

**SCIENCE AND
TECHNOLOGY**

072 STCMT 06 E
Original: English



NATO Parliamentary Assembly

**SUB-COMMITTEE ON THE PROLIFERATION OF
MILITARY TECHNOLOGY**

NUCLEAR POLICY OF IRAN

DRAFT REPORT

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International Secretariat

28 March 2006

* Until this document has been approved by the Science and Technology Committee, it represents only the views of the Rapporteur.

Assembly documents are available on its website, <http://www.nato-pa.int>

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I. INTRODUCTION

1. The end of the Cold War did not result in elimination of the menace of nuclear war. The threat of nuclear weapons ending up in 'wrong hands' is probably the greatest global security challenge. The international community has a rich history of launching various multinational initiatives agreements, such as Nuclear Non-Proliferation Treaty (NPT), designed to contain nuclear threats. Unfortunately, the world's record of circumventing these agreements is just as rich. Both nuclear- and non-nuclear-weapons states need to live up their parts of the NPT bargain: nuclear disarmament and peaceful exploitation of nuclear energy.

2. Nuclear programme of Iran constitutes a test case for global non-proliferation regime. How to define 'peaceful nuclear programme'? How to address the question of dual-use technologies? What instruments are in place for the international community to deal with transgressors? How to avoid the policy double standards towards certain countries? These are the fundamental questions that surface when discussing the case of Iran.

3. The Euro-Atlantic community, which our Assembly represents, needs to come up with a clear and unified strategy towards Iran's nuclear programme. Such a political strategy should be based on a sound and sober understanding of technological characteristics of this programme, in order to avoid certain myths that may lead to ill-founded decisions. Therefore, the goal of this report is to present a condensed overview of Iran's advancements in nuclear fuel cycle development, attempting to provide NATO legislators with a background for their political judgement. Your Rapporteur wishes to seize this opportunity to express her appreciation of the excellent analysis of nuclear and missile policies of Iran by Committee Rapporteurs Sen. Pierre Claude Nolin and Lothar Ibruegger in their 2004 reports on "Nuclear Weapons Proliferation" and "Missile Defences and Weapons in Space", respectively.

II. IRAN'S NUCLEAR PROGRAMME

A. HISTORY OF IRAN'S NUCLEAR PROGRAMME

4. Iran's nuclear ambitions date back to mid-1960s, when the pro-Western regime of the Shah Mohammed Reza Pahlavi acquired first modest nuclear capabilities from the United States - small 5-megawatt-thermal (MWt) research reactor for the Tehran Nuclear Research Center (TNRC). To its credit, Iran agreed to sign the Nuclear Non-Proliferation Treaty (NPT) in 1968 (ratified in 1970), and, in 1974, completed a comprehensive safeguards agreement with the IAEA. The geopolitical developments in early 1970s (Arab-Israeli conflict and the subsequent oil crisis) impelled the Shah's government to accelerate country's nuclear programme. The Atomic Energy Organisation of Iran (AEOI) announced ambitious plans to generate 23,000 MW of nuclear energy within 20 years (to illustrate, a typical 1,000 MW reactor can provide enough electricity for a modern city of close to one million people. Iran's population is now almost 70 million, considerably up from approximately 30 million in mid-1970s). The US authorities, and the administration of G.Ford in particular, together with French and German companies, were actively engaged in Iran's nuclear programmes, supplying Iran with different elements of nuclear fuel cycle technologies and even training Iranian nuclear scientists. Considerable progress was achieved in constructing two nuclear reactors in Bushehr.

5. These nuclear activities were halted and all the assistance from the West effectively stopped during and after the political turmoil in Iran in late 1970s, that resulted in deposition of the Shah. The new Islamic regime, led by the Supreme Leader Ayatollah Ruhollah Khomeini, showed little interest in their predecessors' aspirations. Moreover, many of Iran's top nuclear scientists fled the country. As a result of the war with Iraq, which broke out in 1980, constructions at Bushehr were

bombed and destroyed. On the other hand, the Israel's bombing of Iraq's Osirak nuclear facility in 1981, may have also provided disincentives for Tehran to further develop its nuclear programme. Nevertheless, the weapons research side of Iran's nuclear activities seemed to have continued uninterrupted by the revolution. Uranium conversion and fuel fabrication technologies have been examined at the Esfahan Nuclear Technology Center (ENTC), and some limited research have been conducted on uranium enrichment centrifuge technologies, including purchase of designs and samples from the A.Q.Kahn network in 1987.

6. In late 1980s, when Khomeini was replaced by a much more "pro-nuclear" Ali Akbar Hashemi Rafsanjani, Tehran decided to substantially revive its nuclear programme. Iran required considerable assistance from foreign suppliers, yet a number of countries refused (often under pressure from the US) to cooperate with Iran on this matter. Nevertheless, Tehran managed to conclude long-term cooperation agreements with Pakistan (in 1987. In mid-1990s, Iran also acquired components of P-1 centrifuges and blueprints of more advanced P-2 centrifuges from the A.Q.Kahn network) and China (several agreements between 1990 and 1992). China provided Iran with small research reactors, laser enrichment equipment, conversion technologies, and even shipped over a ton of natural uranium to Iran. China also reportedly trained Iranian nuclear technicians and engineers. In 1992, however, Beijing was persuaded by Washington to suspend its assistance to Iran.

7. In mid-1990s, Russia and Iran were developing plans for extensive cooperation, designed to assist Iran in acquiring full nuclear fuel cycle capabilities. However, after the explicit intervention by President Clinton, the Russia agreed to limit its assistance to building a light-water reactor at Bushehr. Apart from work on Bushehr plant, different Russian scientific entities continued to provide know-how assistance to the Iranian projects, such as the secret 40MW heavy-water production plant at Arak or the development laser enrichment capabilities.

8. In the beginning of the new millennium it became evident that Iran was seeking to develop a full-fledged nuclear fuel cycle capabilities. Substantial *reserves of uranium ore* were discovered as far ago as 1985 at Saghand, Yazd province. In 2000, Iran formerly declared the Esfahan *conversion* facility to the IAEA. At the same time the Iranian scientists and engineers were already able to begin first centrifuge-based uranium *enrichment* tests. In 2000, Iran began construction of a secret pilot- and industrial-scale centrifuge facilities at Natanz. The *heavy water* and *laser enrichment* capabilities were already briefly mentioned. Tehran denied the existence of Natanz and Arak facilities, until the National Council of Resistance of Iran (NCRI), an exiled Iranian opposition group, revealed it in August 2002. These events convinced many in the West that Iran was developing a nuclear power plan that would rely solely on indigenous resources.

