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IRAN'S NUCLEAR ACTIVITIES

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The major powers suspect that Iran is clandestinely developing nuclear weapons. Firm evidence for this suspicion comes mainly from the International Atomic Energy Agency (IAEA). Nuclear-weapon activities in Iran are not new – in fact, they date back 40 years to the days of the Shah who had ambitions to acquire a nuclear force. Because of its long experience in nuclear physics and engineering and because it has been operating nuclear research reactors for decades, Iran has a cadre of trained personnel that could be switched to a nuclear-weapon programme.

If it produces the fissile material – highly-enriched uranium or plutonium or both – needed for nuclear weapons it could fabricate them in a relatively short time of some months rather than years. But today's Iranian government insists that its nuclear activities are solely related to its civil nuclear programme and that it is not developing nuclear weapons.

The IAEA has announced that Iran is building two plants at Natanz to enrich uranium, plans to construct a heavy-water research reactor in Arak, and a plant to produce heavy water for the Arak reactor. The Iranian government has acknowledged the existence of these previously secret facilities and plans but claims they are part of its civil nuclear programme and not part of a military nuclear-weapon programme. The Iranian government, however, admitted to these activities only after the National Council of Resistance, an Iranian opposition group, announced that they were underway.

Both of the uranium enrichment and the heavy water production plants raise concerns. A heavy-water reactor is a particularly efficient way of producing plutonium for use in nuclear weapons. A uranium enrichment plant can produce the highly enriched uranium needed for nuclear weapons.

Many argue that because Iran has enormous reserves of oil and gas it does not need nuclear energy and that its nuclear programme demonstrates ambitions to produce nuclear weapons. Iran claims that it needs to export as much of its oil as possible to earn much needed foreign currency, that its oil reserves are finite and that nuclear power is a sensible investment for the future.

Iranian Nuclear Activities

Apart from the heavy water and uranium enrichment plants and plans to build a heavy-water reactor, there are other Iranian nuclear activities that raise suspicions. These include:

- the development of uranium mines;
- the construction of a uranium conversion facility at the Esfahan Nuclear Technology Centre (ENTC) to convert uranium ore (yellow cake) into uranium hexafluoride gas, suitable for use in gas centrifuges for the enrichment of uranium; and
- the operation of a pilot laser enrichment facility at Lashkar Ab'ad, now shut down.

The IAEA has also discovered that Iran has in the past:

- imported uranium hexafluoride gas to test gas centrifuges at the Kalaye Electric Company, thereby producing some enriched uranium;
- imported uranium metal for use in laser enrichment;

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- produced uranium dioxide, uranium hexafluoride, and a number of other uranium compounds using imported uranium dioxide; and
- produced uranium dioxide targets at ENTC and irradiated them in the Tehran Research Reactor (TRR). The targets were then processed in hot cells to separate the plutonium.

Iran violated its Safeguards Agreement with the IAEA, required by the Non-Proliferation Treaty (NPT), by failing to report many of these activities to the Agency as the Safeguards Agreement requires. Disclosures by Iran of its nuclear programme show that it had concealed many of its nuclear activities, and consequently violated its obligations under the Safeguards Agreement and the NPT.

Iran has signed an Additional Protocol to its Safeguards Agreement with the IAEA but the Iranian parliament (the Majlis) has not yet ratified it. The Additional Protocol permits the IAEA improved access to Iran's nuclear facilities, including the collection of environmental samples.

These violations are the basis of the international suspicions that Iran is secretly developing nuclear weapons. None of these activities are in themselves illegal; it is the failure to report them to the IAEA that is illegal.

Iran's Current Nuclear Activities

It is common knowledge that Iran has a civilian nuclear-power reactor under construction. The Russians have essentially completed the 1,000 megawatt-electrical light-water reactor, of the Russian VVER type, at Bushehr. It will use low enriched (about 3.5 percent in uranium-235) as fuel. Under the contract Iran has with Russia, Russia will provide the fuel for the lifetime of the reactor and will take back to Russia the spent fuel for storage and possibly reprocessing.

