Iran's Nuclear Program Overview

Updated July 2023

UNITED AGAINST NUCLEAR IRAN

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Glossary

AEOI	Atomic Energy Organization of Iran
AVLIS	Atomic Vapor Laser Isotope Separation
BRC	Bonab Atomic Energy Research Center
FEP	Fuel Enrichment Plant
FFEP	Fordow Fuel Enrichment Plant
FLUM	Flow-Rate Unattended Monitoring
FPFP	Fuel Plate Fabrication Plant
HWPP	Heavy Water Production Plant
HEU	High-Enriched Uranium
IAEA	International Atomic Energy Agency
ICAC	Iran Centrifuge Assembly Center
ISIS	Institute for Science and International Security
JCPOA	Joint Comprehensive Plan of Action
KHWR	Khondab Heavy Water Research Reactor
LEU	Low-Enriched Uranium
PFEP	Pilot Fuel Enrichment Plant
SPND	Organization of Defensive Innovation and Research
TNRC	Tehran Nuclear Research Center
UCF	Uranium Conversion Facility
UD_3	Uranium Deuteride
UN	United Nations
UNSCR	United Nations Security Council Resolution
UF_4	Uranium Tetrafluoride
UF_6	Uranium Hexafluoride
UO_2	Uranium Oxide
U-235	Uranium-235

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Introduction

In 2002, Iran's construction of covert nuclear sites at Natanz and Arak was revealed to the world. Iran's unwillingness to reveal the full scope of its secretive nuclear program has increased fears that Iran seeks a nuclear weapons capability.

In January 2021, the U.N.'s International Atomic Energy Agency (IAEA) confirmed that Iran resumed enriching uranium to 20 percent at its Fordow Fuel Enrichment Plant. Uranium enriched to this level has no civilian purposes. This technical capability is drastically more difficult to achieve than enriching 20 percent uranium to weapons-grade 90 percent, indicating Iran has the technical capability to produce weapons-grade uranium. This escalation surpassed the limits imposed by the JCPOA in 2015, which enabled Iran to enrich to 3.67 percent.

In April 2021, Iran began enriching uranium to 60 percent at Natanz. Then, in November 2022, it began enriching to 60 percent at Fordow. In February 2023, the U.N. reported that uranium particles enriched to 83.7 percent were found at Iran's Fordow nuclear site, just shy of weapons-grade.

Today, despite Iran's long history of intransigence and its continuing uncooperative stance regarding full disclosure, we know far more about its nuclear program and the numerous sites that comprise it. It is extensive, highly-developed, and advanced to the degree that a military nuclear capacity is within the realm of possibility. With significant deposits of uranium, research facilities, uranium conversion and enrichment plants, and advanced light and heavy nuclear reactors, Iran has all the ingredients for the complete nuclear cycle, including weaponization. This resource offers an overview of Iran's extensive nuclear infrastructure.

Uranium Mines

The nuclear fuel cycle begins with the extraction of uranium ore from mines. Saghand, Narigan, and Gachin are the locations of Iran's developed uranium mines.

Saghand Uranium Mine

Located northeast of the Yazd province in the central Iranian desert, Saghand is an open pit and deep mine reached by shafts over 1,000 feet deep. In November 2004, the IAEA forecasted that ore from this mine would be processed into uranium ore concentrate at an associated mill in Ardakan, beginning in 2006. However, Saghand did not become operational until 2013. Chinese and Russian technicians assisted in the design and construction of the mine.

Iran's largest uranium mine, Saghand, was assessed in 2009 to have 1,400 tons of total uranium reserves. Its estimated yearly output is 50 tons of uranium ore. The mine employs conventional underground mining techniques to exploit hard rock ore bodies, according to the IAEA. In April 2021, timelapse satellite imagery of the Saghand Uranium Mine showed significant excavation activities.

Narigan Mining and Industrial Complex

The Narigan Mining and Industrial Complex is the country's largest uranium-molybdenum mine in Yazd province. In 2006, Iran discovered additional significant uranium sources in the center of the country,

specifically at Narigan, as well as Charchooleh, and in the Khoshoomi region. Then Deputy Chief for Nuclear Research and Technology, Mohammad Ghannedi, heralded the news by announcing, "We have got good news: the discovery of economically viable deposits of uranium in central Iran." An additional 20 sites are reportedly under survey for potential uranium deposits.

