IRAN'S NUCLEAR PROCUREMENT PROGRAM: HOW CLOSE TO THE BOMB?

by Andrew Koch and Jeanette Wolf

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Over the past six months, internal pressure has been mounting for the United States to rethink its dual-containment policy that seeks to isolate Iran and Iraq internationally. These calls have increased steadily since Mohammad Khatami was elected President of Iran on May 24, 1997. Khatami, a previously obscure political force and the most moderate of the candidates hand-picked by Tehran's ruling clergy, upset the powerful, hard-line speaker of the Iranian parliament, Ali Akbar Nateq-Nouri. Khatami's victory was a vote against the clergy and suggests that Tehran may be willing to moderate its behavior internationally. The United States has maintained a trade embargo against Iran as part of the dual-containment strategy, citing its "rogue" behavior, including support for terrorism and attempts to acquire weapons of mass destruction. In particular, U.S. officials have repeatedly said that Iran has an active program to build or acquire nuclear weapons, and is five to 10 years away from realizing that goal. This study analyzes the available open-source information on Iran's nuclear program and outlines its potential for success by tracking activities and capabilities in each of the fuel cycle technologies: from mining and milling uranium to fissile material production by uranium enrichment or plutonium reprocessing.[1]

MINING, MILLING, AND FUEL FABRICATION

As part of a program to master the nuclear fuel cycle, Tehran has sought to acquire the capability to mine and mill uranium ore. In 1985, Atomic Energy Organization of Iran (AEOI) specialists located over 5,000 metric tons (MT) of uranium in the Saghand region of eastern Yazd province, making it one of the biggest deposits in the Middle East.[2] They also found 4,000 tons of molybdenum, a mineral which is mixed with steel to make hardened alloys that have nuclear applications.

Following subsequent unsuccessful efforts to mine and mill the province's vast uranium deposits indigenously, Tehran sought external assistance. China's Beijing Research Institute of Uranium Geology (BRIUG), a division of the China National Nuclear Corporation (CNNC), helped Iran explore for uranium deposits.[3] Russia provided advice and assistance about mining and milling uranium ore, according to U.S. intelligence reports.[4] This assistance may be continuing, despite Moscow's assurances to the contrary, although it is not clear whether it is controlled by the central government.[5] The AEOI also sought other nuclear suppliers, approaching Argentina about the possible sale of $18 million worth of machine-tools for a pilot-scale uranium mill and a pilot-scale fuel fabrication plant.[6] Argentine President Carlos Menem prohibited Argentina's Applied Research Institute (INVAP) from supplying the equipment in February 1992 due to nonproliferation concerns.[7]

Iran requires foreign assistance because it does not possess the capability to mine and mill significant quantities of uranium. In 1992, IAEA inspectors visited the site of an alleged operational mill in Saghand, but found only a small uranium ore drilling rig that was at least five years from production.[8] Iran does have a laboratory-scale uranium mill at the Tehran Nuclear Research Center (TNRC), used to produce yellowcake from raw uranium ore. Further Chinese or Russian assistance will likely allow Tehran to acquire the capability to mine large amounts of natural uranium ore and mill it into yellowcake within a few years. The yellowcake could then be fabricated into heavy water reactor fuel or converted into uranium hexafluoride gas (UF6) for use in a uranium enrichment plant. If Tehran continues plans to build a UF6 conversion facility at Isfahan, it would need a steady supply of yellowcake, although it has a small supply that was acquired from South Africa in the 1970s.[9]

ENRICHMENT AND URANIUM HEXAFLOURIDE CONVERSION

Centrifuges

Iran has explored several different technologies as part of a program to acquire the capability to enrich uranium to weapons grade (90 percent enriched). Sharif University of Technology in Tehran, a major research and development (R&D) center and nuclear procurement front, has been central to this effort. Western intelligence officials allege that the Physics Research Center (PHRC) there is the site of Iranian attempts to produce highly enriched uranium (HEU) by the gas centrifuge method, and the German intelligence agency Bundesnachrichtendienst (BND) lists it as a procurement front.[10]

Following a strategy similar to Iraq's and Pakistan's nuclear development programs, Iran has attempted to acquire a uranium enrichment capability by purchasing centrifuge components piecemeal from Western European suppliers. Tehran established a network of front companies to procure dual-use and prohibited items, with Sharif University as the intended destination. As part of this program, it has used design information for Urenco G-1 and G-2 type centrifuges that the BND said was obtained through Pakistan.[11] In 1991, Sharif University officials tried to buy specialized ring magnets from the German firm Thyssen, but were rebuffed because the end-user was not specified.[12] The officials then approached Germany's Magnetfabrik Bonn (MFB) about "alnico"(a combination of aluminum and nickel)-type ring magnets, which can be used in gas centrifuges.[13] When questioned, MFB officials admitted that they had sold Iran ferritic ring magnets since 1993, but denied the deals included either alnico magnets or Sharif University.[14] The MFB officials added that Germany's Federal Export Control Office (BAFA) approved the ferritic ring magnet deal because the devices could not be used for enriching uranium. Also in 1991, Germany's Leybold corporation negotiated the sale of a vacuum arc furnace with Said Kareem Ali Sonhani, an official at the Iranian embassy in Bonn.[15] Leybold further negotiated the sale of vacuum pumps to a university in Tehran from 1990 to 1991, although these may not have been delivered.[16] Another supplier of the Iranian program is the company Karl Schenck of Darmstadt, which sent at least one balancing machine to Sharif University before canceling the rest of the order.[17] The balancing machine, which can be used to produce gas centrifuges, was sent after Schenck was assured in writing that the machines would not be used for military purposes.

