Technical Implications of Trump’s JCPOA Announcement

by **Simon Henderson (/experts/simon-henderson)**

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ABOUT THE AUTHORS

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Brief Analysis

Now that the nuclear deal is off, Iran’s next steps will be shaped at least in part by the technical capabilities of its enrichment program and related efforts.

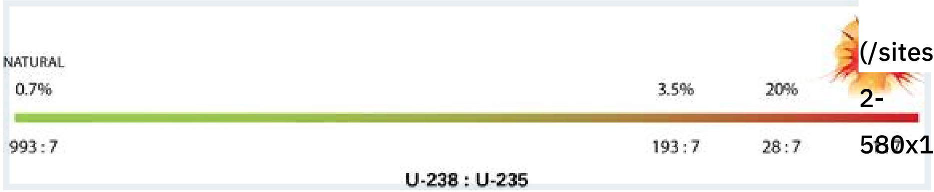
Amid President Trump’s announced withdrawal from the Joint Comprehensive Plan of Action, Iran has threatened to expand its nuclear program beyond the restraints mandated in that agreement. Assessing the potential significance of this threat requires a closer look at the technical details behind the JCPOA and the regime’s current nuclear capabilities.

URANIUM ENRICHMENT

The main focus of concern is Iran’s ability to enrich uranium. Natural uranium, known as U-238, contains only 0.7% of the fissile isotope U-235. Fissile means capable of a chain reaction—in a civil power reactor, this reaction is controlled to generate electricity, while in an atomic bomb it is uncontrolled.

Some power reactors can use natural uranium, but most use low-enriched uranium containing around 3.5% U-235. To make an atomic bomb, one needs high-enriched uranium (HEU) containing around 90% U-235. Theoretically, it is possible to make a nuclear explosive device with 20% U-235, so this is the level that the International Atomic Energy Agency defines as “high-enriched.”

The enrichment process usually involves spinning gaseous uranium hexafluoride (UF6) in ultra-high-speed centrifuges, with the goal of changing the ratio of U-238 atoms to U-235 atoms. In natural uranium, this ratio is 993:7. When U-235 is around 90% of the mix, the ratio is 1:7. The intermediate stages of 3.5% and 20% have ratios of 193:7 and 28:7, respectively. In other words, even 3.5% represents a considerable level of enrichment, and by 20% most of the work of enrichment has been done—965 U-238 atoms have been removed, and only another 27 need to separated out in order to achieve weapons-grade material.



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CENTRIFUGES

A centrifuge's efficiency is measured in terms of its ability to do this separation work. The standard measure is known as a "separative work unit" (SWU).

The enrichment process involves hundreds of machines joined by piping in a "cascade," all of them spinning around the clock for months. The output of a centrifuge plant depends on the number and type of centrifuges used and the length of time they are spun.

Iran currently has two working centrifuge models, IR-1 and IR-2m, based on designs that Pakistan obtained illegally from a European civilian enrichment program in the 1970s and early 1980s. According to unclassified U.S. government information, Pakistan's P-1 centrifuge—the model for Iran's IR-1—has a rating of around 2 SWUs/year. The IR-2m is similar but not identical to Pakistan's P-2, which is rated at around 4 SWUs/year.

A centrifuge's length is part of what determines its efficiency (or height, since it is mounted vertically). Also crucial is the speed at which it can be spun. The main design challenge is to maximize the machine's length and speed while enabling it to withstand the forces that arise when a cascade is put into operation, including potentially destructive resonant frequencies.

When the nuclear agreement was reached in 2015, Iran was operating 19,138 IR-1 centrifuges and 1,008 IR-2m models. Under the JCPOA, it agreed to reduce the IR-1 tally to 6,104 and limit the level of enrichment to 3.67 percent. It also agreed to stop using IR-2m centrifuges for nuclear purposes.

WHAT IS NEEDED FOR AN ATOMIC BOMB?

A nuclear explosion is typically created by using specially shaped charges to squeeze fissile material (e.g., weapons-grade HEU) until a chain reaction occurs. **Information released by Israeli prime minister Binyamin Netanyahu last week (http://www.washingtoninstitute.org/policy-analysis/view/the-details-reveal-the-true-danger-of-irans-secret-nuclear-program)** confirmed that Iran had worked on implosion designs prior to the JCPOA, and that it initially intended to build five atomic bombs.