9. In February 2003, Iran President Khatami officially acknowledged the existence of Natanz and Arak facilities and full fuel cycle plans. The IAEA officials visited Iran several times and were allowed to take environmental samples at the Natanz facility. The analysis of these samples revealed particles of both LEU and HEU. The Iranian authorities attributed the particles of HEU to contamination originating from imported centrifuge components, thereby indirectly admitting that Iran had collaborated with the A.Q.Kahn network. In his report to the IAEA Board of Governors (BoG), in November 2003, the IAEA Director-General Mohamed ElBaradei revealed the scope of Iran's covert nuclear programme, including development of uranium enrichment, conversion and reprocessing capabilities. Mr. ElBaradei concluded that "Iran has failed to meet its obligations under its Safeguards Agreement". The BoG reiterated this message in the subsequent resolution, choosing, however, not to refer the issue to the UN Security Council, an option preferred by the US.

10. The foreign ministers of Germany, France and the United Kingdom, the so-called E3, took the initiative, focusing primarily on engagement with Iran, rather than confrontation. Iran agreed to cooperate with the IAEA with full transparency, sign the Additional Protocol to the NPT,¹ and

suspend all enrichment and reprocessing activities for an "interim period." Iran signed the Additional Protocol on 18 December 2003. Although the Iranian parliament never ratified this Protocol, Iran voluntarily abided it until February 2006, considering it as a 'voluntary confidence-building measure'.

11. In 2004, the cooperation between Iran and the IAEA progressed with mixed success. Despite suspension, Iran believed it had retained the right to proceed with some, less sensitive, fuel-cycle-related work. In summer 2004, the BoG of IAEA again criticized Iran for its failure to provide the agency with "full, timely and pro-active co-operation". In response to criticism, Iran announced its plans to resume enrichment activities at Natanz as well as conversion activities at Esfahan. The tensions were partly settled in November 2004, when the foreign ministers of the E3 and Iran and the EU High Representative Javier Solana signed a new agreement in Paris. Iran agreed to sustain the suspension,ⁱⁱ while the E3 obliged to prepare a number of proposals to guarantee fuel supplies to Iran.

12. In August 2005, when the E3 was about to present a package of detailed European proposals, Tehran unilaterally decided to resume uranium conversion activities in Esfahan. Ever since, the tension seems to be escalating rapidly. Following the IAEA Director General's report, the BoG adopted a resolution (22 in favour, 12 abstentions and only 1 against)ⁱⁱⁱ on 24 September 2005, finding Iran in non-compliance with its obligations under its Safeguards Agreement.

13. In January 2006, Iran removed U.N. seals at Natanz uranium enrichment plant and resumed research on nuclear. Iran also announced that it would no longer comply with voluntary measures (Additional Protocol) designed to enhance international inspectors' access to its nuclear facilities. On 4 February 2006, the BoG voted to report Iran's nuclear case to the United Nations Security Council, albeit leaving one month for Iran to revise its policy. The resolution, which passed by a vote of 27 to 3 with five abstentions, reflects increasing suspicion around the world that Iran is determined to develop nuclear weapons. The latest report of Mr. ElBaradei (February 2006) once again noted that Iran was advancing its uranium enrichment program. However, the IAEA still was not able to determine whether the country was secretly developing nuclear weapons. At the time of writing, the issue of Iran was about to be considered in the Security Council. The year of 2006 is expected to be a crucial year in the saga surrounding the Iran's nuclear programme.

B. NUCLEAR-FUEL-CYCLE RELATED FACILITIES

1. Mining and milling

14. Iran has its own reserves of uranium ores, but they are not rich. Proven reserves include more than 3,000 tons uranium oxide (U_3O_8). However, it is possible that further explorations will discover additional resources at the range of 20,000-30,000 tons of U_3O_8 .

15. The largest uranium mine in Saghand reportedly 1,55 million tons of uranium-bearing ore. However, natural uranium constitutes only 0.05% of it, or approximately 775 tons. The deposits are situated deeply below the surface, thus making the extraction process rather costly. Iran plans to reprocess 100-120 thousand tons of Saghand ore annually, producing 59-70 tons of yellowcake (containing 50-60 tons of natural uranium). Iran also opened a smaller near surface mine at Gchine, which is expected to supply more than 20 tons of uranium annually. Construction of milling facilities both at Saghand^{iv} and Gchine is nearing completion. In developing its mining and milling capabilities, Iran received significant assistance from Russia and China.

16. According to media reports, Iran has recently made a new breakthrough in its 'yellowcake' production programme, successfully using biotechnology. According to the manager of this Iranian project, "the new technique used for the production of yellowcake will reduce costs, and efficiency will increase one hundred-fold as well."^v

2. Conversion

17. Iranian scientists started some small-scale covert uranium conversion activities (i.e., converting yellowcake into UF_6 gas to make uranium suitable for enrichment in centrifuges) at the Esfahan Nuclear Technology Center (ENTC) already in 1980s, as well as at the Tehran Nuclear Research Center (TNRC) in 1990s. Considerable assistance was once again provided by China, including significant supply of uranium compounds in 1991, which Iran did not declare to the IAEA. These compounds included 1.9 kg of UF_6 , 402 kg of UF_4 and about 400 kg of natural UO_2 . In 2000, the Iranian government informed the IAEA that a plant for uranium conversion was being constructed at Esfahan. The conversion plant is intended to have process lines for production of UF_6 , unenriched uranium dioxide UO_2 (which can be used as fuel in certain reactors, such as heavy-water reactors), and uranium metal (potentially usable in fabrication of some elements for reactors as well as for weapons, including nuclear weapons). Conversion activities in Iran were officially suspended in 2003, and restarted in August 2005. According to the latest IAEA Director General report, Iran has already produced 85 metric tonnes of UF_6 at its uranium-conversion facility in Esfahan since September 2005, which would be enough for several atomic bombs once Iran masters full-scale enrichment technology.

