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Update on the Arak Reactor

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Despite the delays and problems in procuring essential equipment abroad and making fuel domestically, Iran is currently expected to finish the Arak reactor. However, additional delays in commissioning are expected. In any case, the reactor is widely viewed as unnecessary. Sufficient medical isotopes—Iran's stated justification for the reactor—can be produced in the Tehran Research Reactor or obtained via international commercial markets. Iran has also recently announced its siting of a second research reactor, which would also produce medical isotopes. More importantly, the Arak reactor's operation would open a second potential route to nuclear weapons for Iran, in this case via plutonium. The first route is its centrifuge program that could make highly enriched uranium. Operating the Arak reactor would heighten concerns that Iran aims to build nuclear weapons. Its operation would needlessly complicate negotiations and increase the risk of military strikes.

Iran has stated that its IR-40 heavy water reactor, located near the city of Arak, will begin operating in 2014. This reactor has been under construction since June 2004 and development work goes back at least another decade. The IR-40 reactor is designed to produce 40 megawatts thermal (MWth) of power and use natural uranium oxide fuel that Iran is producing at the Esfahan conversion and fuel fabrication facilities. Figure 1 is a recent commercial satellite image of the reactor complex. The reactor's dome is visible in the center of the image.

United Nations Security Council resolutions, the first of which dates to 2006, have called for Iran to halt construction of this reactor. The reactor poses a notable proliferation threat because it can produce significant amounts of weapons-grade plutonium – about 9-10 kilograms annually or enough for about two nuclear weapons each year. Before it could use any of this plutonium in a nuclear weapon, however, Iran would first have to separate it from the irradiated fuel. Iran has no declared plans to separate plutonium from the irradiated Arak fuel, although it has not agreed to forgo separating plutonium. If it decided to create a secret plutonium separation program, it would also need to divert the irradiated fuel, which would be detected relatively quickly by the International Atomic Energy Agency (IAEA). Nonetheless, suspicions remain that after the reactor operates, Iran will overtly or covertly build a plant to separate plutonium produced in this reactor.

Although the reactor still will require significant work before it operates, Iran reported to the IAEA during the last Design Inventory Verification (DIV) visit in May 2013 that pre-commissioning of the reactor using dummy fuel assemblies and light water will begin in the fourth quarter of 2013 and commissioning using real fuel assemblies and heavy water would begin in the first quarter of 2014, with the start-up planned for the third quarter of 2014.

As Iran moves closer to bringing the Arak reactor online, it is important to note that Iran has failed to provide the IAEA with updated design information about the reactor and its fuel since 2006. The information would be in the form of an updated Design Inventory Questionnaire (DIQ) on the IR-40 reactor. Although Iran started to allow DIV visits a few years ago, after having refused them, these visits are not sufficient for Iran to satisfy its safeguards obligations.[1] The IAEA notes in its May 2013 safeguards report on Iran that "this lack of up to date design information is having an increasingly adverse impact on the Agency's ability….to implement an effective safeguards approach."

The lack of updated information about the reactor also makes understanding its purpose difficult. This paper seeks to use available information to understand better Iran's expected progress in starting the IR-40 reactor, the reactor's fuel and core loading plans, and the likelihood or advisability of delaying the reactor's fueling and operation. Two central findings are that further delays in the reactor's operation seem likely based on the remaining work, and delays are desirable from the standpoint of improving prospects of a negotiated solution while avoiding military conflict.

Major Components

For several years, Iran has been steadily installing components at the Arak reactor. ISIS has monitored Iran's progress via satellite imagery; however, because Iran completed the external structure for the reactor, satellite imagery analysis is limited in its ability to assess Iran's progress on this facility. Knowledge of Iran's foreign procurements for this reactor continues to provide some information about the reactor's status, as do IAEA safeguards reports. Based on the past two quarterly International Atomic Energy Agency Reports, Iran continues to install key components at the facility, but it has not yet installed all of them. According to the May 2013 IAEA safeguards report, the IAEA observed during a DIV that the reactor vessel had been received at the site but not yet installed. It observed that "a number of other major components had yet to be installed, including the control room equipment, the refueling machine and reactor cooling pumps." In early June, Iran announced that it had installed the reactor vessel, releasing a photo of the vessel being lowered into the reactor shield (see figure 2). Despite this progress, questions continue to be raised over whether Iran can install all the required components and equipment in time to meet the announced start-up schedule.