According to the Atomic Energy Organization of Iran (AEOI), the Narigan mine became operational in February 2023. The mine contains 650 tons of uranium and 4,600 tons of molybdenum.

Gachin Uranium Mine

Located near Bandar Abbas, a port city on the Persian Gulf, the Gachin Uranium Mine has an estimated annual production capacity of 21 tons of uranium. This capacity corresponds to the 21 tons of uranium per year milling capacity of the nearby Bandar Abbas Uranium Production Plant. Gachin went into service as early as 2004 and was assessed in 2007 to contain 100 tons of uranium reserves.

Yellowcake Plants

The second step in the nuclear fuel cycle is milling. At this stage, the ore is pulverized into a fine powder and then mixed with chemicals that separate the uranium from other minerals, resulting in a substance of approximately 80 percent uranium oxide, known as yellowcake.

Ardakan Yellowcake Production Plant

The IAEA expected this facility to begin producing uranium oxide in 2006 from uranium mined at the nearby Saghand Uranium Mine. However, the facility did not become operational until 2013, around the same time Saghand became operational. Ardakan has an annual processing capacity of 50 to 70 tons, corresponding to Saghand's yearly output potential. The facility is named after Iranian scientist Darioush Rezaeinejad, who was assassinated in 2011.

Bandar Abbas Uranium Production Plant

This mill was first tested in July 2004, producing 40 to 50 kg of yellowcake from uranium ore mined at the nearby Gachin Uranium Mine. Its annual processing capacity of 21 tons of uranium corresponds to the annual production capacity of the Gachin Uranium Mine. According to some reports, the mill became operational in 2006 and was closed down in 2016.

Uranium Conversion Facilities

Uranium oxide ("yellowcake") is then transferred to a conversion plant where fluorine will be added to produce uranium hexafluoride gas (UF_6) in preparation for enrichment via gas centrifuges at Natanz and Fordow.

Isfahan Uranium Conversion Facility

The Uranium Conversion Facility (UCF) at the Isfahan Nuclear Technology Center has process lines to convert yellowcake into uranium oxide (UO_2) and uranium hexafluoride (UF_6). The line for converting yellowcake to uranium hexafluoride has an annual capacity of 200 tons. The IAEA noted in 2004 – the same year construction on the first UCF process line had been completed – that uranium hexafluoride

produced at the conversion facility would then be transferred to the uranium enrichment facility at Natanz for enrichment to 5 percent U-235.

In March 2022, the IAEA identified a discrepancy at the UCF in the quantity of nuclear material verified by the IAEA and that declared by Iran. Iran declared the dissolution of 302.7 kg of natural uranium from the Jaber Ibn Hayan Multipurpose Laboratory at the Tehran Nuclear Research Center. As of April 2023, Iran had not adequately explained the surplus nuclear material. According to some media reports, Iran may have added undeclared material from Lavisan-Shian. The discrepancy makes Iran non-compliant with Article 55 of the Safeguards Agreement, a key part of the Nuclear Non-Proliferation Treaty (NPT).

The UCF is a critical step toward producing highly-enriched uranium for nuclear weapons. Several anti-aircraft missile batteries are deployed in the area.

Varamin, aka "Tehran Plant"

Also identified as the "Tehran Plant" in documents seized from Iran by Israel in 2018, Varamin was a secret pilot uranium conversion site that Iran overhauled in 2004. The IAEA requested access to the site in January 2020 but did not receive permission from Iran until August 2020. In May 2022, the IAEA confirmed that Varamin was used for processing and milling uranium ore for conversion into uranium oxide ("yellowcake") and possibly uranium tetrafluoride (UF_4) and uranium hexafluoride (UF_6) between 1999 and 2003. In May 2023, the IAEA reported that Iran had not addressed outstanding safeguards issues pertaining to the transfer of nuclear material and/or contaminated equipment from Varamin to the Turquz Abad warehouse.

Enrichment Facilities

The uranium hexafluoride gas produced at a uranium conversion facility is then transferred to a uranium enrichment facility. Gas centrifuges separate the U-235 isotope from the U-238 isotope, thereby increasing the concentration of U-235. Lighter gas molecules containing U-235 tend to collect closer to the center of the centrifuge, while the heavier gas molecules containing U-238 are forced outward to the perimeter by centrifugal force.