Once the fuel has been loaded into the reactor and the reactor goes critical it will quickly produce a very large amount of highly radioactive fission products. To bomb the reactor after it has gone critical would spread radioactivity over a very large area indeed.

This power reactor is, according to Iran, the first of a series of power reactors planned to generate 6,000 megawatts of electricity. It is reported that Iran intends to build a second power reactor at the Bushehr site of a similar type as the first and with Russian assistance. Iran explains that it is interested in establishing a capability to produce low-enriched uranium so that it has an indigenous supply of nuclear reactor fuel for its reactors and possible to export to other countries. Again, observers question the need for an extensive nuclear power infrastructure, given Iran's huge fossil fuel reserves and rather limited uranium ore fields.

Iran operates four small research reactors, supplied by China, three at the Estahan Nuclear Technology Centre and one, supplied by the USA, at the Nuclear Research Centre in Teheran. Two, at Estahan, are sub-critical assemblies used for training nuclear physicists and technicians; they have both been operating since 1992. The third at Estahan (Tehran) is a 30-kilowatt research reactor used for research purposes; it has been operating since 1994. The fourth is a 5 megawatt-thermal reactor also used for research; it has been operating since 1967, an indication of the length of time during which Iran has been interested in nuclear technology.

The two facilities suspected of being part of a nuclear-weapon programme are: a plant to produce heavy water, located near the town of Arak, about 250 kilometres from Teheran; and two gas centrifuge plants under construction at Natanz, 40 kilometres from Kashan. One is a Pilot Fuel Enrichment Plant (PFEP) and the other is a large commercial-scale Fuel Enrichment Plant (FEP). Iran has acknowledged that components for gas centrifuges have been produced and tested in the workshop of the Kalaye Electric Company in Tehran.

PFEP will apparently contain about 1,000 centrifuges and may already be completed. Iran plans to install more than 50,000 centrifuges at the commercial scale FEP; installation of centrifuges started in early 2005.

A uranium Conversion Facility at Isfahan converts yellowcake (U308) into uranium dioxide that is in turn converted into uranium hexafluoride gas. The facility also produces other uranium compounds; it is also the fuel fabrication part of Iran's nuclear fuel cycle. There is a Zirconium Production Plant nearby that produces ingredients and alloys for nuclear reactors.

Uranium hexafluoride gas was introduced into the first centrifuge at PFEP in June 2003 to test a single centrifuge. In August 2003, Iran began testing a ten-centrifuge cascade with uranium hexafluoride gas.

Saghand is the location of Iran's first uranium ore mines that have recently become operational. The deposit reportedly contains between 3,000 and 5,000 tonnes of uranium spread over an area of roughly 130 square kilometres.

The Bonab Atomic Energy Research Center is a facility to investigate the applications of nuclear energy and technology to agriculture and there is a Center for Agricultural Research and Nuclear Medicine at Hashtgerd, Karaj.

The IR-40 research reactor

Iran claims that it wants to replace the aged (35-year old) Tehran Research Reactor and plans to do so by building a new heavy water reactor, called the IR-40, at Arak. The IR-40 will be a 40-megawatt (thermal) reactor cooled with heavy water and fuelled with natural uranium. According to the IAEA, Iran plans to manufacture the fuel (uranium dioxide) elements for the IR-40 in the Fuel Manufacturing Plant (FMP) to be built at the Esfahan establishment. Iran says that the purpose of the IR-40 reactor is the production of radioactive isotopes for medical and industrial uses.

IR-40 could produce about 8 kilograms of plutonium a year, enough to produce two nuclear weapons a year. Plutonium from the Arak research reactor is, however, unlikely to be available before about 2014

Iran says that about 85 tonnes of heavy water will be initially required for IR-40 and less than 1 tonne will be need annually. Iran is constructing a heavy water plant at Khondab near Arak with an initial capacity of 8 tonnes of heavy water per year. Apparently, a second production with a similar production capacity is under construction.