Iran has depended extensively on foreign, illicit procurement for many of the parts of the reactor and questions persist about whether Iran has acquired all it needs. Of the remaining uninstalled major components, the cooling pumps appear the most critical. These pumps, which must be highly reliable for safe operation of the reactor, are in the primary reactor circuit and circulate heavy water that cools the reactor core. Whether Iran obtained these pumps overseas or is building them indigenously is unknown. Technical experts with extensive knowledge of Iran's reactor programs do not believe that Iran can make them, meaning that Iran would have to acquire them overseas. Thus, uncertainty

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[1] In 2009, the IAEA stated that Iran's refusal to provide updated design information and allow DIV visits are inconsistent with Iran's safeguards obligations. See Meeting of Board of Governors, March 2009, Statement by the Legal Adviser: http://www.armscontrolwonk.com/file_download/162/Legal_Adviser_Iran.pdf Iran has consistently refused to provide updated design information and had refused to allow the IAEA to undertake design information verification (DIV) visits of the Arak reactor and adjacent buildings on October 26, 2008 and again in April of 2009. See Director General, *Implementation of the NPT Safeguards Agreement and relevant provisions of the Security Council Resolutions 1737, 1747, 1803, and 1835 in the Islamic Republic of Iran*, November 19, 2008: http://www.isis-online.org/publications/iran/iaea-iranreport-111908.pdf and Director General, *Implementation of the NPT Safeguards Agreement and relevant provisions of the Security Council Resolutions 1737, 1747, 1803, and 1835 in the Islamic Republic of Iran*, June 5, 2009: http://www.isisnucleariran.org/assets/pdf/IAEA_Iran_Report_5June2009.pdf

surrounds whether Iran has all the cooling pumps it needs and if they are of sufficient quality to ensure safe operation.

Making Fuel

Another unfinished task is making the first core load of fuel. As of the May 2013 IAEA safeguards report, Iran had not made any fuel assemblies for the reactor. The IAEA carried out a DIV at the Esfahan Fuel Manufacturing Plant (FMP), where Iran fabricates Arak fuel rods and assemblies, and confirmed that manufacture of fuel assemblies using nuclear material for the IR-40 reactor had not yet begun. Only dummy fuel assemblies had been produced as well as prototype natural uranium fuel rods and assemblies intended for testing (see below).

Iran has limited experience fabricating reactor fuel rods or assemblies, and it has no prior experience fabricating assemblies for a heavy water reactor. The fuel for Iran's only current commercial light water power reactor, the Bushehr reactor, was supplied by Russia. The fuel and assemblies for the Tehran Research Reactor (TRR) were supplied by the United States and Argentina over the course of its operation, and Iran has only recently begun working to indigenously produce fuel plates and their respective assemblies for the TRR. It started a fuel fabrication laboratory at Esfahan in 1985, but this laboratory could make fuel pellets and small rods on a small-scale only.[2] Fueling the IR-40 will require fuel rod and assembly production the scale of which Iran has not had to achieve in any of its nuclear facilities to date. Whether fuel fabrication presents a significant bottleneck for Iran's operation of the IR-40 reactor remains to be seen.

In March 2013, Iran informed the IAEA that it plans to produce 55 fuel assemblies for the reactor by August 2013. The reactor core is estimated to hold up to an estimated 187 fuel assemblies, if all channels in the core are used for fuel (see figure 2). Since some of the channels would hold control rods and perhaps instruments, fewer fuel assemblies would be in the core. Information about how many fewer fuel assemblies is unavailable. However, there are likely to be more than 55 fuel assemblies in the core. One would assume that the core would contain two to three times that number, or about 100-150 fuel assemblies, based on the simple fact that the vast majority of the channels in a reactor would be dedicated to fuel assemblies and a certain amount of fissile material, here uranium 235, is needed to achieve criticality and generate the desired amount of power.