Natanz Fuel Enrichment Complex

A previously clandestine underground uranium enrichment facility, whose existence Iran acknowledged in February 2003, the Natanz Fuel Enrichment Complex is the primary site of Iran's gas centrifuge program. The complex began construction in 2000 but was not disclosed to the IAEA until 2002, when a dissident group first identified it. The complex consists of the above-ground Pilot Fuel Enrichment Plant (PFEP) and the underground Fuel Enrichment Plant (FEP).

The PFEP is a centrifuge research and development facility that became operational in 2003. The facility has two cascades designated for producing low-enriched uranium (LEU) enriched up to 20 percent U-235. Between 2010 and 2015, the PFEP produced 202 kg of 19.75 percent enriched uranium from 1,631 kg of 3.5 percent low-enriched uranium.

In July 2020, a major explosion rocked the Natanz complex, damaging a centrifuge manufacturing warehouse. The cause of the explosion was never publicly revealed.

In April 2021, Iran began enriching to 60 percent at the PFEP, using a cascade of IR-6 centrifuges. President Hassan Rouhani announced the escalation after an explosion destroyed the internal power system supplying Natanz's underground centrifuges, an act which Iranian officials blamed on Israeli sabotage. U.S. and Israeli intelligence officials later confirmed Israel's role.

In November 2022, amid reports that Iran had escalated uranium enrichment to 60 percent purity at Fordow, the IAEA reported that Iran plans to install a second production building at Natanz capable of housing over 100 centrifuge cascades.

In May 2023, Iran's ongoing efforts to expand Natanz into the nearby Zagros mountain range were exposed. Some experts believe that the new facility will be deep enough in the earth to protect it against powerful U.S. weapons designed to destroy hardened targets.

Fordow Fuel Enrichment Plant

The Fordow Fuel Enrichment Plant (FFEP) is a repurposed IRGC tunnel complex located near the city of Qom. The main enrichment halls are buried deep within a mountain to protect the facility from military strikes. Construction on the site began between 2002 and 2004, but Iran did not disclose the existence of the Fordow facility to the IAEA until September 2009. The facility's size, secrecy, and proximity to an old IRGC base have led analysts to speculate that the facility is being used to produce weapons-grade uranium.

The IAEA confirmed in January 2021 that Iran had resumed 20 percent uranium enrichment at the Fordow Fuel Enrichment Plant. The IAEA reported that 4.1 percent U-235 was being further enriched to 20 percent in six centrifuge cascades. A stockpile of 20 percent uranium could potentially be transferred to a small, clandestine facility for further enrichment to 90 percent.

In November 2022, Iran began enriching at Fordow to 60 percent. While this was not the first time Iran enriched to 60 percent (they had already begun enriching to 60 percent at Natanz in April 2021), it was significant because it was the first time that this level of enrichment occurred at the underground Fordow facility. IAEA Director General Rafael Grossi confirmed that uranium hexafluoride was enriched to 60 percent in the existing two cascades of IR-6 centrifuges at the facility. As of February 12, 2023, Iran had already accumulated a stockpile of 87.5 kilograms (192 pounds) enriched up to 60 percent purity.

In February 2023, the IAEA reported that uranium particles enriched up to 83.7 percent were found at Iran's Fordow nuclear site. The U.N.'s report clarified that only particles were found, not a stockpile. Iran claimed that they were produced accidentally. The discovery of the 83.7 percent enriched particles followed inspectors' recognition that the IR-6 centrifuges at the facility had been configured differently than previously declared.

In May 2023, the IAEA accepted Iran's explanation of the particles containing 83.7 percent U-235. Iran claimed that the particles were an accidental byproduct of enrichment at lower levels, and the IAEA stated that their information was "not inconsistent with [this] explanation."

At least two of Iran's six operational IR-6 cascades, its most advanced, are located at Fordow. However, according to the IAEA, Iran has plans to install 14 more IR-6 cascades at Fordow, that will be capable of enriching to 20 percent.

Fuel Production Sites

Fuel production is the next step in the fuel cycle. Iran's fuel production sites, purportedly necessary for making fuel for Iran's nuclear reactors, have also been used to produce uranium metal, a critical component used in the core of a nuclear bomb.

