Deciphering Iran's Latest Nuclear Messaging

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Brief Analysis

Tehran will continue maneuvering to secure a favorable new nuclear deal with the Biden administration, likely using a combination of bluffs and escalation.

In explaining its intention to reverse the Trump administration's 2018 withdrawal from the Joint Comprehensive Plan of Action (JCPOA), the incoming Biden team has focused on constraining various technical aspects of Iran's nuclear program, particularly the number and type of high-speed centrifuges it uses to separate the crucial U-235 isotope from natural uranium. In response, Tehran has announced or threatened new nuclear steps in an apparent bid to improve its bargaining position, from resuming "20% enrichment" at its Fordow plant to expelling UN inspectors if sanctions are not lifted.

This could be a dangerous diplomatic game, however. If Iranian officials feel compelled to depict the program as being more formidable than it really is, they risk inviting international intervention, perhaps military action. Alternatively, greater foreign scrutiny could wind up revealing key technical limitations, potentially harming the program's value to the regime's deterrent efforts abroad and political legitimacy at home.

To avoid prematurely showing its hand or folding altogether, Iran often cloaks its nuclear pronouncements in terms that are difficult to comprehend without a scientific background. Thus, it is important to review the key nuclear issues currently under debate by recasting them in layperson's language.

Centrifuges

Similar to a top-loading washing machine on spin cycle, a centrifuge is intended to separate a gaseous form of uranium into two substances: the dominant U-238 isotope and the rarer but more important isotope U-235. Success depends on the centrifuge being well-balanced and made of a very strong material that does not distort under the stress of acceleration to high speeds.

A centrifuge's efficiency—its ability to separate U-235—is proportional to its height and spin speed. The taller and faster a centrifuge is, the quicker and better its accumulation of U-235. At low levels of enrichment, U-235 can be used as reactor fuel, but when highly enriched, it can form the explosive core of an atomic bomb.

Iran acquired this enrichment technology from Pakistan, which developed the P1 and P2 centrifuge models from European designs. In Iran, the P1 is known as the IR-1. An Iranian adaptation of the P2, known as the IR-2m, was developed as well and should have been converted to nonnuclear purposes under the JCPOA. Tehran is now claiming that it will bring the IR-2m back into nuclear service, but few if any of these machines are believed to be workable due to lack of use, and the plant used to assemble them was severely damaged by an explosion in July 2020. Moreover, while the IR-2m and the related IR-4 and IR-6 are often called "advanced," their technology dates back to the 1970s.

Enrichment

For every 1,000 atoms of natural uranium, only seven are U-235, so natural uranium is said to be 0.7% enriched. When the level of enrichment (sometimes described in the media as "purification") is 3.67%—the agreed maximum in the JCPOA—the ratio of atoms has changed from 993:7 to 183:7. This shift in ratios shows that despite the seemingly small jump in percentages, most of the work of separation has been done once 3.67% is reached.

The ratio for 20% enrichment is even starker at 28:7—hence the concern about Iran's recent decision to enrich to this level. Theoretically, uranium enriched to 20% could be used to cause a nuclear explosion, though 90% (1:7) is the usual design requirement for a nuclear weapon.

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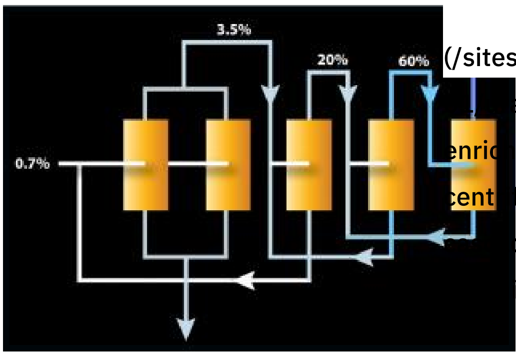
Cascades

Another key to uranium enrichment is the arrangement of piping that allows uranium hexafluoride (UF6) gas to travel through the centrifuges again and again, each time shedding U-238 atoms. Adapting a design obtained from Pakistan, the Iranian enrichment process takes place in stages: from 0.7% to 3.5%, then 3.5% to 20%. If Iran wanted to obtain bomb-grade material, it would need two extra stages: 20% to 60%, and 60% to 90%. On paper, reaching that target would require 38 cascades containing a total of 5,832 centrifuges—about the same number Iran was limited to under the JCPOA. In practice, however, IR-1 centrifuges cannot be used to complete such a cascade arrangement due to UF6 stability problems that prevent them from enriching to the highest levels.