3. Enrichment

18. Iran's uranium enrichment programme is based on gas centrifuge technology, although some progress was made in laser enrichment as well.

19. **Centrifuge programme.** As mentioned before, Iran has been engaged in some initial centrifuge-based enrichment research and development since 1985. Covert activities mostly took place at the Kalaye Electric Company facility. In 2003, Iran admitted that gas centrifuges were tested with uranium gas at this site between 1998 and 2002. However, Iran claims that it did not enrich uranium beyond 1.2 percent U-235. Samples of HEU particles, later found by the IAEA inspectors at Kalaye as well as at Natanz facility, were attributed to imported Pakistani centrifuges.

20. As revealed in 2002, Iran has been constructing a pilot-scale centrifuge facility and a larger, as yet incomplete, industrial-scale centrifuge facility, both located at Natanz, approximately 200 miles south of Tehran. Iran planned to install up to 1,000 P-1 centrifuges (organized in 6 cascades) at the pilot fuel enrichment plant (PFEF). Before of suspension in November 2004, the site contained one 164-machine test cascade. The commercial-scale fuel enrichment facility (FEP) is expected to house over 50,000 centrifuges. In addition to the P-1 centrifuges, designs and components of which are widely believed to be acquired from the A.Q.Kahn network, Iran has a program to develop the much more advanced P-2 model (which are also associated with Kahn's network). Revealing of P-2 plans raised suspicions in the West that Iran was pursuing clandestine military-related enrichment activities in some undiscovered facilities. Iran has procured magnets useful in the P-2 from Asian suppliers and has sought to acquire about 4,000 magnets suitable for the P-2, which indicates that Iran's P-2 centrifuge programme might be larger than officially declared. However, IAEA inspections were unable to find any evidence substantiating such claims.

21. After the suspension period in 2003-2005, Iran announced resumption of uranium enrichment work at Natanz 164-machine test cascade in January 2006. In fact, Iran will first need to repair or replace these test centrifuges, damaged during the suspension, which will take at least from six months to one year. It will then need to build new larger cascades able to produce significant amounts of enriched uranium.

22. **Laser enrichment.** Iran's laser enrichment programme dates back to 1970s and is based on two main techniques: atomic vapour laser isotope separation (AVLIS) and molecular isotope separation (MLIS). Laser isotope research and development programme was conducted at two

facilities: Lashkar Ab'ad laser laboratory and TNRC's Laser Research Center. Although Iran's initial denial of laser enrichment activities rose some suspicions, the IAEA believes that these works do not pose serious non-proliferation threats. Laser enrichment techniques are extremely sophisticated, and Iran, despite receiving some assistance from China and, allegedly, Russia, was only able to produce insignificant quantities of LEU.

4. Fuel Fabrication

23. Iran's progress in fuel fabrication has been rather slow. Iran admitted that, from 1985 to 1993, it conducted a series of laboratory-scale operations at Fuel Fabrication Laboratory of the Esfahan Nuclear Technology Center. However, the plans for construction of a commercial-scale fuel fabrication plant (FMP) at Esfahan were announced only in recent times. This facility is expected to produce both low-enriched UO₂ fuel pellets (for Bushehr light-water reactor) and natural UO₂ pellets (for heavy-water reactors). It is difficult to predict when such a plant will become operational, yet is likely that the FMP will need years to be able to produce sufficient quantities of fuel for Bushehr plant.

5. Reactors

24. The *light-water* plant at Bushehr, the key element of Iran's nuclear power generation programme, is a joint project with the Russian Federation. According to the Russian-Iranian agreement of 1995, Russia was to invest \$800 million to build 1,000 MW pressurised light-water reactor based of Russian designs. By 2006, the Bushehr facility is almost complete. Since Iran is not yet able to produce enough indigenous fuel for the Bushehr reactor, it will heavily rely on Russia's supplies in upcoming years. The key pre-condition was the requirement to return the spent fuel back to Russia, thereby depriving Iran of possibility to extract plutonium from the spent fuel. After lengthy negotiations, in February 2005 Iran and Russia finally reached such an agreement on long-term Russian nuclear fuel supplies for the Bushehr facility.

25. The capacity of Bushehr plant (1,000 MW) is not sufficient to meet Iran's ambitious plans for nuclear power generation (7,000 MW by 2020). Therefore, Iran is also considering the construction of up to six additional reactor facilities, which may or may not be located at Bushehr. Russia's assistance is critical to achieve this goal.

26. Iran also operates four small research reactors (one in Tehran and three in Esfahan), but they do not seem to be capable of producing significant quantities of fissile material.

27. Iran has also been engaged in efforts to develop *heavy water* technology. In 2003, Iran announced plans to construct a 40MW heavy water moderated research reactor (IR-40) at Khondab near Arak. The foundations for IR-40 were laid in 2004, and works proceed at a rapid pace. Iran claims that IR-40 is designed purely for production of industrial and medical radioisotopes, many Western experts believe it is larger than necessary for research. If operating in full capacity, this reactor has a potential of producing up to 14 kg of plutonium (enough to construct 2 nuclear bombs) annually.

28. The heavy water for the IR-40 reactor is to be produced at the Arak Heavy Water Production Plant (HWPP), the construction of which began in 1990s and was revealed in 2002. The plant is nearly completed by now. While IR-40 requires approximately 80-90 tons of heavy water, HWPP's official capacity is only 16 tons of heavy water per year. Two Russian nuclear research institutes are suspected of having assisted Iran in developing its heavy water technologies.

6. Reprocessing

29. Iran claims that it has no plans to develop a tangible reprocessing capability. In its declaration to the IAEA in 2003, Iran admitted that it conducted some laboratory-scale reprocessing experiments at TNRC in 1990s, using "glove boxes" in a "hot cell".^{vi} Although the IAEA inspections found some discrepancies to the Iran's report, in general, Iran's progress in reprocessing R&D is not considered significant.

7. Waste management

30. Iran constructed waste storage sites at Karaj (related to the laser enrichment programme), Anarak and Tehran (in both waste resulting from the processing of the imported material is being stored). A new storing facility is designed in Esfahan.