Fuel Plate Fabrication Plant in Isfahan

In February 2021, according to the IAEA, Iran produced uranium metal at the Isfahan Nuclear Technology Center facility. The IAEA discovered 3.6 grams of natural uranium metal at the site.

In July 2021, Iran announced its plans to produce uranium metal enriched to 20 percent at the same facility. Iran claimed that the metal would be utilized for the Tehran Research Reactor, which is ostensibly designated for producing radioisotopes for medical purposes. The IAEA confirmed this announcement, stating that Iran had informed it that "uranium oxide (UO_2) enriched up to 20 percent U–235 . . . would be converted to uranium tetrafluoride (UF_4) and then to uranium metal enriched to 20 percent U–235" at the Fuel Plat Fabrication Plant (FPFP). This action aligns with a law passed in Iran's parliament in December 2020, which called for nuclear escalation.

Fuel Manufacturing Plant in Isfahan

The Fuel Manufacturing Plant is located at the Isfahan Nuclear Technology Center. In 2003, Iran submitted documentation to the IAEA stating that the facility's purpose was to process 30 tons of uranium oxide from Iran's Uranium Conversion Facility into fuel for power and research reactors annually. The operational facility started producing fuel rods as early as 2009, and during that time, the IAEA reported the presence of a process line for manufacturing fuel specifically for the Arak heavy water reactor.

Uranium Metal Production

Iran also possesses two uranium metal production facilities, which are necessary for developing the core of a nuclear weapon. Iran denied its work on metallurgy to the IAEA in 2015, saying that "it had not conducted metallurgical work specifically designed for nuclear devices." Israel's seizure of the "Nuclear Archive" documents in 2018 exposed these claims as lies.

Shahid Mahallati Uranium Metals Workshop

Located near Tehran, the Shahid Mahallati facility was first revealed through documents seized by Israel in early 2018. According to the Institute for Science and International Security (ISIS), the facility was established as part of the "Amad Plan" prior to 2003, with the objective of researching and developing

uranium metallurgy for nuclear weapons. The undisclosed pilot facility was intended to provide Tehran with this capability by the time weapons-grade uranium became available. It was intended to be phased out once construction of the Shahid Boroujerdi facility at Parchin, designed for the same purpose on a larger scale, was completed.

It is unclear whether the pilot facility was closed down or repurposed in 2003, when the Amad Plan was supposedly terminated. Satellite imagery analyzed by ISIS revealed that the facility was dismantled between 2010 and 2011.

Shahid Boroujerdi at Parchin

In 2019, ISIS conducted an analysis of over 40 documents obtained from Israel concerning Shahid Boroujerdi, an underground tunnel complex located at the Parchin Military Complex. Israeli security officials informed ISIS that they were unaware of this site's connection to the "Amad Plan" until the "Nuclear Archive" documents were seized in 2018. The facility was originally planned to be completed in 2003 but experienced delays. Satellite imagery indicates that Shahid Boroujerdi was operational as recently as September 2018. While it is possible that the facility was repurposed after the purported discontinuation of the Amad Plan in 2003, the specific activities carried out there remain undisclosed to the public. International inspectors have never been granted access to the site.

Light Water Reactors

The Bushehr Nuclear Power Plant is Iran's only currently operational civil nuclear power reactor. It operates by heating water to produce steam, which in turn drives turbines to generate electricity.

Bushehr Nuclear Power Plant

The Bushehr Power Plant is a 1000-megawatt electric pressurized water reactor located near the town of Bushehr in southeastern Iran. The plant was established in the mid to late 1970s under a contract with the German company Siemens. Due to diplomatic pressure from the U.S., Siemens declined to continue construction after the Iran-Iraq War (1980-1988) amid concerns of potential extraction of weapons-grade plutonium from the reactor's spent fuel. The contract was awarded to Russia's Rosatom Corporation, which took over construction in the 1990s. In 2005, Russia and Iran signed an agreement under which Russia would supply fuel for the reactor and handle the disposal of spent fuel to address international concerns. The plant commenced operations in August 2010.

The Bushehr reactor has raised safety concerns due to its unique hybrid design, which involves using Russian and older German equipment, some of which have failed since the plant began operations. Additionally, the plant's proximity to a major fault line in a region prone to earthquakes adds to the concerns.

