



The Plutonium Pathway: Arak Heavy Water Reactor and Reprocessing

Institute for Science and International Security

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We are releasing a series of reports containing our analysis of specific key issues in the Joint Comprehensive Plan of Action. We are neutral on whether the deal should be implemented. We are using our role as a technical nonproliferation organization to instead highlight strengths as well as potential problems and remediation steps.

The Joint Comprehensive Plan of Action (JCPOA) provides extensive provisions that collectively provide an adequate base for blocking the plutonium pathway to nuclear weapons in Iran for at least 15 years. The relevant provisions are described below.

Under the deal, the modernized Arak reactor will not produce weapon-grade plutonium. It will be redesigned and rebuilt at a lower power with the result that it will produce smaller quantities of plutonium of a lesser quality. China has reportedly agreed to take the lead in working with Iran to remake this reactor. This project is expected to take many years, certainly more than five.

In a potentially significant change from Iran's commitment in the April 2015 U.S. fact sheet describing the Lausanne Framework of parameters, Iran has committed not to reprocess spent fuel or separate plutonium for only 15 years. The commitment was stated to be indefinite in the April framework. This means that after year 15 Iran could separate plutonium from irradiated fuel or perhaps targets, providing another way to rapidly build nuclear weapons. If it reprocessed the irradiated reactor fuel expected to be discharged from the Arak reactor, it would not be weapon-grade. Nonetheless, this lower quality plutonium could be used in crude nuclear explosives. Moreover, Iran may be able to modify the reactor's operations to produce a small amount of weapon-grade plutonium in targets. It could also plan to reprocess spent fuel from other reactors built in the future.

However, this weakened limit on reprocessing is in contrast to the provisions that Iran will or intends to send all its spent fuel abroad. In particular, the JCPOA states: "All spent fuel from Arak will be shipped out of Iran for the lifetime of the reactor." Moreover, it states: "Iran intends to ship out all spent fuel for all future and present power and research nuclear reactors, for further treatment or disposition as provided for in relevant contracts to be duly concluded with the recipient party." It is worth noting that the use of the word "intends" may signify a loophole in this provision with regards to both current and future reactors.

The JCPOA also seeks to block Iran's ability to buy separated plutonium and other nuclear explosive materials from abroad, such as from other sanctioned states like North Korea. According to the agreement: "Iran will not produce, seek, or acquire separated plutonium, highly enriched uranium (defined as 20% or greater uranium-235), or uranium-233, or neptunium-237 (except for use as laboratory standards or in instruments using neptunium-237) for 15 years." This condition is important in fully blocking Iran's plutonium pathway to nuclear weapons. However, this condition on buying or making separated plutonium only applies for 15 years.

In addition, this provision includes another condition not present in the Lausanne fact sheets, namely a commitment not to make highly enriched uranium (HEU) for 15 years. This provision importantly blocks Iran's purchase of HEU and supplements an Iranian commitment from the April framework not to enrich over 3.67 percent that also exists in the JCPOA. But the addition of this new negative formulation about the production of HEU, like the negative formulation about not reprocessing, raises questions about whether Iran intends to make not only near 20 percent enriched uranium again after year 15, something it stated it in the negotiations, but also highly enriched uranium. Both would be highly destabilizing developments.

These are many strengths in the agreement but also obvious shortcomings that need to be remediated. There is unlikely to be any economic reason for Iran to produce uranium enriched over 5 percent or to separate plutonium. Given the inherent risk to international security and the dangerous norm created by these time-bound provisions, actions are needed to remediate these provisions.

The United States should state that Iran reprocessing spent fuel, producing, seeking, or acquiring separated plutonium, HEU, or other nuclear explosive materials, or producing enriched uranium over 5 percent in the isotope uranium 235 would be seen as violating the intent of this agreement whenever it were to occur. Such acts would be viewed as inconsistent with the fundamental purpose of this agreement, which is to ensure that Iran does not build nuclear weapons.

Highlights of the Agreement with commentary in italics:

- **Design:** agreed upon and attached to the deal:
 - Fuel: up to 3.67% enriched uranium in the form of UO₂;
 - Full core load mass: ~350 kg of UO₂;
 - Fuel design: to be reviewed and approved by the Joint Commission;
 - First fuel core load: fabricated by the international partnership with Iran (fabricated outside of Iran);
 - Future core loads: the international partnership will cooperate with Iran, also providing technical assistance, to fabricate, test, and license, fuel fabrication capabilities in Iran. Destructive and non-destructive testing of this fuel including Post-Irradiation-Examination (PIE) will take place in one of the participating countries outside of Iran and that country will work with Iran to license the subsequent fuel fabricated in Iran for the use in the redesigned reactor under IAEA monitoring.
 - The parameters in this conceptual design are subject to possible and necessary adjustments in developing the final design. They, however, need to preserve the purposes and principles of modernization:
 - Purpose: to support peaceful nuclear research and radioisotope production for medical and industrial purposes.
 - Principles of modernization: minimize the production of plutonium and not produce weapons-grade plutonium in normal operation. Power must not exceed 20MWth.
- **Calandria:** removed. However, Iran is allowed to retain it. It will be rendered inoperable by filling openings with concrete. *In the U.S. factsheet of the Lausanne Framework, the original core, or calandria, was to be removed from the country or destroyed, ensuring that the reactor's conversion is not reversible.*
- **(Arak) Working Group:** composed of P5+1 participants established to facilitate the redesign and rebuilding of the reactor. Other countries can be added.
- **International Partnership:** composed of Iran + Working Group will implement the Arak modernization project. They will have to conclude an official document before implementation

day expressing their commitment to the project. Subsequently, contract can be concluded. Then they will cooperate to develop the final design and of the subsidiary labs and review conformity with international safety standards.

