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IAEA Iran Safeguards Report Analysis

Iran Commits Multiple Violations of the Nuclear Deal, Several Non-Reversible

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On November 11, 2019, the International Atomic Energy Agency (IAEA) released its latest safeguards report on the verification and monitoring of the Iran nuclear deal in light of United Nations Security Council Resolution 2231 (2015). This report details a large number of violations of the Joint Comprehensive Plan of Action (JCPOA) and possibly Iran's Comprehensive Safeguards Agreement. The main violations, some of which are not fully reversible, are highlighted here; several are discussed in more detail below:

1. The IAEA found natural uranium of "anthropogenic origin" at an undeclared site in Iran;
2. Iran introduced uranium hexafluoride and started uranium enrichment at the Fordow Fuel Enrichment Plant (FFEP);
3. Iran further increased its quantity of low enriched uranium above the JCPOA's 300 kilogram (kg) cap (uranium hexafluoride mass), ramping up monthly production significantly;
4. Iran continued to produce enriched uranium above the limit of 3.67 percent, producing at a level of up to 4.5 percent;
5. Iran initiated the operation of many advanced centrifuges at the Natanz Pilot Fuel Enrichment Plant (PFEP) to accumulate enriched uranium;
6. Iran increased the number and type of centrifuges enriching uranium above the limit of 5,060 IR-1 centrifuges. The total separative work involved in uranium enrichment has increased from an estimated 4,550 to 6,200 separative work units (SWU) per year, a 36 percent increase over the enrichment capacity allowed by the JCPOA;[2]
7. Iran withdrew advanced centrifuges from storage for installation at the PFEP. It reinstalled a cascade of 164 IR-4 centrifuges and one of 164 IR-2m centrifuges in the PFEP and initiated the collection of enriched uranium;

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[2] This estimate ignores smaller cascades that are also enriching uranium and includes only production-scale cascades, with the exception of the 30-centrifuge cascade of IR-6 centrifuges, which Iran intends to fill out to 164 IR-6 centrifuges as soon as possible.

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8. Iran installed and operated several new advanced centrifuge types at the PFEP not listed as permitted for installation in the nuclear deal;
9. Iran enriched uranium in a cascade of 30 IR-6 centrifuges at the PFEP and initiated the installation of a total of 164 IR-6 centrifuges that would accumulate enriched uranium;
10. For twelve days, Iran conducted mechanical testing of three IR-4 centrifuges simultaneously at the Tehran Research Center;
11. Iran "prepared a new location," beyond those specified in the JCPOA and unidentified in the report, for mechanical testing of centrifuges;
12. Iran used declared centrifuge manufacturing equipment for activities beyond those specified in the JCPOA, such as for producing centrifuges in type or number not allowed by the JCPOA;
13. Iran continued to use carbon fiber in making rotor tubes that was not subject to continuous IAEA containment and surveillance measures, in violation of conditions in the JCPOA and a January 14, 2016 Joint Commission implementing decision on how rotor tubes would be manufactured with materials such as carbon fiber that must be taken from a designated storage location under IAEA monitoring. This case implies that Iran's nuclear program had hidden stocks of carbon fiber or had acquired it from abroad or from another Iranian entity without subjecting the carbon fiber to the rules established on storing it under IAEA monitoring prior to its use in manufacturing rotor tubes. (Any such carbon fiber was likely obtained via illicit procurement from abroad);
14. As described by U.S. authorities, Iran may be violating the JCPOA's procurement restrictions by illicitly importing nuclear dual-use equipment.

The report does not discuss Iran's denial of access to an inspector at Natanz. Moreover, the report is vague on whether Iran has violated Section T of the JCPOA involving the use of controlled equipment related to the development of nuclear weapons. Although not a violation of the JCPOA, Iran may be selling heavy water to a foreign buyer, which could be subject to U.S. sanctions.

The IAEA report is completely silent on the issue of the IAEA's investigation of the Nuclear Archive and whether this matter could rise to the level of a violation of the JCPOA, under which Iran committed "under no circumstances will [it] ever seek, develop or acquire any nuclear weapons." The existence of archive may also violate the Nuclear Non-Proliferation Treaty and Iran's safeguards agreements.