Darkhovin Nuclear Reactor

Also known as Ahvaz, Esteghlal, and Karun, the Darkhovin Nuclear Reactor is a planned nuclear power plant located on the Karun River south of Ahvaz. While plans for the Darkhovin reactor have existed since 1979, the project was abandoned following the Iranian Revolution. In 1992, Iran sought a contract with China to revive the project, but it was later suspended. However, in 2008, Iran announced that it

had entered the "design stage" of constructing a 360 MW power reactor at the site. In 2013, the IAEA requested design information on the proposed plant, but it was not provided.

According to Iranian authorities, the Darkhovin plant was initially planned to become operational in 2016. However, in December 2022, the facility's construction was just getting underway. The 300-megawatt plant is expected to be completed by 2031, with an estimated cost of $2 billion.

Heavy Water Complexes

The heavy water reactor transmutes uranium into plutonium-239, raising red flags in Western capitals because plutonium can be used to produce nuclear weapons.

Arak IR-40 Heavy Water Reactor

Construction of the IR-40 reactor in Arak commenced in 2004. In 2013, Iran installed the main components of the IR-40 reactor, which included the moderator storage tanks and the pressurizer for the reactor cooling system. Heavy water reactors like the IR-40 raise significant proliferation concerns due to their suitability for the production of high-quality, weapons-grade plutonium. Analysts estimate that the IR-40 will have the capability to produce approximately 9 kilograms of plutonium per year.

In May 2023, Iran informed the IAEA that the IR-40 reactor, now renamed the Khondab Heavy Water Research Reactor (KHRR), would begin operations in 2024. The IAEA assessed that the IR-40's design remained consistent with the design set out in Annex I of the JCPOA.

Khondab Heavy Water Production Plant

The Heavy Water Production Plant (HWPP) located at Khondab is responsible for supplying heavy water to the IR-40 reactor, which is currently under construction in Arak. The HWPP became operational in November 2004 and has the capacity to produce up to 16 metric tons of heavy water annually. Although the plant temporarily suspended operations following an IAEA report in 2009, satellite imagery confirms that the plant has continued to operate.

Iran removed the Flow-Rate Unattended Monitoring (FLUM) equipment from HWPP in June 2022. Consequently, the IAEA no longer has monitoring capabilities at the site. However, the agency has verified through satellite imagery that the plant has remained operational even after the removal of the monitoring equipment.

Research Centers

Tehran Nuclear Research Center

The Tehran Nuclear Research Center (TNRC) is Iran's primary nuclear research facility, located at the University of Tehran and overseen by the AEOI (Atomic Energy Organization of Iran). According to the Nuclear Threat Initiative, the TNRC encompasses several research facilities, including the Jabr Ibn Hayan Multipurpose Laboratories, Molybdenum, Iodine, and Xenon Radioisotope Production Facility, and Radiochemistry Laboratories. Additionally, the TNRC houses the Tehran Research Reactor, which is Iran's largest research reactor primarily used for producing medical isotopes. It is worth noting that the TNRC is also involved in various research and development activities such as plutonium reprocessing and laser

enrichment research, which are believed to have military applications and potentially linked to Iran's secret nuclear weapons program.

Isfahan Nuclear Technology Center

The Isfahan Nuclear Technology Center is a complex that includes three small Chinese-supplied research reactors, a uranium conversion facility, a fuel production plant, a zirconium cladding plant, and other facilities and laboratories, as identified by the Nuclear Threat Initiative. Iran Watch specified that there is an enriched uranium powder plant for converting UF_6 into uranium oxide, a fuel manufacturing plant for the Arak heavy water reactor, a fuel plate fabrication plant for the Tehran Research Reactor, a heavy water zero power reactor, and a light water sub-critical reactor. Additionally, the Isfahan site is reported to house Iran's largest missile production facility, and there have been allegations suggesting that it serves as the primary location for Iran's chemical weapons facilities.

Bonab Atomic Energy Research Center

The Bonab Atomic Energy Research Center (BRC) has been operational since 1995 and is primarily focused on conducting research related to nuclear technology for agricultural applications. It is located south of Tabriz and is considered one of the key research facilities associated with the AEOI (Atomic Energy Organization of Iran). In May 2011, the European Union listed the BRC as an entity linked to Iran's development of nuclear weapon delivery systems.

