enriched uranium, and assuming no initial setup time. Including a two-week setup time would increase this value to 3.2 months. If breakout continued, a second significant quantity of WGU would be produced two months later, and a third quantity would be produced by the end of six months. The second and third quantities would be produced more quickly because of the increased enrichment capacity installed during the first four months of breakout. So, enough WGU could be produced for three nuclear weapons in as little as six months.

Second, Iran's stock of uranium enriched up to 4.5 percent but greater than 2 percent is assumed to be all 3.5 percent enriched (likely an overly conservative assumption), resulting in a total stock of 2796 kilograms (hexafluoride mass). In this case, the breakout timeline to produce enough WGU for one nuclear weapon is 3.0 months, assuming no setup time, and 3.5 months if a setup time is included. With continued breakout, the second quantity of WGU would be produced after a total of five months.

[3] In this report, the IAEA now refers to uranium enriched up to 5 percent rather than 4.5 percent, as was done in the last several reports. The reason for the change is not given, but there is no evidence that Iran increased the level of enrichment in its product. We continue to use 4.5 percent as the upper bound of this category of enriched uranium in the breakout calculations.

A major factor in the first scenario is that the LEU is already enriched to 4.5 percent instead of 3.5 percent, a significant change from estimates performed before the JCPOA's Implementation Day, since this one percent increase in enrichment can provide up to a 15 to 20 percent reduction in breakout time to produce 25 kilograms of WGU. The greater enrichment level also means that the production of 25 kilograms of WGU requires less LEU than if it were enriched to 3.5 percent, or 900 kilograms of 4.5 percent LEU vs. 1250 kilograms of 3.5 percent LEU in hexafluoride mass. This last condition is particularly significant in the first scenario, since it means that the existing amount of LEU enriched up to 4.5 percent is enough to reach the requisite amount of weapon-grade uranium for three nuclear weapons without the need to also use some lesser enriched uranium, such as the 3.5 percent stock, or natural uranium to make a portion of the needed WGU. As a result, the process is strictly a three-step one instead of a three-step process followed by a four-step one, if natural uranium were required. The ability to use only three steps to reach weapon-grade, instead of four, is why the media often discusses a key threshold of about 1000 kg of LEU as significant.[4]

Both scenarios are calculated because of the lack of information about the average enrichment of the LEU stocks. If the average range of 2.7 to 3.5 months is used, the estimated breakout time as of late February is as short as 3.1 months. It is also now the case that Iran could produce its second amount of WGU, and have enough for two nuclear weapons, within five months.

Part 4: Other Information - Uranium Metal Production, Heavy water, Arak reactor, Additional Protocol

Uranium Metal Production

On December 16, 2020, Iran notified the IAEA that it would start R&D activities related to the production of uranium metal using natural uranium, before moving to produce uranium metal enriched to up to 20 percent U-235 for fuel for the Tehran Research Reactor (TRR). This work would occur at the Fuel Plate Fabrication Plant (FPFP) at Esfahan. The uranium metal would be produced at the second stage of a three-stage process.

On January 10, 2021, Iran informed the Agency that installation of the equipment at FPFP needed for the first stage of the process was expected to be completed in 4-5 months and that since the other two stages of the process were still in the design phase, no additional timeline was available. On February 2, 2021, the IAEA verified the receipt of 265 g of natural uranium tetrafluoride (UF_4) at the FPFP from Iran's Uranium Conversion Facility (UCF) at Esfahan.

On February 8, 2021, the IAEA verified that Iran had produced 3.6 g of uranium metal from 13 g of the aforementioned natural UF_4 in a laboratory experiment conducted at the FPFP on

[4] David E. Sanger and William J. Broad, "Iran Crosses a Key Threshold: It Again Has Sufficient Fuel for a Bomb," *The New York Times,* March 3, 2020, https://www.nytimes.com/2020/03/03/world/middleeast/iran-nuclear-weapon-trump.html

February 6, 2021. On February 21, 2021, the IAEA verified the transfer of 1.5 kg of natural uranium in the form of UF_4 from UCF to FPFP for additional R&D experiments on uranium metal production. On February 16, 2021, the IAEA verified at the FPFP that Iran had started installing equipment for the first stage of the process, involving the production of UF_4 from UF_6.

Heavy Water Production Plant (HWPP)

Iran continued to operate the HWPP during the reporting period and shipped out heavy water to unknown buyers. According to the IAEA report, on February 15, 2021, the IAEA verified that the HWPP was in operation and that Iran's stock of heavy water had increased to 131.4 metric tonnes (+3.4 metric tonnes since the previous quarterly report). It continued to permit IAEA monitoring of its heavy water production activities.

On February 15, 2021, the IAEA confirmed that in this reporting period, Iran had produced 7.0 metric tonnes of heavy water. According to the report, during the same period, Iran had shipped out 5.4 metric tonnes of heavy water and had used 2.2 metric tonnes of heavy water for R&D activities related to the production of deuterated compounds for medical applications. As of the same date, the IAEA verified that Iran had purified 4.0 metric tonnes of heavy water from 5.4 metric tonnes of contaminated heavy water which had resulted from the production of deuterated compounds. The 4.0 metric tonnes is included in Iran's stock of heavy water.

Arak Reactor

The IAEA again reported that Iran "has not pursued the construction of the Arak heavy water research reactor (IR-40 Reactor) based on its original design." It also "has not produced or tested natural uranium pellets, fuel pins or fuel assemblies" for the original reactor design.

Additional Protocol implementation

As of February 23, 2021, Iran stopped implementing the provisions of the Additional Protocol, as mandated by its new nuclear law. Based on a February 21, 2021 joint statement by the IAEA and Iran, Iran agreed to fully implement the comprehensive safeguards agreement and a "temporary bilateral technical understanding, compatible with the Law, whereby the IAEA will continue with its necessary verification and monitoring activities for up to 3 months (as per technical annex)." The technical annex remains secret, and as such, its effectiveness cannot be evaluated. The IAEA still has not been able to reach a Broader Conclusion for Iran.