The IAEA includes its usual statements that it is verifying non-diversion of declared nuclear materials in Iran but is continuing its "evaluations regarding the absence of undeclared nuclear material and activities." The latter essentially states that the IAEA has not determined that Iran's nuclear program is exclusively peaceful.

With the additional production-scale centrifuge cascades enriching, Iran now has an installed enrichment capacity of 6,190 SWU per year, compared to 4,554 SWU per year at the end of the last reporting period.

The breakout time, or the amount of time Iran would need to produce enough weapon-grade uranium for a nuclear weapon, has shifted downward. Based on new modeling by the Institute

and Iran's stock of 550 kg of enriched uranium (uranium hexafluoride mass), Iran's breakout time has been reduced from about 8-12 months to 6-10 months. The breakout time will decrease further as Iran increases its stock of enriched uranium and installs more centrifuges.

Additional increases in deployed centrifuges dedicated to uranium enrichment will decrease the breakout time further, as will any production of higher enriched uranium.

Presence of Undeclared Natural Uranium

As confirmed during a special meeting of the IAEA Board of Governors on November 7, the IAEA reported the finding of natural uranium of "anthropogenic origin" at an unnamed site, likely a warehouse complex in Tehran's Turquz-Abad district. In September 2018, Israel announced publicly that it had information that this site housed nuclear-related material and equipment. Iran had emptied the site over the summer of 2018, following Israel's disclosure that it had seized a vast set of files from a separate Nuclear Archive in Tehran. The IAEA delayed in acting on the information but has since followed up by visiting the site and taking samples.

The IAEA called upon Iran to cooperate on this issue, raising the potential finding of non-compliance with its safeguard agreements. According to the IAEA report:

> *It is essential for Iran to continue interactions with the Agency to resolve this matter as soon as possible. On-going interactions between the Agency and Iran relating to Iran's implementation of its Safeguards Agreement and Additional Protocol require full and timely cooperation by Iran.*

In a recent briefing to journalists, Israeli intelligence and national security officials stated that the analysis of the uranium in the sample showed that Iran stored nuclear material at the Turquz-Abad site that had been converted from raw uranium but not yet enriched. The Israelis also stated that the uranium's characteristics and age do not correspond with uranium from any nuclear facility previously disclosed by Iran, implying that there exists or existed an undeclared Iranian uranium conversion facility. The existence of such a site, as well as the Turquz-Abad site, could be violations of Iran's safeguards agreement.

Low Enriched Uranium

The IAEA reports that Iran has continued to exceed the JCPOA's cap of 300 kilograms (kg) of low enriched uranium (hexafluoride mass), or 202.8 kg (uranium mass). On July 1, the IAEA first reported that Iran had surpassed the JCPOA's LEU stock limit by enriching 205.0 kg of LEU (uranium mass). Iran also continued to enrich to 4.5 percent, in violation of the 3.67 percent enrichment limit under the deal. The IAEA first stated on July 8 that Iran was enriching up to a level of 4.5 percent.

On November 3, 2019, the IAEA's most recent verification date, Iran possessed a total stockpile of about 551 kg of low enriched uranium (hexafluoride mass), all enriched below 5 percent, or the equivalent of 372.3 kg (uranium mass). Iran added 130.7 kg (uranium mass) to its low enriched uranium stockpile during the reporting period. The IAEA reports that of the 372.3 kg

figure, Iran has produced 159.7 kg of up to 4.5 percent LEU (uranium mass), all in the form of uranium hexafluoride (UF_6), including about 30.5 kg of uranium enriched in advanced centrifuges to two percent (uranium mass), at the PFEP. In terms of uranium hexafluoride mass, Iran possessed 236 kg of up to 4.5 percent enriched uranium and 315 kg of uranium enriched to about 3.5 percent.

The additional stocks of enriched uranium reported in this IAEA report were produced at the Natanz Fuel Enrichment Plant (FEP) and the PFEP. At the FEP, the IAEA reports that no more than 5,060 IR-1 centrifuges are installed in 30 cascades, as permitted by the JCPOA. In violation of the JCPOA, the IAEA reports that enrichment is now also occurring at the PFEP at Natanz and at the Fordow plant (see below). (Enrichment started at Fordow on November 9, 2019, which is after the date when the IAEA verified the enriched uranium inventory).