Although fuel assemblies had not been made as of May 2013, Iran was making natural uranium pellets at the Fuel Manufacturing Plant, where afterwards the pellets are inserted into the fuel rods and then the rods joined together into fuel assemblies. According to the May 2013 safeguards report on Iran, the IAEA reported that Iran continued to produce fuel pellets using natural UO2 for the IR-40 reactor.

Iran produces natural uranium oxide (UO_2) for manufacture into fuel rods at the Uranium Conversion Facility (UCF) at Esfahan. This facility also produces natural uranium hexafluoride. Between February and May 2013, Iran began what were reported as "research and development activities" to the IAEA regarding natural UO_2 production, and the IAEA verified that Iran had produced 12.02 tonnes of natural uranium UO_2 (U mass), 6.73 tonnes of which had been transferred to the FMP, evidently for the production of pellets.

The annual production capacity of the FMP was stated in 2004 and 2005 to be slated at 40 tonnes of uranium oxide, 30 tonnes of uranium oxide for a 1,000 MWe nuclear power plant and 10 tonnes of

[2] IAEA Director General, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, GOV/2004/83, November 15, 2004.

uranium oxide for the Arak reactor.[3] The actual current capacity is unknown, but it appears more than sufficient for fueling the Arak reactor.

Nonetheless, Iran has clearly fallen behind in making fuel assemblies. It publicly announced in the spring of 2009 that it had mastered fuel fabrication for the Arak reactor at the FMP. Yet, only now does it finally appear ready to make the fuel assemblies, four years after this announcement. The reason for the multi-year delay is not known, but it could reflect problems in obtaining necessary equipment and mastering process steps.

The fuel assembly for the Arak reactor is relatively complicated for a first generation heavy water reactor, and its design reflects considerable foreign assistance.[4] When Iran announced it had mastered fuel fabrication for the reactor in 2009, former President Mahmoud Ahmadinejad also unveiled a fuel assembly. The fuel rod bundle is shown in photographs of President Ahmadinejad's visit to the FMP (see figures 3 and 4). It is visually similar to a Russian fuel bundle used in a modified Russian RBMK (Reaktor Bolshoy Molschnosti Kanalyiy) power reactor fuel design. RBMK reactors are the commercial descendants of Soviet-era large plutonium production reactors of the 1940s and 1950s, and were designed by the Russian research and design institute NIKIET.[5] Based on interviews with knowledgeable officials, NIKIET and a Russian company in Obninsk provided key technology for the Arak reactor. This assistance included modifying the design of a RBMK fuel rod bundle for use in the Arak heavy water reactor. As a result of U.S. pressure, this assistance for Arak stopped in the late 1990s.

Neither Iran nor the IAEA has provided the amount of natural uranium in each Arak fuel assembly. However, a rough estimate is based on an RBMK fuel assembly containing 114.7 kilograms of uranium.[6] The Arak fuel assembly is half as long as an RBMK assembly and thus contains an estimated one half of the uranium, or about 57 kilograms. Thus, 55 fuel assemblies would contain about 3,500 kilograms of uranium, and 150 would contain about 8,600 kilograms.

The unusualness of the fuel assembly has led to speculation about whether the reactor would use a simpler fuel assembly, possibly made from natural uranium metal. Such fuel is much easier to make than the declared fuel assemblies and would more easily facilitate weapon-grade plutonium production. Moreover, if this fuel is clad in aluminum, it can be relatively easily processed in a radiochemical plant to extract plutonium.

Iran did have plans to install facilities at Esfahan to make natural uranium metal. This plan is suggested by a statement made by Mohammad Saeidi, Vice President for Planning & International Affairs, Atomic Energy Organization of Iran, in a 2005 presentation to the World Nuclear Association

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[3] Mohammed Saeidi, *Nuclear Fuel Cycle Activities in Iran***,** World Nuclear Association, Annual Symposium 2005: http://www.world-nuclear.org/sym/coidx.htm. See also IAEA Director General, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, November 15, 2004, op. cit., par. 63.