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This diagram shows how UF6 gas passes through four processes during enrichment: (1) through two groups of 12 cascades of centrifuges, each having 164 machines, taking the enrichment level to 3.5%; (2) through 8 cascades with 164 machines each to increase the level from 3.5% to 20%; (3) through 4 cascades of 114 machines each to increase from 20% to 60%; (4) through 2 cascades of 64 machines each to increase from 60% to 90%. At each stage, gas depleted of U-235 is passed back to the previous stage or out of the system completely, with the process becoming relatively easier each time.

Enrichment is usually a slow process. Pakistan's nuclear program got a big head start in 1981 when China gifted it with two bombs' worth of 93% high-enriched uranium (HEU) and weapon design plans. By the late 1990s, Pakistan's two enrichment plants at Kahuta—each equipped with 5,500 P2 centrifuges—were producing enough HEU for one nuclear device every two months.

Breakout Time

This term describes the amount of time needed to acquire enough HEU for one nuclear weapon. Although Iran began acquiring centrifuges in the 1990s, debate persists over whether it ever completed work on a weapon design, with some suggesting that it is still at least two years away from developing such expertise or a test device. For comparison's sake, Pakistan carried out a successful "cold test" (i.e., using nonnuclear material) of its first constructed weapon in October 1984, three years after receiving design plans from China.

Calculating the time to accumulate the amount of 90% HEU needed for one weapon (known as a "significant quantity") is relatively easy when one has information about the efficiency of a program's centrifuges. The productivity of a centrifuge is measured in separative work units (SWU, pronounced "swoo"), or the amount of U-235 that a single centrifuge can yield in one year, measured in kilograms.

According to Pakistani nuclear scientist A. Q. Khan, a P1 or IR-1 type is capable of 3 SWU—though as already mentioned, the IR-1 cannot be used for higher levels of enrichment. Khan has also claimed that a P2 can reach nearly 8 SWU. To produce a "critical mass' of U-235—that is, the amount needed for a single weapon, around 15 kg—a program would need to reach an output of 3,500 SWU, or about four months of spinning in a centrifuge plant with at least 5,000 machines capable of high enrichment. This time could be reduced if low-enriched material is used as feedstock.

The IAEA'S Role

As with other member states, inspectors from the International Atomic Energy Agency monitor Iran to make sure it is adhering to its obligations under the Nonproliferation Treaty (NPT), as well as the JCPOA in Tehran's case. They do so using fixed cameras and in-person visits to acknowledged facilities. If Iran were to stop these visits or restrict them for a substantial length of time, it would prompt a crisis with the United States, Europe, Israel, and Washington's Arab allies. On January 11, IAEA director-general Rafael Grossi ambiguously stated that there were only weeks left to revive diplomacy with Iran. Two days later, the agency revealed that Iran was developing the capability to produce uranium metal, a skill needed for a variety of purposes, including construction of a nuclear bomb core.

Even without the IAEA, Washington would not necessarily be blind to what is happening. Intelligence surveillance of Iran's nuclear program and decisionmaking is almost certainly extensive. And despite placing its centrifuge plants in well-defended facilities at Natanz and inside Fordow mountain, the nuclear program is still vulnerable to military attack.

To be sure, Iran may have established other enrichment plants, perhaps hidden in plain sight. In the 1980s, Pakistan built a 2,000-centrifuge facility in a nondescript warehouse located at a large munitions plant outside Islamabad, as well as a smaller tunnel facility in the hills around Kahuta. (Pakistan is not a signatory to the NPT, so its enrichment facilities have never been inspected.)

Whatever the current status of Iran's facilities, the nuclear issue is likely to be the Biden administration's first foreign policy test. Ultimately, the United States holds the best hand, but Iran may still be able to play the game quite well even with a weak hand.

Simon Henderson is the Baker Fellow and director of the Bernstein Program on Gulf and Energy Policy at The Washington Institute. For more on the technical issues discussed in this article, see his joint report with Olli Heinonen, Nuclear Iran: A Glossary **(https://www.washingtoninstitute.org/policy-analysis/view/nuclear-iran-a-glossary-of-terms)** . ❖

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