31. This brief overview indicates that Iran is seeking, sometimes with mixed success, to master each step of nuclear fuel cycle.

C. PEACEFUL PROGRAMME?

32. The attempts to assess Iran's nuclear programme in terms of its peacefulness is not an easy task. Most of nuclear fuel cycle technologies can be of dual use, and, as a former chairman of the Israeli Atomic Energy Commission, David Bergmann put it "...by developing atomic energy for peaceful uses, you reach the nuclear weapon option. There are not two atomic energies."^{vii}

33. The very fact that Iran joined the NPT in early 1970s (although Iran could have followed the path of India, Pakistan or Israel) indicates that at least originally the nuclear programme was meant to be peaceful. Later, numerous reports were published on Iran's alleged pursuit of nuclear weapons, yet intelligence was not able to provide indisputable evidence of that. A 1992 CIA estimate concluded that Iran would have the nuclear bomb by 2000, which clearly did not happen.

34. Nevertheless, based on totality of indirect evidence, one can draw some conclusions about the nature of Iran's nuclear endeavours. Many prominent experts envisage that Iran will become a nuclear weapons state within several years (most predictions vary within the framework of 2009 to 2012). Estimations are usually based on the supposed timeframe of development of Iran's known nuclear capabilities. However, the possibility of undisclosed nuclear programme, albeit unlikely, should not be completely ruled out.^{viii}

1. The potential of producing weapons-grade material

35. Looking from a technological standpoint, and leaving aside political considerations, Iran's ability to produce sufficient quantities of weapons-grade fissile material depends on progress in completing Natanz enrichment facility (for production of HEU), and the light-water reactor in Bushehr and heavy-water reactor in Arak (for production of weapons grade plutonium).

36. The pilot enrichment facility at Natanz (PFEP) is only partially furnished (164 centrifuges out of planned 1,000), and, according to the analysis of the International Institute for Strategic Studies (IISS), it would require no less than 13 to 17 years for such a 164-centrifuge plant, operating under ideal conditions, to produce enough HEU for a single nuclear bomb (approximately 25 kg). If operating in full capacity with all 1,000 centrifuges (reports suggest that Iran might be not too far away from achieving this goal, since Iran has manufactured components for more than a thousand P-1 centrifuges), PFEP would still need more than two years to produce 25 kg of HEU. If, however, the large (50,000-centrifuge) commercial scale facility (FEP) becomes fully operational (which still is at least a decade away), Iran would be able to produce enough HEU for 1 nuclear bomb within 2-3 weeks (or for approximately 20 nukes per year).^{ix}

37. The above estimations are based on the assumption that the enrichment facility operates on natural uranium. Yet, if LEU is used as feed material, HEU can be produced up to seven times faster. It should be noted, however, that Iran's PFEF will not be capable of produce the sufficient amount of LEU in a few years. Another option thus might be using imported LEU, for example – Russian LEU designated for the Bushehr plant. In addition, the efficiency would be increased more than two times, if P-1 centrifuges were replaced by more advanced P-2.^x

38. On the other hand, technology reconfiguration factor also needs to be taken into account. Centrifuge cascades at Natanz pilot plant are designed to produce LEU, and it would take many months to optimise it for HEU production. If the IAEA monitoring was sustained, such reconfiguration activities would be impossible to conceal. However, the large enrichment facility, such as FEP, could potentially start producing HEU without essential reconfiguration. Various technological hurdles are likely to put off Iran's alleged nuclear weapons programme at least by one to two years.

39. To estimate Iran's ability to produce a plutonium-based nuclear bomb is even more difficult. On one hand, there is very little evidence that Iran is developing spent fuel-reprocessing capability, apart from covert, laboratory-scale experiments in 1988-1998, when Iranian scientists produced a small amount of plutonium outside of the IAEA safeguards. Nevertheless, there are indications that Iran seeks to attain capacity to separate plutonium from spent fuel. According to French experts, Iran has sought to acquire high-density radiation shielding windows for hot cells and 28 remote manipulators from the French nuclear industry. Such equipment is designed for the extraction of plutonium from spent reactor fuel.^{xi}

40. In addition, heavy-water technology programme at Arak seems to advance rapidly, thereby providing a potential for Iran to obtain considerable amount of spent fuel from natural uranium. A number of experts note that the type of heavy-water reactor Iran is constructing is larger than necessary for research, and some countries have used it to produce bombs.^{xii}

41. The light-water reactor in Bushehr, although a purely civilian enterprise, might also pose some proliferation threat. According to a comprehensive study by the US Nonproliferation Policy Education Center, light-water reactors are not nearly so "proliferation resistant" as they have been widely advertised to be. Theoretically, the Bushehr nuclear power reactor could produce sufficient amounts of spent fuel to accumulate substantial quantities of weapons-grade plutonium within only a few months of operating.^{xiii}

2. Iran's record of concealment

42. Iran is not the only country in the world that is seeking to develop a full nuclear cycle capabilities for peaceful uses. Under certain conditions, this right is granted to all nations under the Article IV of the NPT. The problem lies elsewhere – there is a lack of trust in Iran due to its long history of concealment of its nuclear research and activities. Admissions of these activities have been grudging and piecemeal. Even during the period of relatively extensive cooperation with the IAEA in 2002-2005, Iran, as outlined in IAEA reports, was engaged in a systematic practice of denial and misleading statements. For example:

- Iran failed to acknowledge its enrichment programme at Natanz until it was publicly revealed in 2002. Even after the revelation, Tehran presented false information concerning duration of the enrichment activities.
- Iran denied the foreign origin of its gas centrifuges until the IAEA experts found HEU particles in environmental samples taken at the Natanz and Kalaye facilities.
- Iran initially denied it carried out enrichment activities at Kalaye Electric Company facility.
- At one site called Lavizan, facilities were bulldozed by Iran before the IAEA could look at them and take samples.

- Only recently Iran admitted it conducted, for a number of years, laboratory-scale conversion and laser isotope separation experiments, using uranium compounds not declared to the IAEA. Iran also conducted undeclared plutonium separation experiments.

