Post-JCPOA Iran Uranium Enrichment Database Codebook

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December 12, 2024

Version 1.0

Overview

This project developed an open-source dataset compiling, estimating, and standardizing Iranian uranium enrichment and centrifuge development measurements based on raw data from the International Atomic Energy Agency (IAEA)'s *Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015)* reports. These reports were established under the JCPOA to detail quarterly visits to the four locations where evidence suggested Iran conducted undeclared nuclear activities before 2003 and stored both equipment and materials. These locations include the Arak Heavy Water Production Plant and three nuclear facilities: Natanz Fuel Enrichment Plant (FEP), Fordow Fuel Enrichment Plan (FFEP), and Pilot Fuel Enrichment Plant (PFEP). The dataset tracks enrichment activities at FEP, FFEP, and PFEP from the March 3, 2019, IAEA report, the last set of inspections when Iran complied with JCPOA requirements, through the most recent report on November 17, 2024.

Data Sourcing

Twenty-three IAEA reports spanning from 2019 to 2024 were used to source raw data on uranium enrichment and centrifuge production (see the list in Table I below).

Table 1: Raw Data Sourcing

Report Number	Quarter	U-235 Inspection	Enrichment Inspection	Report Release
GOV/2024/61	QIV 2024	10/30/24	10/29-11/6/24	11/21/24
GOV/2024/41	QIII 2024	8/16/24	08/21-26/24	9/11/24
GOV/2024/26	QII 2024	5/11/24	5/1-5/25/24	6/4/24
GOV/2024/7	QI 2024	2/10/24	2/21-24/24	3/6/24
GOV/2023/57	QIV 2023	11/7/23	10/21-11/8/24	11/22/23
GOV/2023/39	QIII 2023	8/19/23	8/22-27/2023	9/4/23
GOV/2023/24	QII 2023	5/13/23	05/12-23/23	5/31/23

GOV/2023/8	QI 2023	2/12/23	02/22-28/23	2/28/23
GOV/2022/62	QIV 2022	10/22/22	11/1-2/22	11/22/22
GOV/2022/39	QIII 2022	8/21/22	08/30-31/22	9/7/22
GOV/2022/24	QII 2022	5/15/22	05/23-25/22	5/30/22
GOV/2022/4	QI 2022	2/18/22	02/21-22/22	3/3/22
GOV/2021/51	QIV 2021	11/3/21	11/8-13/21	11/17/21
GOV/2021/39	QIII 2021	8/21/21	08/30-31/21	9/7/21
GOV/2021/28	QII 2021	5/22/21	05/24-26/21	6/9/21
GOV/2021/10	QI 2021	2/21/21	02/17-21/21	3/4/21
GOV/2020/51	QIV 2020	11/2/20	11/10/20	11/19/20
GOV/2020/41	QIII 2020	8/25/20	09/1-2/20	9/16/20
GOV/2020/26	QII 2020	5/20/20	05/30-06/1/120	6/16/20
GOV/2020/5	QI 2020	2/19/20	2/25/20	3/11/20
GOV/2019/55	QIV 2019	11/3/19	11/6/19	11/21/19
GOV/2019/32	QIII 2019	8/19/19	8/24/19	9/11/19
GOV/2019/21	QII 2019	5/20/19	5/29/19	6/12/19
GOV/2019/10	QI 2019	2/16/19	2/19/19	3/6/19

Enriched Uranium Calculations

The dataset records the enriched uranium stockpiles found upon each IAEA visit and the amount of enriched uranium produced throughout the quarter at each enrichment level (<2%, <5%, <20%, and <60%). The <5% category comprises Iran's brief enrichment at the 3.67% and 4.5% levels, and the <2%, <20%, and <60% align with standard IAEA enrichment categories. This decision was made due to the brevity of each enrichment level: Iran was enriching at 3.67% as designated under the JCPOA until July 8th, 2019, when it informed the IAEA it would begin

enriching to 4.5%.[1] It maintained a stockpile of 3.67% U-235 until November 2nd, 2020, with the Quarter IV 2020 report being the last one to note this category within Iran's stockpile.[2] Similarly, Iran maintained its 4.5% stockpile for presumably under one quarter as a stepping stone with this category stopping by Quarter I 2021 when Iran formally informed the IAEA it would increase enrichment to five percent.[3]

Quarterly production was calculated by summing the quantity produced at various enrichment levels across facilities during a specific quarter. Stockpiling totals were calculated by taking the inventory of the preceding period, subtracting the quantity used for feed at the enrichment level, and adding the quantity produced. The IAEA reports quarterly measurements in either hexafluoride uranium mass (hex mass) or standard uranium mass (U mass). The dataset standardizes these measurements by converting all enriched uranium data points to U mass using the ratio of the molar mass of pure uranium over uranium hexafluoride (0.676).