Gorgan al-Kabir Research Center

The first reports of a secret nuclear research facility at Gorgan surfaced in the early 1990s. According to one report, scientists from Iran, Ukraine, Russia, and Kazakhstan worked at the Gorgan al-Kabir Center to develop nuclear weapons. Also known as Neka, the secret Gorgan facility is believed to be one of Iran's largest nuclear research facilities. Sources have alleged that AEOI Deputy Chairman Mansour Haj Azim supervises the site, while two Russian scientists lead research efforts there.

Parchin Military Complex

Consisting of numerous buildings and test sites, the Parchin Complex serves multiple purposes, including research, development, and production of missiles and ammunition. However, it is believed that under the guise of conventional weapons testing, Parchin also conducts clandestine nuclear weapons research. Iranian officials have consistently denied access to the site for IAEA (International Atomic Energy Agency) inspectors.

ISIS has identified a total of three explosives test sites at Parchin suspected to have been part of Iran's plans to develop a nuclear weapon. Those facilities are Taleghan 1, Talegahn 2, and Golab Dareh.

A U.S. official alleged in 2004 that Iran may be testing "high-explosive shaped charges with an inert core of depleted uranium" at Parchin to see how a bomb with fissile material works. In 2013, ISIS confirmed IAEA allegations that Iran had begun "leveling and compacting of material over most of the [Parchin] site, a significant proportion of which it has also asphalted," probably in an effort to cover up its activities there prior to an IAEA limited inspection of the site.

In 2015, the IAEA discovered uranium particles at the Parchin Complex, refuting Iranian claims that the facility was used exclusively for testing and developing conventional weaponry. The IAEA mentioned the finding briefly in its December 2015 report, months after the JCPOA was signed. Six months later, U.S. officials said that they assumed the uranium indicated nuclear weapons development at the facility.

In 2018, an archive of nuclear weapons-related documents seized by Israel from Iran provided detailed information on Taleghan 1 and Taleghan 2. Both facilities were extensively modified in 2012.

Taleghan 1, the main high explosive test chamber at Parchin, was used in May 2003 to test a specialized neutron initiator for starting the chain reaction of a nuclear explosion. The only visual evidence of Taleghan 1 before the Israeli raid was a schematic published in the Associated Press in 2012. Taleghan 2 is another high explosive chamber equipped with a flash x-ray system to examine small-scale high explosive tests. Before the Israeli raid, Taleghan 2 was unknown to the public. To date, the IAEA has not inspected the site.

Several unexplained explosions have occurred at Parchin, including in 2007, 2014, and 2020. In 2022, Iran's Ministry of Defense confirmed that another "accident" at the Parchin military complex killed one person and injured another. Details of the accident have not been released to the public, but some observers suspect it was sabotage.

In September 2022, ISIS published a technical analysis showing the location and satellite imagery of another secret explosive test site in the Parchin Complex. Known as Golab Dareh, the test site has been on the radar of officials familiar with the seized nuclear documents, but its exact location was unknown prior to the ISIS report. Golab Dareh is believed to be one of the sites where Iran tested nuclear weapons components and developed high-speed diagnostic equipment as part of the Amad Plan, Iran's nuclear weapons program.

Lavizan-Shian Technological Research Center

Located northeast of Tehran in Lavizan-Shian, this research center was the focus of an IAEA safeguards probe starting in 2004, when inspectors first visited the site. In the 1990s, Lavizan-Shian was a Physics Research Center at the heart of Iran's nuclear weapons research. It was subsequently incorporated into the Amad Plan.

By May 2004, the facility had been extensively razed, effectively rendering the IAEA inspection in June 2004 useless. In a June 2020 report, the IAEA disclosed that Lavizan-Shian had been used to drill natural uranium metal discs for the production of metallic flakes and subject the flakes to chemical processing – activities which Iran had not declared to the IAEA as required by the Safeguards Agreement. ISIS indicated that the uranium metal chips, when subjected to deuterium gas under the right pressure and temperature, produce uranium deuteride (UD_3). According to ISIS's research, uranium deuteride is discussed extensively in the "Nuclear Archive" under the codename "Project 3.20," which was part of the Amad Plan.

In May 2022, the IAEA announced it was closing its probe into Lavizan-Shian, saying that due to verification and assessment, the "issue was no longer outstanding at this stage." ISIS suggested that the probe's closure was the result of Iran's "ongoing lack of cooperation."