Iran procured equipment for its gas centrifuge development program from other Western suppliers as well. In 1991, several British firms sent Sharif University a supply of fluorine gas, which is used to make UF6 to feed a centrifuge plant.[18] In August of that year, Ray Amiri and Don Danesh were arrested for selling Tehran an oscilloscope purchased from the U.S. firm Tektronix.[19] Swiss companies may have supplied gas centrifuge technology in 1991 as well, and Iran acquired electrical discharge machinery (EDMs) from the Swiss firms AGIE and Charmilles Technologies in 1993.[20] EDMs cut heavy metals with a high decree of accuracy and can be used to produce gas centrifuge components and to fabricate nuclear fuel.

These activities raise concerns that Tehran has an active nuclear weapons program and is seeking gas centrifuge technology. The proposed Russian supply of an enrichment plant as part of the Bushehr reactor deal heightens this concern. Russia has the world's largest centrifuge enrichment capability with a relatively unsophisticated design, meaning that Iran could conceivably reverse-engineer it or gain clandestine assistance for its centrifuge program. The proposed centrifuge deal is especially worrisome considering the poor economic situation in Russia and the availability there of many unused centrifuges and centrifuge components.[21]

Despite its efforts, evidence suggests that Iran does not yet have a centrifuge enrichment facility, even on a laboratory-scale. While Tehran did acquire some of the necessary equipment, it does not possess sufficient quantities of vital production equipment and materials such as maraging steel, and the program appears to have stalled since 1993. The tightening of export controls in supplier countries following revelations that Iraq was close to building a nuclear weapon has greatly hindered Iran's ability to acquire this material. Even if Tehran were able to build a small enrichment facility, operating the complex centrifuges may be beyond Iran's scientific, technical, and managerial capability without external assistance, at least over the short-term. However, external assistance from a knowledgeable partner, such as Russia or China, could allow Iran to build and operate an experimental-scale enrichment plant.

The current focus of Tehran's program is on developing and bench-testing gas centrifuges at Sharif University.[22] Although unpalatable to Western governments, these efforts do not specifically violate Iran's safeguards obligations because they have not reached the threshold of having to be reported to the International Atomic Energy Agency (IAEA). It is not likely that Tehran has a supply of UF6 gas, has enriched uranium in centrifuges, or has built a laboratory-scale enrichment facility, all of which would require reporting under Iran's safeguards obligations.

Iran could attempt to build a clandestine enrichment plant separate from its safeguarded facilities once it masters centrifuge technology. This would be a long-term objective, as Tehran is years away from having the capability to build even a small, safeguarded, centrifuge plant. In addition to building and operating the centrifuges themselves, a secret enrichment facility would require an unsafeguarded supply of UF6 gas. Iran does not yet have even a safeguarded UF6 conversion plant, nor does it have the ability build a clandestine one. In short, Tehran will not have the capability to build an unsafeguarded uranium enrichment plant using gas centrifuges for many years, unless it receives large amounts of clandestine foreign assistance.

Laser Enrichment

The TNRC houses the Laser Research Center and its subsidiary, the Ibn-e Heysam Research and Laboratory Complex, which has been the focal point of Iran's program to enrich uranium using the laser isotope separation (LIS) method since it officially opened on October 13, 1992.[23] Headed by A. Hariri, the center has production lines for red helium-neon lasers and carbon dioxide gas lasers, a glass-tube manufacturing unit, an optical manufacturing unit, a nitrogen laser laboratory, a solid laser laboratory, a precision laser laboratory, semi-guided laser laboratories, and a polymer laser laboratory.[24] In addition to its indigenous LIS development efforts, Iran received at least one copper-vapor laser from China.[25] During the 1970s, Tehran sought LIS equipment and technology from U.S. scientist Jeffrey Eerkens, who had worked on a classified U.S. government project researching laser enrichment. Eerkens latter said that the laser designs and the more than four lasers he sent to Iran were not suitable for enriching uranium. Iran sought 16 micrometer lasers, and Eerkens focused on five micrometer lasers.[26] Both of these wavelengths are suitable for enriching uranium, but five micrometer wavelength lasers are preferable.[27]

Although the center's production facilities are impressive on paper, the uranium enrichment program using LIS technology has not been successful. The technology, which has not been mastered by many of the most developed countries, is probably beyond Iran's technical and scientific capability. The need to keep the research secret further inhibits Iran's scientific growth in the nuclear field. Tehran may continue research on advanced laser technology, however, because it has military applications other than uranium enrichment.