43. Tehran denounces most the allegations of deception. Iran's ambassador to the IAEA Mr. Ali A.Soltanieh asserted that, in most cases, these allegations are baseless. The laboratory scale researches in Iran, he argued, were very limited, and their results were not deliberately concealed. Plutonium separation activities were paltry, and effectively terminated in 1993. The dismantled equipment was presented to the Agency's inspectors. With regard to initially undeclared facilities at Natanz, Iran argues that a country is not obliged to report such facilities to the IAEA when constructions begin, but rather no earlier than 180 days before nuclear material is introduced to a facility.

3. Cooperation with A.Q.Kahn's network

44. Another source of mistrust in Iran's nuclear endeavours is related to its past relations with the clandestine network of Dr. A.Q.Kahn. Iran would not have been able to achieve so much progress in nuclear technology, had it not received essential centrifuge equipment, designs and know-how from this Pakistani proliferator. The specific examples of this cooperation are constantly referred to throughout our report.

4. Economic rationale of nuclear policy

45. A number of experts question the peaceful nature of Iran's nuclear programme by arguing that Iran has no reason to generate nuclear power, since it possesses natural gas and oil in great abundance.^{xiv} Your Rapporteur does not share such emphatic claims. Indeed, under current rates of production and consumption, Iran's known oil resources will be depleted in 88 years, and natural oil recourses only in 220 years. However, Iran's population is growing at an incredible pace, more than doubling during last three decades. Electricity consumption is also growing exponentially. Thus, Tehran has the inalienable right to prepare for the future with some further diversification of its energy policy and cannot rely exclusively on fossil energy. In addition, it might appear economically wise to increase exports of oil and gas by decreasing internal consumption of these resources.

46. However, it remains questionable whether Iran really needs to develop all elements of nuclear fuel cycle. For example, Tehran's investment in uranium ore mining and milling does not make much sense in economic terms. In addition to being difficult and costly to extract, Iran's known uranium deposits would not be sufficient to provide enough fuel for the lifetime of Iran's only Bushehr reactor, yet Iran plans to construct several additional reactors. Even if all speculative (not proven) uranium deposits were found and extracted, it would not be possible to sustain seven reactors on indigenous fuel for longer than several years. On the other hand, theoretically Iranian uranium reserves are sufficient to produce a significant number of nuclear weapons.

47. It is obvious that Iran will have to rely on foreign (most probably Russian) supplies of nuclear fuel for its civilian reactors. Therefore, there is no clear economic justification for the huge, 50,000-centrifuges enrichment facility planned at Natanz.

48. The international community is trying to talk Iran from developing all nuclear cycle capabilities by suggesting other options. The famous "Russian proposal", which has won support from other UN Security Council members – including the United States – would allow Iran to obtain the enriched uranium it needs for civilian nuclear power directly from Russia. All spent fuel would be sent back to Russia. That would remove a key process in the development of a nuclear program from Iranian hands but still allow Tehran to develop the peaceful energy program it says it

wants. Unfortunately, Iranian negotiators seem to object such plan because they are determined to maintain their right to retain some level of enrichment activity in Iran.

49. At this stage, it's unclear whether Russia or Iran would be doing the fuel fabrication. If Iran were allowed to take possession of the low-enriched uranium that has not been converted into fuel, Iran could potentially use it as input to a clandestine enrichment plant to make HEU.

50. Most experts say concrete action on the Russian plan is unlikely any time soon. The process is likely to drag on for months. If the deal does not come through, Iran certainly ran out of options to gain more time, and UN Security Council intervention is inevitable.

5. Involvement of the military

51. Finally, the critics of Iran assert that Iranian military is highly involved in country's nuclear programme, thereby unveiling the genuine purpose of this programme. In January 2006, the IAEA issued a short report which stated that the IAEA possesses evidence that indicated possible interconnections between Iran's nuclear programme and Iranian activities of a military nature. For instance, seven of the 13 Iranian workshops involved in producing centrifuge components are located on the sites controlled by the Iranian ministry of defense.^{xv}

52. Furthermore, the NCRI, the Iranian dissident organization, announced that Iran had been testing explosives at Parchin and Lavizan II military bases for use in an implosion-type nuclear weapon. IAEA inspectors visited the Parchin military complex and found nothing suspicious. Nevertheless, it seems that some doubts still remain, as the IAEA is repeatedly seeking access to these sites to continue its investigation.

III. NUCLEAR WEAPONISATION

53. Producing critical mass of missile material is not enough if a country is determined to become a nuclear weapons state. Additional devices, such as trigger mechanisms, are also required, as well as means to deliver a nuclear bomb, i.e., missiles capable of carrying nuclear warheads.

A. BUILDING A BOMB

54. There have been no confirmed evidence that Iran has worked on nuclear bomb designs. However, based on indirect data, some reports suggest that Iran could be trying to make a nuclear device. British, French, German and Belgian intelligence agencies prepared a 55-page intelligence assessment, dated July 1 2005, which has been used to brief European government ministers. According to the assessment, Iran has been pursuing, with apparent success, sophisticated equipment and expertise needed to develop a nuclear bomb in some European countries.^{xvi}

55. Indications that point to Iran's alleged interest in constructing a nuclear device include:

- In November 2005, IAEA inspectors discovered that Iran received information related to casting and machining uranium metal into hemispherical forms from the A.Q. Khan network. The only known use for such forms is in nuclear weapons.
- The production of materials such as uranium metal points in the direction of military ambitions as well.
- In September 2003, the IAEA discovered that Iran had experimented with production of polonium-210 (Po-210). While this radioisotope also has some civilian applications (such as in nuclear batteries), the Po-210 is best known for its uses as a trigger for nuclear chain reaction in certain types of nuclear weapons.

- Iran also has reportedly sought to acquire deuterium gas from Russia. Deuterium gas can be used to trigger thermonuclear reactions in hydrogen bombs.
- According to the French intelligence report, Iran has sought nuclear tests and simulation technology.
- Media also reported that Iran's unsuccessful attempt to purchase 44 high-voltage switches a German company. These switches might be used to trigger nuclear weapons.

B. MISSILE PROGRAMME

56. Along the nuclear program, Iran maintains a serious missile program by means of developing an indigenous missile production capability. Iran has received substantial technological aid and know-how from a number of countries, amongst them Russia, North Korea and China. Missile imports in the recent past – notably from North Korea, Syria, and Libya – contributed in a major way to Iran's arsenal, and also played a significant role in development.