Abadeh, aka "Marivan"

Located north of Abadeh, the Marivan site is a test site for conducting large-scale high explosive tests. The IAEA was first granted access to the facility in August 2020, though Iran had already destroyed parts of the facility in July 2019. The agency then discovered traces of enriched uranium. Iran reportedly claimed that the particles were from an old chemical lab. In May 2023, the IAEA accepted this explanation for the presence of depleted uranium participles, saying that it was a "possible explanation" and that there were no "outstanding issues," effectively closing the probe.

However, Iran has yet to adequately explain IAEA findings that in 2003, Iran was preparing to test nuclear material at the explosive testing area. The same IAEA report from May 2023 noted that Iran had not addressed or provided any evidence to support its claims concerning the use of "neutron detectors and the source of the neutrons . . . at the explosive test area at Marivan."

Sanjarian Testing Facility

According to documents seized from Iran by Israel in 2018, the Sanjarian site was used to conduct tests on nuclear weapons components. ISIS reported that the seized documents showed 136 tests at this site between September 2002 to April 2003. The IAEA has never inspected the site.

Centrifuge Manufacturing Sites

Iran Centrifuge Assembly Center at Natanz

The Iran Centrifuge Assembly Center (ICAC) at Natanz was designed to produce several thousand advanced centrifuges annually. However, a massive explosion hit the assembly site in July 2020, setting Iran's nuclear program back several months. Three-quarters of the above-ground assembly hall were reportedly destroyed in the explosion. As a result, the site's yearly production capacity dropped to several hundred centrifuges, so Iran inaugurated a new assembly location in Natanz in April 2021. The new site has reportedly failed to compensate for the damage.

Taba Karaj, aka TESA

Located west of Tehran in Karaj, TESA Karaj was used to produce parts for advanced centrifuges. The facility is now believed to be shuttered. Its previous yearly production capacity is not publicly known. The site was hit with an explosion in June 2021, months after Iran inaugurated a new centrifuge assembly center in Natanz. According to reports, the explosion was caused by a drone strike. Iran claimed to have foiled the attack and then called the attack an act of sabotage by Israel.

In January 2022, Iran moved the centrifuge parts production from Karaj to a new location in Isfahan, possibly inside or near the Isfahan Nuclear Technology Center. It told the IAEA that it would begin producing centrifuge rotor tubes and bellows there. Tehran said the relocation was due to a "terrorist attack" on the Karaj facility. The relocation came one month after Iran agreed to allow IAEA to reinstall monitoring cameras in the Karaj workshop. Reports in April 2022 indicated that some machines were

also moved to Natanz, though it was unclear where at the sprawling complex. The report noted that the IAEA revealed that a new centrifuge production workshop at Natanz had been moved underground. In February 2023, anti-aircraft batteries were activated in Karaj. Iran said it was a drill.

Laser Enrichment Plants

Lashkar Abad

Established in 2002, this pilot uranium laser enrichment facility never became fully operational due to international sanctions constraining Iran's ability to purchase key equipment, such as electron beam guns. Nevertheless, Iran admitted that it had conducted laser enrichment at the facility between 2002 and 2003. The IAEA, initially denied access to the facility, later determined that Iran could produce small quantities of highly-enriched uranium using the facility's atomic vapor laser isotope separation (AVLIS) method.

Th facility's current operational status is unclear based on public reporting. ISIS reported in 2013 based on satellite imagery that the facility appeared to be undergoing additional construction. ISIS indicated that Iran allowed one IAEA visit between 2006 and 2013. In 2008, the IAEA visited the site but was severely constrained in what they could learn and verify, given that it was not officially an inspection.

Storage Facilities

Turquz Abad Warehouse

In September 2018, Israel's Prime Minister Benjamin Netanyahu revealed the existence of this secret warehouse in Iran allegedly used to store "massive amounts of equipment and material from Iran's secret nuclear weapons program." According to ISIS, Iran began emptying the warehouse of its contents after Israel seized thousands of documents on Iran's nuclear weapon program earlier that year. The public revelations of the warehouse, confirmed by satellite imagery, as well as the existence of radioactive materials at the site, have been denied by Iranian officials, who claimed that the site was for carpet-cleaning. Netanyahu said the warehouse had stored 15 kg (33 lbs.) of unspecified radioactive material that had since been removed.