In Table 1 below, the February vs. August vs. November 2019 comparisons show how Iran has increased its production of LEU, as measured only in uranium mass. The net increase in the total stock of LEU in Iran from May 20 to November 3 was 198.2 kilograms LEU (uranium mass), at an overall average rate of about 38 kilograms (uranium mass) per month. Alternatively, these values convert to 293 kg LEU (hexafluoride mass), or an average of about 53 kg LEU (hexafluoride mass) per month. During this reporting period, covering August 19 to November 3, the average rate was about 51.6 kg per month of enriched uranium (uranium mass) and 76.3 kg per month of enriched uranium (hexafluoride mass). In this reporting period, compared to the previous one, average monthly production of enriched uranium more than doubled.

Table 1. Enriched Uranium Quantities, less than 5 percent and all quantities in uranium mass*

	May 2019	**August 2019**	**November 2019**
Chemical Form			
UF_6	153.2 kg	218.9 kg	349.9 kg
Uranium oxides and their intermediate products	10.4 kg	11.1 kg	10.4 kg
Uranium in fuel assemblies and rods	4.3 kg	4.6 kg	4.6 kg
Uranium in liquid and solid scrap	6.2 kg	7.0 kg	7.4 kg
Enrichment Level Subtotals			
Uranium enriched to 3.67 percent	174.1 kg	216.5 kg	212.6 kg**
Uranium enriched to 4.5 percent	0	25.1 kg	129.2 kg
Uranium enriched to 2 percent	0	0	30.5 kg
Totals of Enriched Uranium, <5%	**174.1 kg**	**241.6 kg**	**372.3 kg**

*These totals ignore undisclosed stocks of enriched uranium exempted by the Joint Commission.
**The IAEA appears to have changed how it reports this quantity since the last report. The asterisked value is the amount of up to 3.67 enriched uranium produced prior to July 8, 2019. In the last report, this value, which was given as 216.5 kg, was reported as the amount of up to 3.67 percent enriched uranium as of August 19, 2019. The reason for the small difference is not explained in the current report.

IR-1 Centrifuge Deployments at Natanz FEP

At the Natanz Fuel Enrichment Plant, the IAEA reports that Iran withdrew 48 IR-1 centrifuges from storage to replace broken ones. During the previous reporting period, it withdrew 18 IR-1 centrifuges, and during the prior one, it withdrew 52 IR-1 centrifuges, most of which were likely installed as a result of scaling up enrichment activities. The report before, in February 2019, stated that no IR-1 centrifuges were withdrawn.

The total of IR-1 centrifuges withdrawn during the last three reporting periods was 118 centrifuges. Assuming that most of these centrifuges were needed since mid-May 2019, this means that the average rate of withdrawal, which tracks closely the centrifuge breakage rate, is about 20 centrifuges per month.

Fordow Fuel Enrichment Plant

The IAEA reported that it had verified that uranium enrichment started on November 9, 2019 in two cascades at the underground site. The site has a total of 1,020 installed IR-1 centrifuges in six cascades, two of which have remained "spinning" since January 2016, as allowed by the JCPOA. Iran restarted uranium enrichment in these two cascades. Each cascade at Fordow contains an average of 170 IR-1 centrifuges, so uranium enrichment is occurring in roughly an additional 340 IR-1 centrifuges. Enrichment may proceed to the next two cascades over the coming weeks, and eventually involve all six cascades if Iran decides to use for enrichment the two cascades devoted to stable isotope production. Any of the centrifuges set aside for that project that have been used for stable isotope production will first need to be replaced.

It is unclear whether work at Fordow on stable isotope separation project will continue in light of the plant's conversion back to enrichment purposes. Iran's Atomic Energy Organization (AEOI) spokesman, Behrouz Kamalvandi, stated on November 9 that the project would continue with Russia's help. However, the IAEA again reports that only ten IR-1 centrifuges were installed in a layout of 16 IR-1 centrifuge positions and one IR-1 centrifuge was installed in a single position "for the purpose of conducting initial research and R&D activities related to stable isotope production." Another 13 IR-1 centrifuges, possibly related to stable isotope research, were being stored within the facility, although the IAEA does clearly state these centrifuges' purpose.