1. Short range ballistic missiles

57. Currently the Scud B guided missile forms the core of Iran's ballistic missile forces. It is a relatively old Soviet design that first became operational in 1967. With a range of 290-300 kilometres it is capable of hitting cities like Baghdad. It can be equipped with nuclear as well as biological and chemical warheads. According to most estimates Iran now has up to 250-300 Scud B missiles, and is capable of manufacturing virtually all parts of the missile, with the possible exception of the most sophisticated components. Iran also possesses newer long range North Korean Scuds, often referred to as Scud C, with ranges near 500 kilometres. Most sources report the number of missiles to be over 100. The older and improved versions of Scuds are likely to have enough range to give Iran the ability to strike targets on the southern coast of the Gulf and most of the populated areas in Iraq.

2. Medium range ballistic missiles

58. Numerous reports attest that Iran has ordered the North Korean No Dong missile, which was planned to have the capability to carry nuclear warheads with ranges up to 900 kilometers. The No Dong 1 is liquid fueled missile with a range of up to 1000 to 1300 kilometers. This range would allow the missile to hit virtually any target in the Gulf, Turkey and, Israel. Iran was also interested in the Tapeo Dong 1 and Tapeo Dong 2. The estimated maximum ranges of them are 2000 and 3500 kilometers respectively.

59. Since the early 1990, it has become clear that Iran is developing its own longer-range variants of the No Dong with substantial Russian and Chinese aid. In 1997 Iranian tests included the successful firing of the Shahab missile. Israeli reports indicated that the Shahab 3 was a liquid fueled missile with a range of 1200 to 1500 kilometers. It is known to be a very accurate weapon carrying a warhead of one ton. It was first displayed at a military parade in 1998, with the carrier boring signs saying, "The U.S. can do nothing" and "Israel would be wiped from the map". According to NCRI and other sources, the Shahab 4 system with a range of 2000 kilometers, although officially abandoned in 2003, is still in development.

3. Long-range ballistic missiles and the space programme

60. Based on up to date reports, Iran does not yet have long-range intercontinental ballistic missiles (ICBMs) at its disposal, neither the capability to manufacture them. Analysis differs on the likely timing of Iran's first flight test of an ICBM that could threaten all of Europe and the continental United States. Assessments include it to be likely before 2010 and very likely before 2015.

61. There are numerous conflicting reports, amongst them some statements made by Iranian officials, on the development of the Shahab missile family. The Shahab 5 is expected to have a range of anywhere in between 3500 and 4300 kilometers with a one ton warhead, and there is known to be an improved version, called the Shahab 6 carrying the same warhead to ranges up to between 5500 and 6200 kilometers. The development status of these missiles remains unclear; progression however is likely to be slow as it greatly depends on foreign aid in technology and 'know-how'.

62. Some reports speculate that Iran is pursuing a space programme as well. Considerable concern has been expressed that Iran is trying to disguise its ballistic missile program under the pretension of peaceful space launch programs. According to the former head of Israel's anti-missile program Uzi Rubin, Iran is aggressively pursuing space launch technology that would make it capable of launching satellites. He calculated that Iran "could launch a 300-kilogram [660-pound] satellite within two years, something that would pose a strategic threat to both Israel and the U.S."^{xvii}

63. The US 2001 National Intelligence Estimate indicated that Iran could to launch a space launch vehicle (SLV) already in the second half of the decade. In 2004, this notion was reiterated by Director of Central Intelligence George Tenet.

IV. IMPLICATIONS FOR THE NUCLEAR NON-PROLIFERATION REGIME

64. The case of Iran clearly illustrates the vulnerabilities of the current international system of nuclear non-proliferation. If unchallenged, Iran's example could be emulated by its neighbours, thus further escalating tensions in the region. Under Article IV of the NPT, the Non-Nuclear Weapons State is given an "inalienable right to develop research, production and use of nuclear energy" only if it agrees to forego nuclear weapons capability and to fully cooperate with the IAEA under the Safeguards agreement. The major difficulty is that the present international norm is too permissive.

65. The fact that Iran violated the NPT was recorded in June 2003, in Dr. Eibaradei's report to the IAEA Board of Governors. The IAEA has documented an extensive list of such instances. However, the NPT does not provide tangible and automatic sanctions against such violators. Furthermore, the NPT is not able to provide effective instruments for the international community to deal with possible 'break out' scenarios. The treaty also fails to effectively address the problem of dual-use nature of nuclear reactors and fissile materials. Finally, the IAEA's verification authority remains limited even when a country is found in non-compliance.

66. Unfortunately, the NPT Review Conference in New York in May 2005, expected to address these issues, ended without any results. It is particularly disappointing, as the next conference will take place only in 2010. The differences over Iran were one of the major reasons for the lack of any positive outcome of the conference. Despite of the failure of the Review Conference, follow-up meetings should continue in all possible formats.

67. Needless to say, the NPT/IAEA inspection system needs to be more robust. Pierre Goldschmidt, former head of the IAEA Safeguards department, urged the UN Security Council to adopt a generic binding resolution establishing automatic consequences when a state has been found by the IAEA to be in non-compliance with its safeguards agreement. Such consequences should include:

1. The agency's verification authority should be immediately widened, giving inspectors immediate access to relevant locations, individuals and documents.

2. A state would be obliged to conclude with the IAEA an INFCIRC/66-type safeguards agreement, which would effectively block a noncompliant state from withdrawing from the NPT.
 3. The 10 years moratorium would be established by the UN Security Council for sensitive nuclear fuel cycle-related activities.
68. Various experts, diplomats and politicians suggested a number of additional measures, such as:
- Increasing the costs of withdrawal from the treaty by requiring to surrender and dismantle their nuclear capabilities obtained within the framework of the NPT. Violators should also lose the right to no longer receive nuclear assistance or exports from any other NPT member state.
 - "Carrots" are also very important: non-nuclear-weapons states (NNWS) should receive explicit guarantees of assistance from the nuclear-weapons states and the IAEA.
 - The nuclear-weapons states should also demonstrate their resolve to uphold their part of the NPT bargain, i.e., to seek "the total elimination of their nuclear arsenals." The lack of progress in this area provides an excuse for some NNWS. Israel could also be encouraged to take the first steps to freeze and dismantle its nuclear capabilities.
 - The essential breakthrough is necessary in the attempts to prohibit the production of weapons-grade fissile materials. Unfortunately, the negotiations on fissile material cut-off treaty (FMTC) reached an impasse, primarily due to the unwillingness of China and scepticism of the US government. Washington's position is based on a notion that effective verification of this treaty would not be feasible. However, many experts believe that new technologies, combined with intrusive inspections, might enable the international verification agency to detect even tiny amounts of materials for nuclear weapons.
 - It is absolutely essential to make supply of nuclear technologies and material contingent on states' accession of and adherence to the Additional Protocol.
 - IAEA Director General ElBaradei suggests to multilateralize the nuclear fuel cycle, i.e., a group of countries would agree among themselves to develop different elements of nuclear fuel cycle.