The IAEA came under pressure to investigate and in February 2019 inspected the site and discovered low-enriched uranium with a detectable presence of U-236. In September 2021, the IAEA noted that containers stored at this location – some of which came from the Varamin conversion facility – enclosed "nuclear material and/or equipment heavily contaminated by nuclear material."

In its May 2023 report on the safeguards probe, the IAEA indicated that Iran failed to address "outstanding safeguards issues in relation to Turquz Abad and Varamin, including informing the Agency of the current location(s) of nuclear material and/or of contaminated equipment."

The Organization of Defensive Innovation and Research

The Organization of Defensive Innovation and Research (SPND) was established in 2011 by Mohsen Fakhrizadeh Mahabadi, a nuclear scientist who formerly headed Iran's pre-2004 nuclear weapons program, known as the "Amad Plan." After Iran purportedly discontinued the "Amad Plan" in late 2003, Fakhrizadeh led Iran's covert nuclear weapons program as the head of SPND until he was assassinated in

November 2020. SPND is the primary agency under Iran's Ministry of Defense and Armed Forces Logistics (MODAFL) dedicated to researching and developing nuclear weapons. According to the U.S. Department of State's sanctions notice from March 2019, "SPND has employed as many as 1,500 individuals – including numerous researchers associated with the "Amad Plan" – who continue to carry out dual-use research and development activities . . . potentially useful for nuclear weapons and nuclear weapons delivery systems."

In a coordinated action in March 2019, the U.S. Departments of State and the Treasury designated 31 Iranian entities and individuals for their connection to SPND, pursuant to Executive Order (E.O.) 13382, which targets proliferators of weapons of mass destruction (WMD) and WMD delivery systems and their supporters. These sanctions were built on the U.S. Department of State's designation of SPND in 2014, pursuant to E.O. 13382. In its press release, the U.S. Department of State indicated that its findings on the then-ongoing leadership of Fakhrizadeh, his oversight of proliferation-sensitive research and development at SPND, the discovery and seizure of a secret nuclear archive by Israel in 2018, and the SPND's procurement of foreign dual-use items underscored the flaws of the 2015 Joint Comprehensive Plan of Action (JCPOA).

Policy Recommendations

In October 2003, Iran's Supreme Leader Khamenei allegedly issued a *fatwa*, or religious edict, prohibiting the development of a nuclear weapon. The JCPOA also memorializes Tehran's supposed commitment never to pursue a nuclear weapon. However, by accumulating a stockpile of uranium enriched to 20 and later to 60 percent, Iran has effectively become a nuclear threshold state. It is now capable of producing enough enriched uranium for a nuclear weapon in a matter of weeks. The following recommendations could be adopted in response to this threat:

1. Iran's efforts to harden its facilities diminish Israel's capability to strike Iran's nuclear program. To ensure this capability is maintained, the U.S. should transfer its 30,000-pound Massive Ordnance Penetrator, designed for destroying hardened targets, to Israel and also lease Israel the aircraft necessary to effectively deliver it on target.

2. The U.S., Israel, and other regional partners should conduct regular, coordinated military drills, simulating air strikes on hardened targets, to signal to Iran that it is ready to use military force. The exercises should feature U.S. aerial refueling of Israeli jets, which is necessary for a distant air-to-ground attack. The U.S. should convey to Tehran that it is prepared to support Israel's strike capability.

3. Alongside its European allies, namely Britain, France, and Germany (the "E3"), the U.S. should work toward passing a resolution to formally censure Iran at the IAEA, aiming for the censure to be elevated to the U.N. Security Council. In March 2023, after the IAEA revealed its discovery of uranium particles enriched to 83.7 percent, the U.S. reportedly sought to prevent a formal censure at the IAEA's board of governor's meeting, which the E3 favored.

4. The Biden administration should be more forceful publicly in speaking about the military option. It is referenced almost in passing in the statements of senior U.S. officials, and Tehran picks up

on the hesitancy. The president should publicly warn the Islamic Republic that the military option is on the table.

5. The U.S. should persuade its E3 allies to invoke the snapback sanctions mechanism under U.N. Security Council Resolution 2231. This would restore the pre-JCPOA U.N. arms restrictions architecture, which is rapidly expiring. That should be combined with a multilateral sanctions campaign, aggressive enforcement, diplomatic isolation, and the development of a credible military threat, which the steps above outline.