Calutrons

Inaugurated on May 11, 1991, by Iranian Vice President Hassan Habibi, the Center for Agricultural Research and Nuclear Medicine at Karaj is home to Iran's program to develop electromagnetic isotope separation (EMIS) technology.[28] The AEOI-run center has a 30 Mega-electronvolt cyclotron accelerator provided by Belgium's Ion Beam Applications and a small (one milliamp) Chinese-supplied calutron.[29] The existence of these devices has led to allegations that, in 1995, China was installing a uranium enrichment facility using calutrons at Karaj.[30] A large hydro-electric dam located nearby could reportedly provide the facility with the large amounts of electricity it would require.[31]

These allegations are likely misinterpretations of the Chinese-supplied calutron's capabilities. The device is housed in a gymnasium-sized building that uses an unprotected ventilation system, precluding its work with radioactive substances.[32] Furthermore, the desktop-sized machine is too small to enrich uranium to weapons grade.[33] IAEA inspectors visited the facility in 1992 and determined that its activities were consistent with civilian nuclear research.[34]

Although the Karaj facility does not currently violate IAEA safeguards obligations and is not an immediate proliferation threat, it does present some long-term concerns. Iranian technicians could use the calutron and cyclotron to gain knowledge of EMIS technology. Such technology could be used to build or reverse-engineer larger versions of the devices to clandestinely enrich uranium in a separate facility. However, a secret EMIS enrichment plant would require large amounts of electricity, making it difficult to conceal.

Were Iran to pursue this option, it would need precision machining facilities to make the large magnets that powerful calutrons require. Although Iran has little indigenous capacity to build precision machine-tools, it imported high-capacity computer-numerical-control (CNC) lathes and vertical turning machines from the Czechoslovak firm Strojimport in 1982-83. The Iranian state-owned heavy manufacturing firm Machine Sazi Arak bought eight vertical turning and boring machines, and the Czech firm TST Kovosvit Semimovo Usti provided Machine Sazi Arak with at least five CNC drilling machines.[35]

Iran could acquire additional machine-tools from turnkey factories that foreign firms are establishing in Iran, several of which are scheduled to be completed in the late 1990s. To augment this capability, the Iranian minister for mines and metals signed a letter of intent on December 5, 1996, pledging Tehran's interest in buying the ailing former East German machine-tool manufacturer Magdeburg.[36] Such a move would be similar to Iraq's former arrangement with the British firm Matrix Churchill, from which Baghdad procured machine-tools used in its weapons of mass destruction programs.[37] Acquisitions from any of these suppliers, in conjunction with the Czech-supplied CNC machines, would give Iran the capability to manufacture the necessary large magnets for a calutron.[38]

Uranium Hexaflouride Conversion

During a November 1996 IAEA visit to Isfahan, Iran informed the IAEA Department of Safeguards that it plans to build a UF6 conversion plant at the Nuclear Technology Center.[39] Tehran expects the Chinese-supplied plant, which would be placed under IAEA safeguards, to become operational sometime after 2000.[40] The plans explain the presence of 15 Chinese nuclear experts who were reportedly working at the center in 1995, likely making preliminary preparations for the facility.[41] U.S. officials may have subsequently convinced China to cancel the deal as a prelude to opening U.S. nuclear exports to China. However, Beijing has not agreed to end all nuclear cooperation with Iran, and it has provided Tehran with blueprints for the UF6 facility.[42]

The UF6 plant prompted allegations that research and development (R&D) on gas centrifuge technology was secretly being conducted at Isfahan.[43] There is no logical explanation for Iran to build such a plant, the product from which is used to feed a uranium enrichment facility. Iran does not have a declared uranium enrichment facility, nor does it require one for its civilian nuclear program. The country's lone commercial reactor, at Bushehr, will use nuclear fuel imported from Russia. Due to the absence of commercial nuclear power plants and the high investment costs associated with building nuclear facilities, the development of fuel cycle facilities such as the UF6 plant suggests that Tehran may wish to use them for non-peaceful purposes.

POWER REACTORS

Power Reactors Under Construction

After years of searching for a supplier to complete its first nuclear power plant, Iran secured a contract with the Russian Ministry of Atomic Energy (Minatom) to finish the reactors at Bushehr, which will be under IAEA safeguards. The $800 million contract, signed in January 1995 by Minatom chief Viktor Mikhailov and then AEOI head Reza Amrollahi, calls for Russia to complete the first reactor at Bushehr within four years.[44] A protocol to the deal stipulates that the two sides will prepare and sign contracts for Russia to provide a 30 to 50 megawatt thermal (MWt) light water research reactor, 2,000 tons of natural uranium, and training for 10 to 20 Iranian nuclear scientists per year.[45] The Iranian nuclear specialists will be trained at the Russian Research Center (Kurchatov Institute) and at Russia's Novovoronezh nuclear power plant.[46] Both sides also agreed to discuss the construction of a nuclear desalination plant, a uranium mine, and a gas centrifuge uranium enrichment facility in Iran.[47] In May 1995, the U.S. government said it convinced Russia to cancel the centrifuge deal during the U.S.-Russia summit, although Russian officials later denied the deal ever existed.[48] The light water research reactor deal has also been canceled, but Russia is providing limited uranium mining assistance.[49] A supplemental agreement was signed on August 24, 1995, under which Russia will supply $30 million worth of nuclear fuel each year from 2001 to 2011.[50] According to Yevgeniy Mikerin, head of Minatom's nuclear fuel activities, the first core of low-enriched uranium (LEU) fuel for Bushehr-1 would be produced at the Novosibirsk Chemical Concentrates Plant in 1998.[51]