V. CONCLUSIONS

69. The available information on Iran's nuclear programme explains why the questions about its peacefulness are raised by the international community. It is quite evident that Iran has been seeking to develop all elements of nuclear fuel cycle, although its progress in different areas is not comparable. For instance, while Iran's ultimate enrichment plans of 50,000-machine facility are extremely ambitious, Tehran does not seem very resolute to build a plant to fabricate fuel for reactors. Iran is determined to exploit vigorously its modest uranium ore mines and to convert the 'yellowcake' into 'hex' at Esfahan, yet it so far was not able to present any tangible plans of building additional power reactors. In other words, Iran seems to make greater progress in those steps of nuclear fuel cycle that can be potentially used to create a HEU-based nuclear weapon. It is quite safe to assume that, technologically, Iran is only several years from acquiring such weapon.

70. On the other hand, the existing data does not support the claim that Iran might be actively developing a plutonium bomb. The purpose and extent of heavy-water-related activities at Arak may not be convincingly reasoned, but there is virtually no indication that Iran has acquired necessary reprocessing capabilities and expertise to extract plutonium from the spent fuel.

72. It is practically impossible to conceal production of nuclear weapons material in a country that permits intrusive IAEA inspections. For example, to produce HEU at Natanz pilot enrichment plant, visible reconfiguration of centrifuges would be required. Therefore, inducing Iran to revive its

comprehensive cooperation with the Agency, based on the Additional Protocol, is vital to appease the international community. The presence of IAEA inspections does not, in any way, impede Iran's declared striving for peaceful nuclear energy.

73. The resolution of the current crisis will have profound impact on global nuclear non-proliferation regime as a whole. Therefore, the decisions need to be thought-out, well balanced and based on reliable technological analysis. Although, according to the famous quote of Dr. ElBaradei, the patience of the international community is running out, Your Rapporteur is convinced that there is still time and room to try to engage Iran into cooperation, and avoid drastic measures and confrontation.

ANNEXE 1: THE CONCEPT OF NUCLEAR FUEL CYCLE

The era of nuclear energy started with the famous Albert Einstein's equation $E=mc^2$, which states that mass and energy are equivalent. Since c (the speed of light) is a huge amount (300,000 km/s), especially when squared, even a tiny bit of mass can be converted into an enormous amount of energy. The physicists discovered that some heavy atoms spontaneously fission, or split, into lighter atoms, and that considerable amount of energy is yielded during the process.

Uranium is the heaviest of all the naturally occurring elements. Uranium as found in the earth's crust is a mixture largely of two isotopes (forms of one chemical element with different number of neutrons): uranium-238 (U-238), accounting for 99.3% and U-235 about 0.7%.^{xviii} The latter is the cornerstone of nuclear power generation as it is less stable and therefore undergoes fission much more readily. Hit by a neutron, U-235 atom splits into lighter elements, such as barium and krypton, and at the same time emitting 2 or 3 highly energetic neutrons. These neutrons, in turn, hit other U-235 atoms, thereby causing a chain reaction. The mass of U-235 plus the neutron coming in is slightly bigger than the aggregate mass of all the elements after fission. This minuscule lost of mass converts into an immense outburst of energy, according to the Einstein's formula.

Uranium, or "nuclear", fuel cycle (NFC) is a complex of techniques for nuclear power generation. NFC is a much more complicated and compound process than the fuel cycles of oil, natural gas or coal. NFC can be divided into three major parts:

1. The "front end" of NFC, i.e., preparing uranium for use in a nuclear reactor. The "front end" includes such steps as:
 - Mining and milling
 - Conversion
 - Enrichment
 - Fuel fabrication
2. Power generation in reactors
3. The "back end" of NFC, i.e., managing the 'spent fuel'. This includes:
 - Temporary spent fuel storage
 - Reprocessing and recycling
 - Waste disposal

Mining and milling. Although uranium occurs naturally in most rocks and seawater, only a small fraction is found in concentrated ores. Uranium-bearing ores can be mined on the surface, underground, or using *in situ*^{ix} leaching. The mined ore then goes to a milling facility, where, through a series of mechanical (grinding) and chemical processes, uranium oxide (U_3O_8) concentrate (also known as 'yellowcake') is separated from a waste rock. The yellow cake typically contains more than 60% of uranium. The 'yellowcake' is the form in which uranium is sold. The waste from the mill, called mill tailings, is 99% of the weight of the original ore.

Conversion. Before it can be enriched, uranium has to be in the form of a gas. Therefore at a conversion facility, the 'yellowcake' (U_3O_8) is, through a number of chemical processes, converted into the gas uranium hexafluoride (UF_6 , often referred to as 'Hex'), which is a gas at relatively low temperatures.^{xx} The process of conversion is also used to remove impurities remaining after milling. UF_6 can also be converted into a uranium metal (this process is called reduction), which can be used to fabricate some elements for reactors as well as for nuclear weapons.

Enrichment. Uranium enrichment process serves to increase the share of a more radioactive U-235 isotope at the expense of U-238. For most of commercial nuclear power reactors, it is sufficient to increase the proportion of the U-235 from its natural level of 0.7% to 3-4%. The

research reactors normally use 12-20% enriched uranium. Uranium enriched above the natural U-235 abundance but to less than 20 percent is called low enriched (LEU).

Uranium enriched to 20 percent or more U-235 is called highly enriched (HEU). The nuclear-bomb-grade uranium contains more than 90% of U-235, though for a crude weapon even 20% might be sufficient. HEU is also used to power warships, particularly nuclear submarines.