[4] David Albright, Paul Brannan, and Robert Kelley, "Mysteries Deepen Over Status of Arak Reactor Project," ISIS Report, August 11, 2009; and "Update on the Arak Reactor in Iran," ISIS, August 25, 2009.

[5] The RBMK has an unusual fuel design. The basic building block is a *fuel pin*, a long thin pin of zirconium cladding holding the uranium dioxide fuel pellets. Eighteen pins are arranged to make a *fuel rod bundle*. Each fuel rod bundle is 3.5 meters long. The RBMK core is 7 meters high so 2 fuel bundles are joined together vertically to make a *fuel cell*, 7 meters long. The fuel cells are suspended from the top of the reactor core by a suspension system that is used to insert them and lift them out. The entire assembly of fuel rod bundles and suspension is a *fuel assembly* and contains 114.7 kilograms of uranium in the form or uranium oxide. In the case of the Arak reactor, only one fuel bundle is used to form an assembly. See "Mysteries Deepen Over Status of Arak Reactor Project," op. cit, and "Update on the Arak Reactor in Iran," op. cit.

[6] An RBMK fuel rod contains enriched uranium, but the assumption is made that an equal amount of natural uranium is used in each Arak fuel rod.

Symposium where he describes the characteristics of different parts of the Uranium Conversion Facility at Esfahan. He wrote:[7]

> **Unit 101B – Conversion of AUC to UF_4** The section 101B is a production building, supplying intermediate product-UF_4 with an annual output of 285.8 tonnes for both UF_6 production (with a yield of 200 tonnes uranium as UF_6 per year) and natural U-metal production line (with a yield of 10 tonnes uranium annually).

The 10 tonnes annual capacity is similar to the capacity of the FMP dedicated to making uranium oxide fuel for the Arak reactor. This could be a coincidence but it increases suspicions.

As of this report's publication, Iran has not built a uranium metal production line at the Uranium Conversion Facility at Esfahan. In addition, as stated above, IAEA safeguards reports on Iran make clear that the fuel for this reactor is made from uranium oxide. Thus, available evidence supports that Iran will not currently fuel the reactor with natural uranium metal fuel. With regard to the future, there are no indications that Iran is planning to use uranium metal fuel in the Arak reactor. But in the absence of updated, verified design information from Iran, caution is warranted, pending more clarification.

Testing Prototype Fuel Assemblies

At the FMP, Iran has constructed 37 prototype natural uranium fuel assemblies, one of which was sent to the Tehran Research Reactor for irradiation several months ago and 36 of which were transferred to the Heavy Water Zero Power Reactor for testing in April 2013.

The fuel assembly sent to the TRR is likely undergoing irradiation testing. The reasons are less apparent for sending so many assemblies to the Heavy Water Zero Power Reactor. This reactor, constructed by China, is a heavy-water moderated research reactor near Esfahan, and Iran's only reactor that uses heavy water.[8] The IAEA report did not state the purpose of the testing in either reactor.

Iran may have a number of possible reasons for testing the prototype Arak fuel at the Zero Power Reactor, according to an ISIS expert on heavy water reactors. One reason would be to test the quality of the uranium fuel and cladding. When the zero power reactor goes critical, the test would determine if the fuel and cladding have impurities that unduly absorb neutrons, potentially interfering in reactor operations. The operators could also investigate the process of starting the fission chain reaction in general. None of these tests necessarily mean there is a problem but fall more in the category of quality control prior to the beginning of operations at Arak.

Zirconium Production Plant (ZPP)

Iran has declared that Arak reactor fuel has a cladding made from zirconium, a metal that is extremely resistant to water corrosion and difficult to manufacture. To produce zirconium, Iran has built a plant

[7] *Nuclear Fuel Cycle Activities in Iran***,** op. cit. He also wrote: The mixture of UO_2 and UF_4 is forced from the high temperature area of the first reactor into the low temperature area of the second reactor. When the solid material is transferred into the high temperature area of the second reactor, it will react with AHF, preheated to complete the hydrofluorination of UO_2. The qualified UF_4 thus obtained is discharged into the hopper for temporary storage. Under the prerequisite of a given material seal height, UF_4 can be discharged into the container by the screw conveyer and transported either to the fluorination section in Building 101C for producing UF_6 or to Building 104 for producing natural U-metal.