Construction of the Bushehr nuclear power plant has already cost Iran billions of dollars. The German firm Siemens and its subsidiary Kraftwerke Union (KWU) began work on the plant in 1974, but stopped following the Islamic revolution in 1979. At that time, Unit-One was 90 percent complete, with 60 percent of the equipment installed, and Unit-Two was 50 percent complete.[52] During the 1980 to 1988 Iran-Iraq war, the Bushehr reactors were bombed by Iraq six times.[53] Iraqi attacks in November 1987 destroyed the entire core area of both reactors; Iran then sealed the structure of Bushehr-1 and covered its dome with sheet metal.[54] According to officials from West Germany's national reactor inspectorate, before the bombings, Bushehr-1 could have been completed in about three years, but following them, it would cost an estimated $2.9 to $4.6 billion to repair the damage.[55] KWU officials noted, however, that none of the core equipment had been installed and vital components for the two reactors were not located at Bushehr.

Starting in the mid-1980s, Iran approached several nuclear suppliers about the possibility of completing Bushehr-1. A consortium of West German, Spanish, and Argentine companies bid to finish the reactor in the late 1980s, but the deal was never completed due to U.S. pressure. In a similar deal, Iran signed a protocol in February 1990 with Spain's National Institute of Industry and Nuclear Equipment to complete the plant, and National Uranium Enterprise to supply the reactor's fuel.[56] The Spanish firms canceled the deal citing U.S. pressure and nonproliferation concerns.

Unable to find a Western European supplier, Iran turned to China and the Soviet Union for nuclear technology. On March 6, 1990, the Soviet Union and Iran signed their first protocol on the project, stipulating that Moscow would complete the plant and build an additional two VVER-440 reactors in Iran.[57] The deal was delayed, however, by technical and financial problems.[58] In 1993, Minatom and the AEOI signed a contract for the construction of two VVER-440 reactors at Bushehr.[59] That contract never entered into force because Iran asked for a postponement of the fixed time limits due to financing difficulties. Iranian and Russian officials have said that once Bushehr-1 is completed, Russia could also complete the 1,000 MW Bushehr-2 reactor and eventually build two VVER-440 reactors there.[60]

Prior to the 1995 contract, Tehran made several unsuccessful attempts to procure components for the project. Again, the United States successfully lobbied the suppliers' governments not to provide Iran with nuclear assistance. Iranian agents tried to acquire eight steam condensers, built by the Italian firm Ansaldo under the KWU contract, but they were seized by Italian customs officials on November 11, 1993.[61] The Czech firm Skoda Plzen also discussed supplying reactor components to Iran, but canceled negotiations in 1994.[62] Tehran then tried to buy nuclear power reactor components from Poland's unfinished VVER-440 reactor at Zarnowiece, but was rebuffed.[63] More recently, under pressure from the United States, the Ukrainian government abrogated a 1996 agreement between the Russian contractor for Bushehr and Ukraine's Turboatom for the supply of two turbines.[64] Minatom officials have subsequently said the turbines will be manufactured in St. Petersburg and that Ukraine's refusal to cooperate would not affect the project.[65]

The Russian-Iranian contract entered into force on January 12, 1996, and calls for the reactor to be completed within 55 months.[66] Minatom subsidiary Zarubezhatomenergostroy (Nuclear Energy Construction Abroad) is conducting the work, having completed site preparations; the reactor vessel has been manufactured, and building of the steam generators and other equipment has begun.[67] However, without technical specifications for the German-supplied components, it is doubtful that Russia will be able to complete the reactor on time because existing equipment installed by Siemens may have to be replaced with Russian equipment.[68] Russia plans to install a VVER-1,000 reactor which requires six horizontal steam generators; the planned Siemens reactor was 1,300 MWe, designed to hold four vertical steam generators.[69] Metallurgical specifications of the German equipment differ from those of Russian primary- and secondary-side components, and the horizontal steam generators are materially different from the vertical Siemens steam generators, which could lead to corrosion or other serious problems.[70] Unless Minatom can match these specifications, the cost of the project will increase greatly and completion could be delayed until at least 2003.[71]

Iran has repeatedly asked the German government to allow Siemens to ship reactor components and documentation that Tehran has paid for. Under a 1982 International Commerce Commission (ICC) ruling, Siemens was obligated to deliver all plant materials and components stored outside Iran. In 1984, the German government refused to grant Siemens an export license for the materials and refused to grant permission to complete the plant.[72] In response, Iran filed a lawsuit in August 1996 with the ICC, asking for $5.4 billion in compensation for Germany's failure to comply with the 1982 ruling.[73] German officials, however, have stated that any decision to release information or equipment related to Bushehr would be carefully weighed and that Bonn would most probably reject any such request.[74]

Uncertainty surrounding the work schedule, and disagreement on how much of the German equipment can be used, has caused friction between the two partners. Iran is insisting that it will not pay more than $100 million unless Russia agrees to a firm completion deadline, while Russia insists that it needs a down payment in hard currency before it can proceed.[75] Although Iran paid Russia $60 million in March 1997 and work is continuing, uncertainty over the Siemens equipment threatens to significantly delay or even derail the project.[76] Questions remain whether Russian technicians can overcome the incompatibility problems within a reasonable timeframe and budget. If the delays and costs are significantly higher than expected, Iran will not be able to afford any new large-scale nuclear projects until Bushehr-1 is completed, meaning at least into the next century.