Iran has rendered defunct the JCPOA's provision that the Fordow plant be converted to a nuclear, physics, and technology research center. Instead, as we warned in our previous analysis, Iran retained its enrichment plant at Fordow four years into the JCPOA's implementation. Kamalvandi recently emphasized that reality, stating on November 9, "In fact, we can say that we have abandoned a number of clauses of the JCPOA, including the 44th, which stipulates that Fordow should be transformed into an international nuclear and physical center." Iran has also been actively creating a domestic nuclear equipment production plant at nearby Fordow support facilities.

Advanced Centrifuges

Iran took many steps during the reporting period to violate the JCPOA's limitations on advanced centrifuges. The following summarizes the deployment of advanced centrifuges at the Natanz PFEP, their enrichment status, and their enrichment capacity, if known.

The first change was that Iran would no longer remix the product and tails (waste), but collect it separately, meaning that Iran has started accumulating enriched uranium at the PFEP. As of November 3, 2019, 30.5 kilograms of uranium enriched up to two percent had been collected from lines 2 and 3 of the six lines at the PFEP. In the future, the accumulation of enriched uranium, according to Iran, will occur in lines 2, 3, 4, 5, and 6.

Iran also told the IAEA that it was deploying a large number of new advanced centrifuges. Iran provided the IAEA with a revised list of all the centrifuge types at the PFEP: IR-1, IR-2m, IR-3, IR-4, IR-6, IR-6m, IR-6s, IR-6sm, IR-7, IR-8, IR-8s, IR-8B, IR-s, and IR-9. No information was provided on how well these centrifuges work or why so many of them are being developed. Typically, a centrifuge program that has 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.

Iran has also redeployed 164 IR-2m and IR-4 centrifuge cascades in lines 4 and 5 of the PFEP, in violation of the JCPOA. As of October 30, 2019, the IAEA verified that both cascades were accumulating enriched uranium without specifying how much had been produced so far. The IR-2m centrifuge is Iran's most successful advanced centrifuge. When previously operated in a production-scale cascade, each IR-2m centrifuge had an enrichment capacity of about 3.7 SWU per year. The total cascade thus has an enrichment capacity of about 607 SWU per year. This is equivalent to about 675 IR-1 centrifuges operating in production cascades, where each IR-1 is assumed to have a capacity of 0.9 SWU per year. The IR-4 has a lower capacity than the IR-2m, estimated here as ten percent lower, or about 3.3 SWU per year per centrifuge. The production cascade would have a total output of about 540 SWU per year, or equivalent to about 600 IR-1 centrifuges. These two cascades represent a total increase of capacity of about 1,147 SWU/year, or the equivalent of about 1,275 IR-1 centrifuges.

Line 6 at the PFEP holds IR-6 centrifuges. Iran stated that it will hold 164 IR-6 centrifuges in a cascade. As of November 5, 2019, Iran was enriching in a cascade of 30 IR-6 and was quickly preparing to expand this cascade to hold a total of 164 IR-6 centrifuges. The IR-6 has a single machine estimated capacity of 6.8 SWU per year. No data are available on its performance in a cascade. Assuming that the cascade value would be less than about 90 percent of the capacity achieved by an IR-6 operating by itself, 30 IR-6 centrifuges in cascade would have an output of about 183 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.

Lines 2 and 3 contained a variety of centrifuge types and numbers that were accumulating, or once fully installed, would accumulate enriched uranium. These centrifuges are what led to the

accumulation of 30.5 kg of enriched uranium discussed above. The following is a summary of all the centrifuges installed as of November 5, 2019:

1. Up to 22 IR-2m centrifuges, including a cascade of 20 centrifuges;
2. Up to 22 IR-4 centrifuges, including a cascade of 20 centrifuges;
3. Up to 11 IR-5 centrifuges, including a cascade of IO centrifuges;
4. Up to 34 IR-6 centrifuges, including a cascade of 10 and another of 20 centrifuges;
5. Up to 33 IR-6s centrifuges, including a cascade of 20 centrifuges and 12 centrifuges installed in a new "modular" configuration (IR-6smo);
6. Three single IR-8 centrifuges;
7. One single IR-3 centrifuge;
8. One single IR-6m centrifuge;
9. One single IR-6sm centrifuge;
10. Two single IR-7 centrifuges;
11. One single IR-Ss centrifuge;
12. One single IR-SB centrifuge;
13. One single IR-s centrifuge; and
14. One single IR-9 centrifuge.