Uranium enrichment using gas centrifuges

The capacity of a gas centrifuge is measures in separative work units (SWUs). A reasonable estimate is that each centrifuge of the type that Iran is likely to produce (most likely made from carbon fibre) would have a capacity of about 2.5 SWU per year. That this is likely is indicated by the example of Iraq. In 1991, Iraq was a prototype centrifuge with a carbon-fibre rotor spun at up to 60,000 rpm (a wall speed of roughly 450 meters per second). The enrichment capacity during the best test run reached 1.9 SWU per year. IAEA inspectors estimated that an output of 2.7 SWU per year could have eventually been achieved.

A reasonable estimate is that each centrifuge of the type that Iran is likely to produce, the P-1 type, would have a capacity of about 2.5 SWU per year. Iran is experimenting with the P-2 type gas centrifuge (operated by Brazil, Pakistan and India) that may be about twice as efficient, with a capacity of about 5 SWU per year.

An Iranian facility containing, say, 3,000 P-1 centrifuges could produce 7,500 SWU per year or about 40 kilograms of highly enriched uranium per year. It would take this facility at least 5 years to produce enough highly enriched uranium for the nuclear force of six nuclear weapons. With sufficient expertise in HEU-based nuclear weapons 40kg per year could provide 2 nuclear weapons.

Assuming that about 60 per cent of the centrifuges have to be rejected as sub-standard, a reasonable assumption, Iran would need to produce about 5,000 centrifuges for the facility. Moreover, gas centrifuges break down frequently because of the mechanical stresses they are under. A steady supply of replacement machines must, therefore, be produced.

A facility operating a cascade of 3,000 centrifuges would use as much energy, electrical power, as a largish city – approximately 200 kilowatt-hours per SWU or roughly 1,000 kilowatt-hours per gram of highly enriched uranium. It would, therefore, be impossible to operate such a facility clandestinely. Building and operating effectively a gas centrifuge facility of a useful size is not a trivial task – it is an industrial undertaking. It would probably take Iran at least four or five years to build such a facility and begin producing significant amounts of highly enriched uranium.

Iran will need to produce many thousands of gas centrifuges to produce enough highly enriched uranium to make a strategically significant number of nuclear weapons – say 5 or 6 weapons (comparable to the South African arsenal). They are unlikely even to begin producing a significant amount of highly enriched uranium for 5 years or longer. If Iran does produce highly enriched uranium suitable for use in nuclear weapons, it is unlikely to have significant amounts until between about 2012 and 2015 or later. (For use in nuclear weapons, uranium should be enriched to at least 90 per cent in uranium-235; for use as fuel in nuclear-power reactors, uranium should be enriched to about 3.5 per cent in uranium-235.)

Laser isotope separation (LIS)

Uranium can be enriched using a laser method called laser isotope separation (LIS). LIS separates uranium isotopes more efficiently than gas centrifuges because it is based on the fact that each isotope of an element has a unique set of electronic energy states. Consequently, electrons of atoms of each isotope will absorb light of a specific colour (i.e., of a specific energy level). If illuminated by a laser beam containing light of this precise colour, electrons of atoms of the selected isotope will absorb photons and become excited. An atom may give up its excited electron, and become a positively charged ion. The atoms of the other isotopes will not absorb photons, because they do not have the “right” energy, and will not be ionised. The ionised atoms can be separated from the neutral ones by an electromagnetic field.

The Iranians have experimented with an Atomic Vapor Laser Isotope Separation (ALVIS) system that consists of two main units - a separator and a laser. When used to separate uranium isotopes, natural uranium metal is vaporised in the separator, using an intense electron beam that creates a uranium vapour stream in a vacuum chamber that rapidly moves away from the uranium metal. The vapour contains atoms of U-235 and U-238.

The laser unit uses powerful copper-vapour lasers that emit beams of green-yellow light. This light energizes (excites) ‘dye’ lasers that emit beams of red-orange light of precisely the right colour (i.e., frequency) to photoionise preferentially U-235 atoms. The red-orange beams are passed through the vapour of uranium atoms.