- **Final design:** to be submitted to the Joint Commission. It will review and endorse within 3 months. If not, Iran can raise the issue through the dispute resolution mechanism.
- **IAEA:** will monitor construction and report to the Working Group to make sure the construction is consistent with approved final design. Iran will submit the DIQ of the redesigned reactor to the IAEA which will include information on the planned radio-isotope production and reactor operation program. The reactor will be operated under IAEA monitoring.
- **Iran is the project manager,** the P5+1 simply support, via the purchase or transfer of materials, equipment, instrumentation and control systems and technologies. This will all happen using the mechanism established in the agreement. They can also provide technical cooperation and financial assistance.
- **Old fuel:** Iran will not produce or test natural uranium pellets, fuel pins or fuel assemblies (that were for the originally designed Arak reactor). Iran will store under IAEA continuous monitoring all existing natural uranium pellets and IR-40 fuel assemblies until the modernized Arak reactor becomes operational, at which point these natural uranium pellets and IR-40 fuel assemblies will be converted to UNH, or exchanged with an equivalent quantity of natural uranium.
- **Old fuel production line:** Iran will make the necessary technical modifications to the natural uranium fuel production process line (intended to supply fuel for the IR-40) so that it can be used for the fabrication of the fuel reloads for the new reactor.
- **FMP:** Iran will operate the Fuel Manufacturing Plant only to produce fuel assemblies for light water reactors and reloads for the modernized Arak reactor.
- **Spent Fuel:** regardless of its origin, for the lifetime of the reactor, all spent will be shipped out of Iran to a location in P5+1 countries or third countries. Contract for the disposition and treatment are to be concluded. The spent fuel is to be transferred within one year from the unloading of the reactor or whenever deemed safe for transfer by the recipient country.
- **Timeline of the Operation of the Modernized Reactor:** The agreement is silent on the schedule of the reactor's construction, although the startup of the reactor would be expected to be years from now.

Heavy Water:

- All excess will be made available for export for 15 years.
 - ❖ Excess: beyond Iran's needs for the modernized Arak research reactor, the Zero power heavy water reactor, quantities needed for medical research and production of deuterate solutions and chemical compounds including, where appropriate, contingency stocks.
- Iran's needs: estimated to be 130 metric tonnes of nuclear grade heavy water or its equivalent in different enrichments prior to commissioning of the modernized Arak research reactor, and 90 metric tonnes after the commissioning, including the amount contained in the reactor.
- Iran will inform the IAEA about the inventory and the production of the HWPP.
- Iran will allow the IAEA to monitor the quantities of the heavy water stocks and the amount of heavy water produced, including through IAEA visits, as requested, to the HWPP.

Other reactors allowed:

- But must be LWRs. *The U.S. Lausanne factsheet stated that Iran agreed not to build additional heavy water reactors for a defined period of time (15 years). This provision now appears stronger.*

- Spent fuel must be, or is intended to be, shipped out.

Reprocessing:

- For 15 years:
 - No spent fuel reprocessing or spent fuel R&D activities; no production of separated plutonium.
 - Exception: irradiated enriched uranium targets for production of radio-isotopes for medical and peaceful industrial purposes.
 - No Pu separation plants (other than for the exception above).
 - Only develop, acquire, build, or operate hot cells (containing a cell or interconnected cells), shielded cells or shielded glove boxes with dimensions less than 6 cubic meters in volume compatible with the specifications set out in Annex I of the Additional Protocol. These will be co-located with the modernized Arak research reactor, the Tehran Research Reactor, and radio-medicine production complexes, and only capable of the separation and processing of industrial or medical isotopes and non-destructive PIE. The needed equipment will be acquired through the procurement mechanism established by this JCPOA.
 - Iran will develop, acquire, build, or operate hot cells (containing a cell or interconnected cells), shielded cells or shielded glove boxes with dimensions beyond 6 cubic meters in volume and specifications set out in Annex I of the Additional Protocol, only after approval by the Joint Commission.
 - Except for the Arak research reactor complex, Iran will not develop, build, acquire or operate hot cells capable of performing PIE or seek to acquire equipment to build/develop such a capability.
 - Iran will undertake non-destructive post-irradiation examination (PIE) of fuel pins, fuel assembly prototypes and structural materials. These examinations will be exclusively at the Arak research reactor complex. However, the E3/EU+3 will make available their facilities to conduct destructive testing with Iranian specialists, as agreed. *This condition plugs a potential loophole whereby Iran could use destructive PIE examination, e.g. dissolving the spent fuel, to further its knowledge and experience of spent fuel reprocessing.*
 - No production or acquisition of plutonium or uranium metals or their alloys, or conducting R&D on plutonium or uranium (or their alloys) metallurgy, or casting, forming, or machining plutonium or uranium metal.
 - If Iran seeks to initiate R&D on uranium metal based TRR fuel in small agreed quantities after 10 years and before 15 years, Iran will present its plan to, and seek approval by, the Joint Commission.

Proliferation Constraint

- Iran will not produce, seek, or acquire separated plutonium, highly enriched uranium (defined as 20% or greater uranium-235), or uranium-233, or neptunium-237 (except for use as laboratory standards or in instruments using neptunium-237) for 15 years.