There were multiple cases where Iran downblended its uranium enrichment for international deals, to ease tensions, and for experimentation. In these cases, the downblending was taken into consideration only when it was recorded by the IAEA as removed from the process and added to Iran's stockpile. These cases are as follows:

- Quarter III, 2024: Footnote 41 notes that sometime after May 11, 2024, but before the

[1] Beth Wangui Glass, "GOV/2019/32," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, September 11, 2019), https://www.iaea.org/sites/default/files/19/09/gov2019-32.pdf.
[2] Rafael Mariano Grossi, "GOV/2020/51," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, November 19, 2020), https://www.iaea.org/sites/default/files/20/11/gov2020-51.pdf.
[3] Rafael Mariano Grossi, "GOV/2021/10," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, March 4, 2021), https://www.iaea.org/sites/default/files/21/03/govinf2021-10.pdf.

reporting date, Iran mixed "a total of 5.9 kg of uranium enriched up to 60% U-235 with 12.5 kg of uranium enriched up to 2% U-235 to produce an additional 18.4 kg of uranium enriched up to 20% U-235 previously reported."[4]

- Quarter I, 2024: Footnote 31 states during two separate campaigns in the reporting period, Iran "mixed a total of 31.8 kg of uranium enriched up to 60% U-235 with 66.4 kg of uranium enriched up 2% U-235 producing 97.9 kg of uranium enriched up to 20% U-235."[5]
- Quarter III, 2023: Footnote 67 states, "during the reporting period, the Agency verified that Iran mixed 6.4 kg of uranium enriched up to 60% U-235 (contained in two 5B cylinders) with 15.8 kg of uranium enriched up 5% U-235 to produce 22.2 kg of uranium enriched up to 20% U-235."[6]
- Quarter II, 2022: Line 34 notes that from March 6-9, "Iran had converted at FPFP 2.1 kg of uranium in the form of UF6 enriched up to 60% U-235 into 1.7 kg of uranium enriched up to 60% U-235 in the form of U3O8."[7]

Centrifuge Calculations

Enrichment capacity was calculated by tracking the quarterly production of traditional centrifuges (IR-1) and advanced centrifuges (IR-2m, IR-3, IR-4, IR-5, IR-6, IR-7, IR-8, IR-9,

[4] Rafael Mariano Grossi, "GOV/2024/61," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, November 21, 2024), https://www.iaea.org/sites/default/files/23/11/gov2023-57.pdf.
[5] Rafael Mariano Grossi, "GOV/2024/7," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, March 6, 2024), https://www.iaea.org/sites/default/files/24/03/gov2024-7.pdf.
[6] Rafael Mariano Grossi, "GOV/2023/39," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, September 4, 2023), https://www.iaea.org/sites/default/files/23/09/gov2023-39.pdf.
[7] Rafael Mariano Grossi, "GOV/2022/24," Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015) (Vienna, Austria: International Atomic Energy Agency, May 30, 2022), https://www.iaea.org/sites/default/files/22/06/gov2022-24.pdf.

and IR-s) at each nuclear facility (FEP, FFEP, PFEP). The stockpile value was calculated from the reported number of each type of centrifuge currently employed (installed in cascades or installed and tested). The quarterly production rate was calculated by subtracting the stockpile quantity from the previous period from the current in each category.

The IAEA reports the number of cascades and centrifuges by type at FFEP and PFEP but had limited access to the number of centrifuges in FEP since February 23, 2021, when Iran suspended compliance with the Additional Protocol. As a result, the number of centrifuges after this date was estimated by multiplying the number of cascades by the average number of centrifuges per cascade based on Iran's most recent Design Information Questionnaire (DIQ) per period.

Variables

For each report, the following variables were used:

Table 2: Variable Descriptions

Variable	**Decscription**
INSPECTION_DATE	Date of inspection for either uranium enrichment or centrifuge production in mm-dd-yyyy format
FACILITY_NAME	The nuclear facility where centrifuge capacity was measured: FEP, FFEP, PFEP
FEP	Natanz Fuel Enrichment Plant
FFEP	Fordow Fuel Enrichment Plan
PFEP	Pilot Fuel Enrichment Plant
SP_2	The amount of stockpiled Uranium-235 at the <2% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg
SP_5	The amount of stockpiled Uranium-235 at the <5% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg
SP_20	The amount of stockpiled Uranium-235 at the <20% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg
SP_60	The amount of stockpiled Uranium-235 at the <60% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg

QP_2	The amount of sroduced Uranium-235 at the <2% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg during the production period
QP_5	The amount of produced Uranium-235 at the <2% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg during the production period
QP_20	The amount of produced Uranium-235 at the <20% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg during the production period
QP_60	The amount of produced Uranium-235 at the <60% refinement level reported across all disclosed enrichment facilities (FEP, FFEP, and PFEP) in kg during the production period
IR_1	Number of employed (installed in cascades or installed and testing) IR-1 centrifuges
IR_2m	Number of employed (installed in cascades or installed and testing) IR-2m centrifuges
IR_3	Number of employed (installed in cascades or installed and testing) IR-3 centrifuges
IR_4	Number of employed (installed in cascades or installed and testing) IR-4 centrifuges
IR_5	Number of employed (installed in cascades or installed and testing) IR-5 centrifuges
IR_6	Number of employed (installed in cascades or installed and testing) IR-6 centrifuges
IR_7	Number of employed (installed in cascades or installed and testing) IR-7 centrifuges
IR_8	Number of employed (installed in cascades or installed and testing) IR-8 centrifuges
IR_s	Number of employed (installed in cascades or installed and testing) IR-s centrifuges
IR_9	Number of employed (installed in cascades or installed and testing) IR-9 centrifuges

Limitations and Disclaimer

This dataset includes estimates and standardized measures derived from raw data reported by the International Atomic Energy Agency (IAEA). Efforts have been made to standardize the data accurately; however, estimating involves interpretation, so errors may exist. Users are responsible for independently verifying the data before use. The author assumes no liability for inaccuracies or misuse of the dataset.