According to an unclassified U.S. estimate, a basic atomic weapon would need at least 25 kg/55 pounds of weapons-grade HEU (though more advanced designs are believed to require only 15 kg). Uranium is a very dense material, similar in weight to gold, so a 25 kg sphere of HEU would have a diameter of around 13.5 cm, the size of a grapefruit. If starting from natural uranium, one would need 5,000 kg of material to make a bomb. Yet if starting from 3.9 enriched material (to use an official U.S. figure), one would need only 1,750 kg.

Prior to the nuclear deal, Iran had 7,154 kg of 3.67% enriched uranium and 196 kg of 19.75% uranium. Under the JCPOA, these stockpiles were reduced to 300 kg and zero, respectively.

BREAKOUT TIME AND IRAN'S INTENTIONS

Breakout is defined as the time required to produce enough fissile material for one atomic bomb. Before the nuclear deal, Iran was estimated to be two to three months away; the JCPOA had the effect of extending this to one year. A rule of thumb provided by unclassified U.S. information is that 5,000 P-1 machines could produce that amount in around six months, while the same number of P-2s would take only four months.

As for making an actual bomb, Israel's recent seizure of Iran's atomic archive confirmed the historical extent of the regime's nuclear weapons program. Whether that program still exists—and, if so, how large and far along it may be—is unknown.

For now, Tehran has not stated **how it will respond (http://www.washingtoninstitute.org/policy-analysis/view/is-washington-too-focused-on-irans-nuclear-program)** to President Trump's announcement. Iranian officials previously threatened to increase the quantity and level of enrichment right away if the United States withdrew from the deal, yet limitations in their centrifuge technology could hinder any such plans, at least in the short term.

Since 2015, Iran's more efficient IR-2m centrifuges have been tasked with producing non-nuclear isotopes, so they may be too contaminated for uranium enrichment work. The older IR-1s are believed to be incapable of enriching to 90% because of criticality issues (i.e., the U-235 becomes unstable). Iran has also been working on more advanced designs (named IR-4, IR-5, IR-6, and IR-8) with claimed efficiency levels as high as 12 SWUs/year. Yet new designs typically take as long as ten years to develop into production units, and even then they may prove unworkable.

THE PLUTONIUM ROUTE

The plutonium isotope Pu-239 is another potential nuclear explosive, and in many ways a more practical one than U-235 because much less of it is needed for a weapon. This allows for a significantly smaller device that is more suitable for a ballistic missile warhead or a weapon carried by fighter aircraft.

Yet Iran's route to a plutonium bomb was cut off by the JCPOA, which put restrictions on its heavy-water research reactor. If Tehran has abided by these limits, the reactor modifications cannot be reversed.

OTHER POSSIBILITIES

Alternate routes to a bomb include a gift or sale of HEU from a nuclear state like North Korea. (China gave Pakistan such material and a weapon design in the early 1980s.) Weapons-grade HEU can also be detonated by a so-called gun-barrel design, which is simpler than an implosion design and so does not need to be tested in advance (though it cannot be used with plutonium). This design was employed in the bomb dropped on Hiroshima in 1945; the bomb dropped on Nagasaki a few days later was a plutonium implosion design previously tested in the New Mexico desert.

Simon Henderson is the Baker Fellow and director of the Gulf and Energy Policy Program at The Washington Institute. ❖

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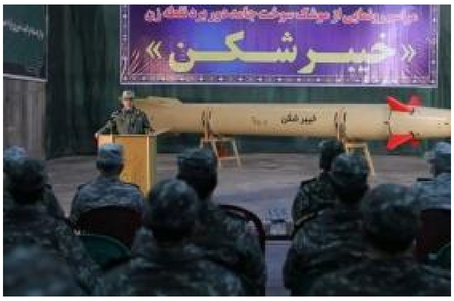

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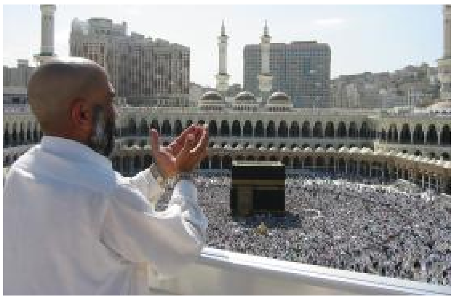

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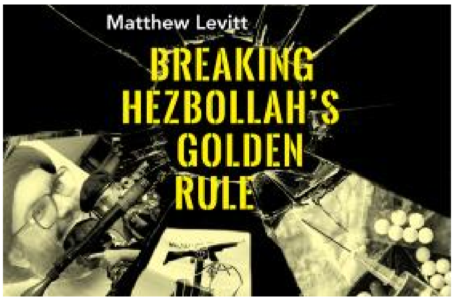

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