[8] IAEA Data on Research Reactors: http://nucleus.iaea.org/RRDB/RR/TechnicalData.aspx?RId=217

at Esfahan that is designed to produce zirconium for nuclear fuel cladding. The ZPP, according to Iranian officials, will be able to produce zirconium sponge, zirconium alloy strip and bar, magnesium, hafnium, 99.99 percent pure magnesium, zirconium alloys, titanium and titanium alloys, and can do ferrous and non-ferrous metal casting. The primary objective of the ZPP is the annual production of 50 tonnes of zirconium sponge, 10 tonnes of tube, and 2 tonnes of strip and bar from zirconium alloys.[9]

In 1990, Iran signed an agreement with a foreign government to build the zirconium production plant, but under pressure, this company backed out of the project in 1998.[10] According to a knowledgeable official, the foreign government was China, which by the time it ended the cooperation had already provided a considerable amount of equipment and technology.

Iran has stated that the plant is ready.[11] However, its operation is not confirmed.

Iran has also sought zirconium pre-forms abroad, as recently as a year ago, according to a knowledgeable official. This suggests that the plant was not making rods as of that date. The pre-forms, which are thick tubes, would then be thinned on a machine, called a Cold Pilger, into tubes used for the fuel cladding. Thus, Iran appears to have pursued a strategy to acquire the preforms both via illicit nuclear trade and by indigenous production. It is unknown how many pre-forms Iran possesses, or the number of fuel rods that Iran could clad with zirconium.

The original Cold Pilger machine in the ZPP was supplied by China. Iranian officials have privately expressed their dissatisfaction with this old machine, raising questions of whether Iran has sought to procure additional ones abroad.

Arak Heavy Water Production Plant at Khondab

To operate the IR-40, Iran must have a reliable supply of heavy water for the reactor. To make heavy water, Iran secretly constructed a heavy water production facility. Figure 5 is a recent commercial satellite image of the heavy water production plant. Figure 6 is a ground image of the facility.

The public existence of this facility was first revealed by the Iranian opposition group, National Council of Resistance of Iran (NCRI), in August 2002. ISIS then located the site in commercial satellite imagery after a wide-area search and published its findings in December 2002.[12] When Iran subsequently admitted to building this plant in 2003, it first denied that the heavy water would be used in a reactor. It subsequently modified its story several months later, telling the IAEA the heavy water would be used in the Arak heavy water reactor. It also told the IAEA that it had decided to build the reactor at Arak in 2002.[13]

Iran's heavy water production plant was commissioned in August 2006. By United Nations Security Council resolution 1737 (2006), Iran was first ordered to suspend all work on heavy water related projects. However, Iran has not halted this work.

[9] *Nuclear Fuel Cycle Activities in Iran***,** op. cit. at http://www.world-nuclear.org/sym/coidx.htm
[10] See "Video Tour of Iranian Nuclear Sites," at http://isis-online.org/isis-reports/detail/video-tour-of-iranian-nuclear-sites/8
[11] "Video Tour of Iranian Nuclear Sites," op cit.
[12] David Albright and Corey Hinderstein, "Iran Building Nuclear Fuel Cycle Facilities: International Transparency Needed," ISIS, December 12, 2002.
[13] *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, November 15, 2004, op. cit., paragraphs 65 and 67.

Iranian officials stated at a March 5-6, 2005 conference in Tehran that the plant was in its first stage of operation. In 2010, imagery of the heavy water production plant analyzed by the IAEA indicated that it was operating. However, operation is believed to have been interpreted afterwards or that subsequent problems have interfered in full-scale production of heavy water.

Under traditional safeguards, heavy water production facilities are not subject to IAEA safeguards or inspection. Though Iran granted IAEA inspectors access on August 17, 2011, they were not permitted to obtain samples of Iran's heavy water. The IAEA monitors the status of the facility via satellite imagery.