If successfully completed, Bushehr-1 will have a great impact on Iran's civilian nuclear program. The training in Russia and experience gained from running a nuclear power plant will give Iranian scientists and engineers a greater understanding of nuclear matters that have both civilian and military applications, potentially increasing Tehran's ability to produce weapons-grade fissile material and to build a nuclear weapon over the long-term. Such training would have to be augmented with additional expertise in critical technologies such as weaponization, reprocessing, or enrichment. The large amount of materiel and technicians moving between Russia and Iran as part of the Bushehr deal could also provide cover for covert weapons-related assistance or smuggling activities. Furthermore, the reactor and corresponding facilities would give Tehran legitimate grounds to conduct research and acquire nuclear-related capabilities that could make a clandestine military nuclear program easier to conduct and conceal.

Of more significant concern is the spent fuel the reactors will produce, which will have to be stored on-site for several years while it cools. The Bushehr plant could be capable of producing up to 180 kilograms (kg) of plutonium each year in its spent fuel.[77] Although it would be subject to IAEA safeguards, the spent fuel could be diverted or stolen from the facility for use in a plutonium reprocessing plant. Such a scenario is a long-term concern, as Tehran does not presently have a large-scale reprocessing plant and is years away from having the technical capability to build one. Even if Iranian scientists do manage to build one, such a plant would have to be declared and safeguarded by the IAEA; clandestine reprocessing facilities are difficult to operate and hard to conceal due to the distinct isotopic signatures of elements released during reprocessing.

The final disposition of Bushehr's spent fuel is another concern. It may eventually be sent back to Russia to be stored or reprocessed, but Minatom official Yevgeniy Mikerin said that Russia and Iran have made no agreements on the issue.[78] The best option would be to return it to Russia for storage at Krasnoyarsk-26, in southern Siberia.[79] Russian environmental law, however, seems to preclude this. The Law on Environmental Protection, two presidential decrees, and a government decree regulate the importation of radioactive waste. Article 50 of the Law on Environmental Protection (December 19, 1991) prohibits storing or burying radioactive waste or materials from abroad on Russian territory. A contradictory law, Presidential Decree 72 of January 25, 1995, allows Krasnoyarsk-26 to temporarily store and reprocess spent fuel from foreign plants. Following criticism of Decree 72, Presidential Edict 389 was issued on April 20, 1995, to improve oversight of importing and handling spent fuel. On April 4, 1996, the Russian Supreme Court repealed the sections of Decree 72 that provide for the importation and reprocessing of spent fuel.[80] Edict 389 requires that products of reprocessing be returned to the country of origin. Russian government Resolution 773 of July 29, 1995 also stipulates that Russia must return solid radioactive wastes and other by-products of reprocessing not intended for further use in Russia. The law further requires that the process be safeguarded by the IAEA and that the country of origin has in place all the necessary regulatory structures as well as the ability to safely handle radioactive waste.[81]

A second disposition option would be to separate the spent fuel at the RT-2 reprocessing plant in Krasnoyarsk once it is completed.[82] Russian environmental law appears to allow this, but only if Moscow returns the vitrified high-level radioactive waste and separated plutonium to Iran.[83] However, the presence of separated plutonium in Iran, even under IAEA safeguards, would draw fierce criticism from the United States due to nonproliferation concerns. Furthermore, the RT-2 plant will not be completed until after Bushehr-1 is operating, meaning that sending spent fuel to Russia would be tantamount to storage and therefore in violation of Russian environmental law.

Postponed or Canceled Power Reactor Deals

In addition to Bushehr, Iran has sought other nuclear power reactors. Tehran sought to build a nuclear power station at Darkhovin, located on the Karun River south of the city of Ahvaz, to be provided by either French or Chinese firms. In 1974, Iran signed a contract with the French company Framatome to build two 950 MW pressurized water reactors (PWRs) at the site which they called Karun.[84] Although Framatome surveyed the area and site preparations had begun, construction had not yet started when Iran canceled the contract following the Islamic revolution in 1979.[85]