U-235 atoms absorb photons of the red-orange light whereas U-238 atoms do not. The excited U-235 atoms eject the excited electrons, becoming ionised; the U-238 atoms remain untouched. An electromagnetic field moves the positively charged U-235 atoms to a collecting plate where they condense. The enriched U-235 can then be removed. The remaining uranium vapour, containing a much greater proportion of U-238 than natural uranium, flows on through the separator chamber and is removed.

The ALVIS photoionisation process has an atomic selectivity of more than 10,000 - only one ion of U-238 is produced for every 10,000 ions of U-235. This high enrichment efficiency, combined with the fact that relatively little energy is needed to operate the separator and laser systems, makes the operating and capital costs of the ALVIS process relatively low. This makes laser-isotope separation appear more attractive than other enrichment technologies.

Iranian laser enrichment research and development and the manufacture of copper vapour lasers have been undertaken in a laboratory located at Lashkar Ab'ad. A pilot plant for laser enrichment was established at Lashkar Ab'ad in 2000 and, the Iranians claim, dismantled in 2003.

Experiments with plutonium

The Iranian government has acknowledged to the IAEA that it has irradiated uranium dioxide targets with neutrons in the Tehran Research Reactor and subsequently chemically separated the plutonium produced in the targets. According to the Iranians, only a small amount of plutonium was separated.

If the heavy water reactor planned at Arak is used to produce plutonium for use in nuclear weapons, it will be necessary to chemically separate the plutonium from the irradiated reactor fuel elements. The experiments performed by the Iranians in plutonium separation are, therefore, significant.[1]

Iran's Ballistic Missiles

If Iran does develop nuclear weapons it will need a delivery system for them. It is likely to use missiles rather than bombers for this purpose. Iran has acquired ballistic missiles and the technology to produce them from China, North Korea and Russia. However, the missiles now deployed by Iran (the CSS-8, Musak-120, and SCUD-B and SCUD-C missiles) have ranges of less than 600 kilometres and are not suitable for the delivery of nuclear warheads.

Iran reportedly has three types of ballistic missiles under development – the Shahab-3, -4, and -5. The Shahab-3, that has reportedly been tested and deployed (by the Revolutionary Guards), has a range of about 1,300 kilometres. The Shahab-4, apparently under development and based on the Russian SS-4 missile (some say it is based on the North Korean Nodong-2 missile), may have a range of about 2,000 kilometres. The Shahab-5, said to be in early development and perhaps based on the Russian SS-5, may have a range of about 4,000 kilometres. The Shahab-3 and Shahab-5 may have payloads of about 750 kilograms and could deliver nuclear warheads, as could the Sahab-4, with a payload of about 1,000 kilograms.

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[1] Removing plutonium from spent reactor fuel elements (known as reprocessing) is straightforward chemistry. The elements are very radioactive and adequate shielding against radiation is required. The purex (an acronym standing for plutonium and uranium recovery by extraction) process is the standard chemical method for reprocessing. Unused uranium, plutonium, and fission products are separated from each other and from the fission products. The spent (irradiated) fuel is first dissolved into concentrated nitric acid. An organic solvent composed of 30% tributyl phosphate (TBP) in odourless kerosene is used to recover the uranium and plutonium; the fission products remain in the aqueous nitric phase. Once separated from the fission products further processing allows the separation of the heavier plutonium from the uranium. The PUREX extraction process uses a liquid-liquid extraction process in which a complex is formed between the tributyl phosphate and the extracted plutonium and uranium.

These missiles are, however, inaccurate. The Shahab-3, -4, and –5 missiles reportedly have circular error probabilities of about 190 metres, 50 metres and 190 metres respectively. They are suitable for attacks on large urban areas, like cities, but not ones on military forces.[2]

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[2] The circular error probability is the radius of the circle centred on a target within which one half of a large number of missiles, fired at the target, will fall.