On a 2009 IAEA visit to the Esfahan Uranium Conversion Facility, inspectors discovered 30 tonnes of heavy water in an area of the facility that inspectors visited infrequently. The IAEA believes that this heavy water was imported, not produced at the Arak heavy water facility.[14]

Most assume that Iran has produced or procured enough heavy water of sufficient purity for the reactor. However, neither the amount nor its purity has been confirmed.

Hot Cell Facilities

Iran will operate a hot cell facility in the vicinity of the reactor to handle irradiated fuel and targets from the reactor, but it is not believed to be sufficient to chemically separate plutonium from irradiated fuel. Instead, it will be dedicated to producing radioisotopes for civilian uses. Moreover, none of the other buildings adjacent to the reactor appear capable of housing equipment to separate significant amounts of plutonium from irradiated fuel.

Iran has no declared plans to separate significant quantities of plutonium from the IR-40 reactor's irradiated fuel. Iran's past attempted procurements have raised suspicions that it had planned to build a plutonium separation plant or could seek to build one in the future. Prior to 2003, it tried to acquire specialized remote manipulators and 1.3 meter thick leaded glass, both distinctive to hot cells designed to separate plutonium from highly radioactive irradiated fuel. In addition, Iran has not formally committed to forgo plutonium separation.

Moreover, Iran originally declared to the IAEA that there were plans to construct a building at the Arak site with hot cells for the production of "long-lived" radioisotopes in addition to the hot cells for the production of "short-lived" isotopes. Iran did not clarify what this distinction meant, although many experts interpreted long-lived radioisotopes to include significant amounts of plutonium. In May 2004, however, Iran revised its declaration for Arak, and eliminated plans to construct any hot cells for long-lived isotopes, citing difficulties with the procurement of equipment.[15]

There are still concerns that Iran will ultimately build hot cell facilities at the Arak site or elsewhere for use in separating plutonium. Thus, the Arak reactor is still seen as a potential source of plutonium for nuclear weapons.

[14] David Albright and Jacqueline Shire," IAEA Report on Iran: Fordow Enrichment Plant at 'Advanced Stage of Construction'; decline in number of P1 centrifuges enriching but P1 centrifuge efficiency increases; discovery of previously unknown stock of heavy water," ISIS, November 16, 2009.

[15] *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, November 15, 2004, op. cit., paragraph 69.

Implications and Recommendations

Despite the delays and problems in procuring essential equipment and fuel abroad and domestically, Iran is currently expected to finish the Arak reactor. However, additional delays in commissioning are expected.

In any case, the reactor is widely viewed as unnecessary. Sufficient medical isotopes—Iran's stated justification for the reactor—can be produced in the Tehran Research Reactor or obtained via international commercial markets. Iran has also recently announced its siting of a second research reactor, which would also produce medical isotopes.[16]

More importantly, the Arak reactor's operation would open a second potential route to nuclear weapons for Iran, in this case via plutonium. The first route is its centrifuge program that could make highly enriched uranium.

Iran would be wise to delay fueling this reactor until its negotiations with the P5+1 are settled. Given the apparent, substantial work needed to start this reactor, announcing another delay would not be unexpected. Adding a second route to creating fissile material for nuclear weapons would further complicate negotiations and concern many in the international community.

As Iran nears completion of the Arak complex, it could become a target for bombing by Israel. Israel has bombed two other nuclear reactors in the Middle East, one in Iraq in 1981 and another in Syria in 2007. Israel may in the next half year issue a new redline warning Iran not to load the reactor with fuel or start it. Israel would be unlikely to want to bomb the reactor after it starts operation and is producing highly radioactive material that may be dispersed after an attack. So, the sooner the start of the reactor, the tenser the situation is likely to become, absent substantial progress in the negotiations.

If there is a pause, Iran should discuss with the P5+1 the conversion of the IR-40 reactor to a significantly more proliferation-resistant light water research reactor. Olli Heinonen, former Deputy Director General at the IAEA and now a senior fellow at the Belfer Center for Science and International Affairs at Harvard University, has made this practical proposal.17 He says that such a reactor could use Iran's current stock of 3.5 percent low enriched uranium as fuel, an approach which has been demonstrated to be feasible. The spent fuel containing plutonium could be sent overseas for storage, reducing concerns about domestic separation of plutonium.