Iran made a second attempt to acquire a nuclear power plant at Darkhovin, contracting China to build two 300 MW PWRs for a project the Chinese called Esteghlal. On September 10, 1992, then Iranian President Hashemi Rafsanjani announced that China's Qinshan Nuclear Power Company and the Shanghai Nuclear Research and Design Institute agreed to build the reactors as part of a nuclear cooperation agreement.[86] Chinese officials said it could take up to 10 years to complete the two reactors.[87] Although preliminary preparations were conducted, the deal now seems to be on hold.[88] China failed to submit a detailed technical plan for the plant and failed to implement an agreement to train Iranian nuclear technicians, while Iran was unable to provide detailed plans on how to raise $2 billion for the project.[89] Chinese Foreign Minister Qian Qichen reportedly told U.S. Secretary of State Warren Christopher on September 27, 1995, that Beijing terminated the contract.[90] Qian changed his statement on September 30, 1995, saying the deal was merely suspended because "the original site is not very appropriate for these nuclear reactors."[91] The planned site was subsequently moved to Bushehr from Darkhovin due to the latter's proximity to Iraq.[92]

Since 1995, however, there have been no new developments on the proposal and it is doubtful that Iran could afford the project while paying for Bushehr-1. If the project were to proceed, the two reactors would likely be built by the CNNC near Bushehr. Although the reactors would be under IAEA safeguards, completion of the plant would provide Iran with nuclear technology from which the country's military could draw expertise and personnel. Fears that the reactors' spent fuel could be stolen or diverted for use in a secret reprocessing program also persist. Furthermore, enlarging the size and scope of Iran's nuclear infrastructure could make it more difficult to detect the progress of a clandestine nuclear R&D program.

Iran also planned to build two Russian VVER-440 MWe power reactors at a facility in Gorgan, sometimes referred to as either the Gorgan al-Kabir Center or Neka.[93] The deal was part of a March 6, 1990, protocol between the Soviet Union and Iran, which stipulated that Moscow would complete the Bushehr plant, as well as build two VVER-440 reactors at an unnamed site, latter identified as Gorgan.[94] Russian technicians conducted a geological survey of the area, but determined that it was unsuitable for nuclear reactors due to seismological instability.[95] It was then decided to build the proposed reactors at Bushehr.[96]

Despite the location change, allegations persist that the area is home to a secret nuclear weapons-related facility.[97] According to one report, Iranian, Ukrainian, Russian, and Kazak scientists are working at Gorgan, earning up to $20,000 a month each.[98] The facility, said to be one of Iran's largest nuclear research centers, is allegedly supervised by AEOI Deputy Chairman Mansour Haj Azim.[99] Other sources have said that Israel threatened to bomb the facility in 1996, ostensibly due to its involvement in Iran's nuclear weapons development efforts.[100] The claims, however, can not be justified by available open-source evidence. They originated with the

Iraqi-based Mojahedin-e Khalq resistance group, and are likely founded on the now canceled reactor plan. These sources likely confused the presence of Russian technicians conducting the site survey for more dubious activities.

RESEARCH REACTORS

Iran possesses several research reactors, with several more either canceled or alleged to exist at clandestine locations. The University of Tehran's TNRC, run by the AEOI, is Iran's primary open nuclear research facility. It houses a safeguarded 5 MWt pool-type research reactor that was supplied by the United States in 1967 and can produce up to 600 grams (g) of plutonium per year in its spent fuel.[101] In 1987, the AEOI paid INVAP $5.5 million to convert the reactor from using 93 percent enriched uranium fuel to burning 20 percent enriched uranium fuel.[102] The Argentine Nuclear Energy Commission (CNEA) has subsequently supplied the reactor with 115.8 kg of safeguarded 20 percent enriched uranium fuel.[103]

Iran has four more small research reactors at the Nuclear Technology Center in Isfahan, which is directed by Kazem Rassouly.[104] Located at the University of Isfahan, the center was founded in the mid-1970s with French assistance in order to provide training for Bushehr reactor personnel.[105] The first unit, a Chinese-supplied 27 kilowatt thermal (kWt) miniature neutron source reactor (MNSR), went critical in March 1994. The MNSR is used to produce isotopes and burns 900 g of HEU fuel supplied by the CNNC.[106] The center also has a Chinese-supplied heavy water, zero power, reactor that went critical in 1995, and two Chinese-supplied sub-critical reactors that were completed in 1992.[107] The CNNC supplied the MNSR and the zero power reactor with heavy water.[108]

These facilities are not a direct proliferation threat because they are safeguarded, the research reactors can not produce significant amounts of plutonium-bearing spent fuel, and only minor amounts of heavy water and HEU are present. However, Iranian attempts to buy a 30 MWt heavy water research reactor from China in 1991 raised concerns.[109] A deal to build the reactor at Isfahan, which would have been capable of producing significant quantities of plutonium in its spent fuel, never materialized due to technical and financial problems. Coupled with the rapid build-up of nuclear facilities at Isfahan, the proposed reactor deal has lead to concerns that the center may be conducting research on nuclear technology with military applications; a worry exacerbated by the fact that part of the center is apparently built underground.[110]

In addition to these deals, numerous unsubstantiated reports claim that Tehran has secret nuclear reactors at various locations. One such report claims that Iran was building a nuclear reactor housed in a reinforced-concrete bunker with Chinese assistance at Bonab.[111] The area, 80 kilometers south of Tabriz, is home to the Bonab Atomic Energy Research Center, which conducts research on nuclear technology for agricultural uses.[112] The facility, run by the AEOI and headed by Hussein Afarideh, is not under IAEA safeguards because it does not house a nuclear reactor or fissile material, although IAEA Secretary-General Hans Blix visited the site in July 1997.[113] Blix found no activities that violated Iran's safeguards obligations, and the reports of a secret nuclear reactor there can not be substantiated by publicly available evidence.