Enrichment Capacity

Iran is increasing its enrichment capacity and its experience in operating advanced centrifuges. While the former is reversible, the latter is not. This knowledge and experience cannot be lost. Table 2 summarizes the enrichment capacity increase by facility. As can be seen, Iran's enrichment capacity has grown by about 36 percent during this reporting period. When all the IR-6 centrifuges slated for line 6 of the PFEP are installed, the capacity will grow by about 50 percent over the allowed capacity.

Table 2. Number of Centrifuges Enriching and Total Enrichment Capacity

Location	Number of Centrifuges	Enrichment Capacity (SWU/yr)
Natanz FEP	5,060	4,554
Fordow FEP	340	306
Natanz PFEP*	see text	1,330
	Total:	**6,190**

*Only centrifuges in lines 4, 5, and 6 of the PFEP are considered here, and line 6 only includes 30 IR-6 centrifuges. If all 164 IR-6 centrifuges were included, then the value would be about 2,150 SWU per year. Although centrifuges in line 2 and 3 are producing enriched uranium and thus could be included in the total enrichment capacity, they are ignored here since they are operating as single machines or in relatively small cascades.

Heavy Water Production and Arak Reactor Conversion

As of October 28, Iran remained under the JCPOA limit of 130 metric tonnes on the stock of heavy water it can possess, at 128.9 metric tonnes. Under IAEA monitoring, during the reporting period, Iran used 0.6 metric tonnes of heavy water for "research and development

activities related to the production of deuterated compounds for medical applications." It was also "preparing to purify 2.2 metric tonnes of contaminated heavy water which had resulted from the production of deuterated compounds."

The IAEA reports that as of October 28, Iran had exported 0.4 metric tonnes of heavy water during this reporting period. During the previous reporting period, it exported 2.2 metric tonnes. In May 2019, the Trump administration tightened a U.S. waiver from sanctions on any third parties storing Iran's heavy water before it is sold to a buyer. The administration stated that it would "no longer permit the storage for Iran of heavy water it has produced in excess of current limits; any such heavy water must not be made available to Iran in any fashion." A U.S. official told one of the authors that Oman, the previous third-party storage point for Iran's heavy water, was cooperating with the new U.S. restrictions. Notably, buying Iranian heavy water directly could be a sanctionable activity. The IAEA reporting appears to indicate that a customer is still purchasing Iranian heavy water.

The IAEA also reports that Iran has "not pursued the construction of the Arak heavy water research reactor (IR-40 Reactor) based on its original design." Conversion efforts at the Arak nuclear reactor, provided for under the JCPOA, are assisted by a consortium of experts and companies from Britain, China, Germany, and the Czech Republic. This project appeared to be moving forward recently after long delays. However, on November 9, the AEOI's Kamalvandi repeated threats made over the summer to return to the original design of the Arak reactor, which operated on natural uranium fuel and used heavy water as a moderator, making it capable of producing weapon-grade plutonium. He stated, "If steps [on the Iran nuclear deal] are not taken quickly from the opposite side, which is engaged in the modernization of the reactor, we will return to the previous type of reactor." The IAEA again does not discuss whether it questioned Iran about a spare set of calandria tubes that Ali Akbar Salehi, head of the AEOI, stated that Iran procured during JCPOA negotiations in order to hedge and be able to circumvent the deal restrictions.

Illicit Procurements

The IAEA reports that it attended one meeting of the JCPOA Procurement Working Group at the UN. It does not report on findings by the United States which may suggest that Iran has been procuring goods controlled on the Nuclear Suppliers Group (NSG) Part 2 dual-use list. In August, the U.S. Department of Justice arrested a man for illegally procuring for Iran computer numerical controlled machines (CNC) that are controlled for export for nuclear proliferation reasons. The alleged violations occurred between 2015 and 2018. The U.S Treasury Department also sanctioned a network called the Shariat network in August for conducting, since at least 2016, alleged illicit procurements for Iranian end-users controlled by Iran's Defense Ministry. These end-users outfit Iran's nuclear and long-range missile delivery system programs. Iran is required to use the JCPOA's Procurement Channel, headquartered at the UN Secretariat, to obtain NSG-listed items. It would be useful for the IAEA to report on such procurement matters which concern JCPOA implementation and Iran's adherence to its commitments.