Iran does not need to operate the Arak reactor, and doing so would heighten concerns about Iran's nuclear intentions and increase the risk of military strikes against Iran. As a result, delaying its fueling and operation is the best option.

[16] "Iran picks site for new reactor," The Associated Press. June 20, 2013
[17] Olli Heinonen, "Iran's first nuclear fuel rod and what it means," *Julian Borger's Global Security Blog*, *The Guardian*, January 5, 2012. http://www.guardian.co.uk/world/julian-borger-global-security-blog/2012/jan/05/iran-nuclear-fuel

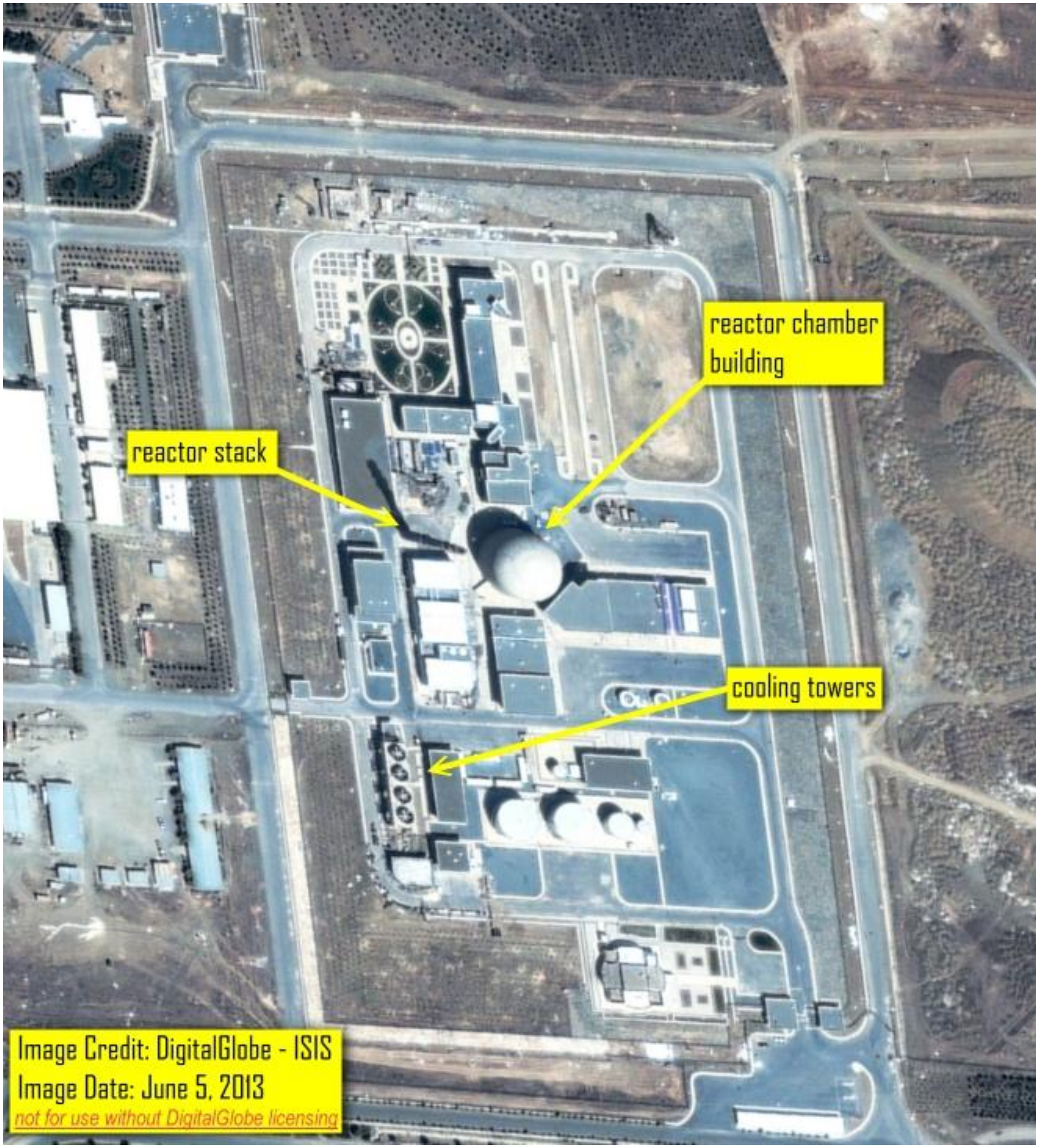

Figure 1. Arak Heavy Water Reactor