Other reports claim that North Korea is helping to build a secret nuclear reactor under the direction of General Myong-Rok at Tabas.[114] Again, there is no open-source information to verify these claims. If North Korea is providing Iran with military assistance at a location in Tabas, it is likely for the production of ballistic missiles or conventional weapons.

Finally, a variety of rumors have circulated about Moallem Kaleyah, located in the mountains northwest of Tehran. Moallem Kaleyah was the proposed site for a 10 MWt research reactor India was going to build under a 1991 agreement with Iran, but New Delhi canceled the deal under U.S. pressure.[115] However, allegations remain that Iran has a secret nuclear facility in the area. The Iranian Revolutionary Guard Corps (IRGC) allegedly oversees a gas centrifuge uranium enrichment plant there, established in 1987 using equipment acquired from French, German, and Italian companies.[116] Other sources claim the area could be where weaponization and design work are conducted.[117]

In response to the charges, IAEA inspectors visited the site in February 1992, but found only a small training and recreation facility being built for AEOI staff.[118] Skeptics argue that the inspectors were taken to the wrong location, far away from the intended site.[119] These critics allege that because the inspectors were not carrying navigation equipment to determine their precise location, they were easily led to an alternative facility that was not the intended inspection site. IAEA officials said those claims "are just plain wrong," and open-source information seems to justify their findings.[120] Iran has not demonstrated an ability to build even a pilot-scale centrifuge facility, and it is unlikely that Tehran could build and hide a large-scale uranium enrichment plant. The allegations could stem from past activity in the area associated with the proposed reactor deal with India.

REPROCESSING

Since the former Shah of Iran's reign, Tehran has had a program to chemically extract plutonium from spent fuel. A former head of the AEOI confirmed Western intelligence claims that the program existed at the TNRC, which is the center of Iran's plutonium reprocessing efforts.[121] A former technician involved in the program provided further evidence, saying that Iran completed and cold tested a plutonium extraction laboratory at the TNRC in 1988, although the facility did not reprocess any plutonium.[122] The status of this facility is uncertain, although it is believed to be inoperable. The TNRC has hot cells, supplied by the United States in 1967, which can be used to reprocess gram quantities of plutonium from spent fuel.[123] Although the hot cells and other lab-scale reprocessing activities there can produce only small amounts (600 g per year) of plutonium, Iranian technicians could use the facilities to gain the scientific knowledge and competence necessary to operate a larger-scale plant.[124] Iran demonstrated its interest in increasing this capability when it approached Argentina about buying additional hot cells, but a deal was never completed.[125] Also, Iran acquired tributylphosphate (TBP) from China, a chemical used in the plutonium separation process.[126] China may have further supplied Iran with data on chemical separation technology.[127]

These efforts could be aided by Tehran's Amir Kabir University of Technology, which has allegedly been used as a front to procure nuclear components, including plutonium reprocessing equipment. University representatives tried to purchase neutron-shielding equipment, usable in a plutonium reprocessing R&D program, from the U.S. firm Reactor Experiments.[128]

Despite these efforts, even small-scale reprocessing activities appear to be currently beyond Iran's technical competence; Tehran is years away from having the capability to build and operate a larger-scale reprocessing plant. Recent Iranian procurement activities suggest that its plutonium reprocessing program is not a priority, possibly due to the sophisticated technical knowledge a reprocessing plant would require. Furthermore, Tehran may be deterred by the IAEA's enhanced safeguard program, called 93+2,[129] that will make it more difficult to hide a clandestine reprocessing plant due to the distinct isotopic signatures of elements released during the process.

If Tehran were to build a secret plutonium reprocessing facility, it would need a supply of unsafeguarded spent fuel to feed it. Although Iran could attempt to divert safeguarded spent fuel from its research reactors or the Bushehr plant, large quantities could not be diverted without being detected by the IAEA inspection regime. Iran could also try to procure spent fuel on the black market. However, there are no documented cases of significant amounts of spent fuel being smuggled internationally, and without its own source of spent fuel, Iran's nuclear weapons program would be at the mercy of smugglers.

A more likely scenario would be for Tehran to secretly build a research-sized heavy water reactor for producing plutonium-bearing spent fuel. Not only do heavy water reactors produce relatively more plutonium in their spent fuel than light water reactors, but they can burn natural uranium fuel, obviating the difficult step of enriching the nuclear fuel. In possible preparation for such a program, Iran negotiated with Argentina for a nuclear fuel fabrication pilot-plant and a pilot-scale heavy water production facility, but the deals were canceled by Argentine President Carlos Menem under pressure from the United States.[130] Such a program would be a long-term objective, as Iran does not have the capability to produce heavy water, fabricate nuclear fuel, and build and operate a reactor of even modest size.