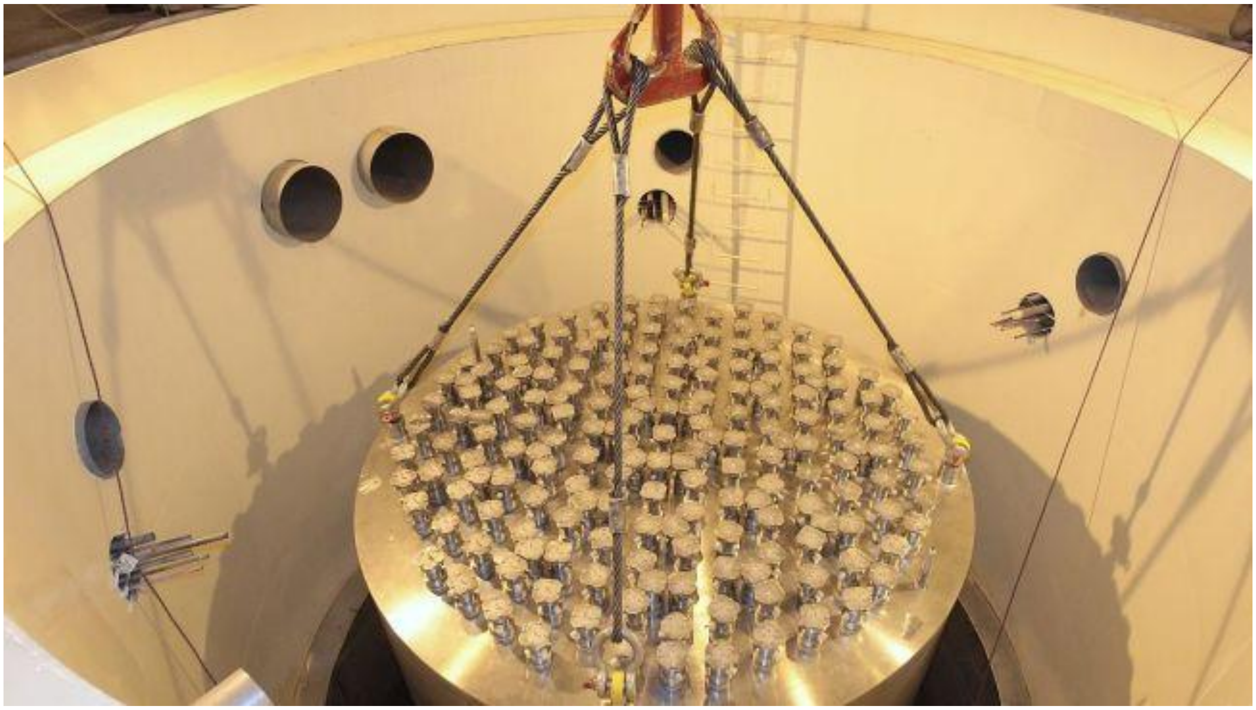

Figure 2. Reactor vessel. There are an estimated 187 fuel assembly, control rod, and instrumentation channels in this vessel.

Figure 3. Iran's President Ahmadinejad examining the lower end of a fuel rod bundle for the Arak reactor at the Fuel Manufacturing Plant at Esfahan. It appears visually identical in every way to an RBMK fuel bundle of 18 pins

Figure 4. The entire length of the fuel assembly on display. Judging by the height of the people, this is a 3.5 m long fuel rod bundle and not full assembly. The suspension is about 4 meters long.

Figure 5. Arak Heavy Water Production Plant

Figure 6. Arak Heavy Water Reactor