OTHER NUCLEAR-RELATED RESEARCH AND DEVELOPMENT PROGRAMS

Weaponization

Iran's R&D centers contribute to other facets of the country's nuclear weapon program as well. The shah had assembled a nuclear weapon design team at the TNRC as part of his government's nuclear research efforts, which could have included computer modeling and basic research of a nuclear explosive device.[131] Following the 1979 Islamic revolution, the new government was able to keep or lure back many key TNRC personnel, and therefore probably inherited most of the nuclear weapon design team's data and knowledge. Although there is a paucity of publicly available information on their current nuclear weapon design efforts, such activities would likely occur at, or involve personnel from, the TNRC.

Their work could be augmented by knowledge and technology developed at Azad University. The university has a HT-6B tokamak fusion research reactor that was installed and supplied by the Chinese Academy of Sciences' Institute of Plasma Physics under a February 1993 agreement.[132] As part of their normal operations, most tokamaks remove and recycle small amounts of tritium, a vital nuclear weapon component. Such a device would give Iranian technicians experience working with fusion technology, which is potentially applicable to a thermonuclear weapon design program. Further assistance could be provided by the Institute for Studies in Theoretical Physics and Mathematics in Tehran, which could train scientists involved in the nuclear program. Established by the AEOI in 1989, the school, which may be known as the Jabit bin al-Hayyan Laboratory, researches theoretical, particle, and high energy physics applications.[133]

Iran has also attempted to acquire equipment that could be used to fabricate weapon parts and assist in design efforts. Tehran sought high-speed cameras and flash x-ray equipment that may have been shipped to Iran through the United Kingdom, and purchased an oscilloscope and pulse generators from a U.S. firm.[134] Such equipment could be used to measure and calibrate the shock wave of an implosion device. Furthermore, Tehran may have procured a vacuum arc furnace and acquired precision machine-tools, which can be used to cast and machine weapon cores, respectively. Despite these efforts, Tehran lacks much of the sophisticated dual-use measurement equipment that building a nuclear weapon requires. Moreover, given its lack of technical experience, Iranian nuclear weapon designs would be limited to simple fission devices that are low yield (about 15 kilotons), heavy, and cumbersome.

Strategic Materials

The National Iranian Steel Company (NISCO), which produces steel for a Defense Industries Organization munitions plant in Isfahan, could provided a number of nuclear-related metallurgical products.[135] With help from Japan's Nippon Steel, the Italian firm Danieli built four specialty steel plants in Isfahan for NISCO that could have the capability to produce maraging steel and other corrosion-resistant alloys useful in a nuclear program and in the construction of ballistic missiles.[136] Danieli's participation in the project is of concern due to its past involvement in producing a maraging steel plant for Iraq's Taji uranium enrichment centrifuge production facility.[137] The Isfahan Alloy Steel Complex, of which the plants are a part, officially opened on August 20, 1996, and has a capacity of 30,000 tons of alloy steel per year.[138] However, the status of the NISCO plants is questionable. In 1996, British customs officials seized a shipment of 55 kg of maraging steel, used to make uranium enrichment centrifuges as well as components for missiles and other military hardware, that was bound from the United States to Iran.[139] If the plants are operable and can produce maraging steel, the Iranian government would be unlikely to waste valuable overseas procurement assets to acquire this high-strength alloy.

The Applied Research Center of Iran, also know as MTK Iran, conducts similar R&D on steel alloy production, processing non-ferrous metals, corrosion resistant technology, and metal casting.[140] Located in Tehran, MTK Iran could develop technology used to produce maraging steel and corrosion resistant alloys. Although it is unclear how much progress Iran has made in these efforts, the maraging steel seizure in the United Kingdom suggests that Iran does not yet have the capacity to produce the high-strength alloy in sufficient quantities.

CONCLUSION

As this report has demonstrated, the open-source evidence suggests Iran's nuclear program is still relatively primitive. Tehran lacks the knowledge and equipment to successfully build or operate most of the fuel cycle facilities. Furthermore, despite attempts to procure equipment and materials that suggest an active nuclear weapons development program, only limited progress has been made since 1993. Tightened export controls in supplier states following the 1992 Gulf War and an increased awareness of proliferation risks played a large role in restraining Iran's nuclear ambitions. Moreover, a lack of scientific and managerial skills, coupled with a need for strict secrecy, has undoubtedly impeded more rapid progress.

Iran will find progress even more difficult in the future, as the IAEA's 93+2 enhanced safeguards regime is adopted and implemented. To date, the IAEA has not found Iran to be in violation of its safeguards obligation, possibly because much of its activities have been at levels below what would trigger a safeguards notification or would be a violation. Given the program's current achievements, it is difficult to substantiate U.S. intelligence claims that Tehran will have the capability to build nuclear weapons within five to 10 years. Rather, unless it secures sufficient quantities of weapons-grade fissile material on the black market, Tehran is unlikely to have the ability to field even simple nuclear weapons for at least 10 to 15 years.

[1] Although this study seeks to confirm or deny allegations that have been made about the Iranian nuclear program, the vast number of claims obviates the need to selectively address the allegations. Furthermore, the assessments made herein exclude the consequences of successful Iranian smuggling efforts, which are not addressed due to the lack of verifiable open-source information about the end-users of smuggling activities.

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