Several enrichment techniques have been used:

- Electromagnetic isotope separation (EMIS), one the earliest techniques, used to produce the Hiroshima bomb. EMIS employs large magnets to separate ions of the two isotopes.
- Thermal diffusion, which produces cold and hot convection currents across a thin liquid or gas. The lighter U-235 gas molecules will diffuse toward the hot surface, while the heavier U-238 molecules will diffuse toward the cold surface.
- Gaseous diffusion, also an early method, in which a porous barrier material separates the lighter and faster molecules of UF_6 containing U-235. Although still a popular technique (about 40% of world enrichment capacity), the gaseous diffusion seems likely to be replaced by a more advanced gas centrifuge technology.
- Gas centrifuge, in which UF_6 gas is whirled in centrifuges spinning at supersonic speed. The centrifugal force pushes molecules containing the heavier isotope to the outside. The enrichment level achieved by a single centrifuge is insufficient to obtain the desired level of 3-5% U-235 in a single step. Therefore, a number of centrifuges are connected in series and in parallel. Such an arrangement of centrifuges is termed a *cascade*. A plant organized in 'diamond-shaped' configurations is suitable to produce LEU. In principle, by rearranging configurations of cascades, engineers can produce weapons-grade HEU. The production of such HEU, however, requires the continuous operation of hundreds and thousands of centrifuges over a long period, and an enormous sustained input of electricity. According to estimation of Richard Garwin, a well-known nuclear scientist, 1,300 high-performance centrifuges would have to operate full time for three years to make the 60 kilograms of weapons-grade HEU.
- Laser isotope separation (LIS), in which lasers selectively ionise molecules containing one isotope of uranium. Then the positively charged U-235 ions are attracted to a negatively charged plate. LIS, although a promising and potentially cheap technique, appears to be extremely sophisticated even for technically advanced nations.

Other less known and used techniques include aerodynamic enrichment processes, chemical and ion exchange, and plasma separation. At present, the gaseous diffusion and gas centrifuge techniques are the commonly used uranium enrichment technologies.

Fuel fabrication. In a fuel fabrication plant, the enriched uranium is changed into an enriched uranium dioxide (UO_2) powder. The powder is manufactured into small pellets, and loaded into metal tubes, forming fuel rods.

Power generation in reactors. The clusters of fuel rods (fuel assemblies) are put into the core of the nuclear reactor along with a moderator (used to slow down the chain reaction inside the reactor). Nuclear fission reactions inside of a reactor heat up water and produce steam, which drives a turbine connected to a generator that produces electricity.

The reactors are of different types, depending on fuel they use (enriched UO_2 or natural uranium); type of coolant (water, heavy water, CO_2) and type of moderator (water, heavy water, graphite). It is interesting to note that If graphite or heavy water¹ is used as moderator, it is possible to run a

¹ 'Heavy water', or deuterium oxide, is very similar to water (H_2O), except that both hydrogen atoms have been replaced with deuterium, the isotope of hydrogen containing an additional neutron in its nucleus.

power reactor on natural instead of enriched uranium. In a heavy-water reactor, plutonium² (a by-product of nuclear processes inside of a reactor) can be bred from natural uranium. Thus, heavy water provides one more route to produce nuclear weapons.

Research reactors are a separate type of nuclear reactors. They are much smaller than power reactors, and they are primarily used for professional training, scientific research, and medical radioisotope production. Many of them still operate with HEU.

Temporary spent fuel storage. Fuel rods are usually kept in reactors several years. When removed, spent fuel is still emitting both radiation and heat, and therefore needs to be cooled, usually in a special pond at the reactor site. However, keeping spent fuel in such storage is only a temporary measure. Spent fuel needs either be reprocessed to recover the usable portion of it, or it should be sent for long-term storage and final disposal.

Reprocessing and recycling. Spent fuel normally contains 96% uranium (of which approximately 1% U-235), 1% plutonium and 3% waste products. Reprocessing is a chemical process that separates these waste products from uranium and plutonium. Uranium can be sent back to a conversion facility for a new cycle.

Waste management. Experts are still elaborating plans for nuclear waste management. The first permanent disposal is expected to occur about 2010. Meanwhile, the waste products are usually being turned into a special (borosilicate) glass and kept in steel canisters, while spent fuel rods (that were not recycled) are being encapsulated in corrosion-resistant metals.

² Plutonium is a heavy artificially created element. It is formed from the U-238, when the latter is bombarded by neutrons in the reactor core. Plutonium isotope Pu-239 is one of two fissile elements (together with U-235) that provide basis for contemporary nuclear power generation. Plutonium can be blended with uranium to produce a mixed oxide (MOX) fuel, suitable for light water reactors. Plutonium can also be used to create a nuclear weapon. The critical mass for a plutonium-based nuclear weapons is merely 8 kg, more than twice less than using uranium.

ANNEXE 2: ENDNOTES

ⁱ The Additional Protocol allows IAEA inspectors' access to any nuclear facility within two hours of their request. It also grants the IAEA greater access to certain documentation and information about country's nuclear program.

ⁱⁱ The Paris agreement was more precise, leaving very little room for interpretation of what the suspension actually covers.

ⁱⁱⁱ This was, in fact, the first time ever the IAEA resolution was put to a vote. All previous IAEA resolutions were adopted by consensus.

^{iv} Actually in Ardakan, 130km from Saghand

^v Iran says has made new atomic breakthrough. Reuters. 2005-08-30

^{vi} These techniques are used by scientists to manipulate dangerous objects or materials without having direct contacts with them. For instance, robotic arms are used in a "hot cell" chamber to manipulate spent nuclear fuel in order to separate plutonium.

^{vii} The Nuclear Fuel Cycle: A Challenge for Nonproliferation. Lawrence Scheinman. Disarmament Diplomacy. Issue No. 76, March/April 2000

^{viii} When asked if the IAEA had any indication that there was some other completely separate Iranian nuclear-weapons program, Dr. ElBaradei replied: "No, we don't. But I won't exclude that possibility"

^{ix} Iran's Strategic Weapons Programmes. A net assessment. IISS. 2005.

^x Ibid.

^{xi} Iran's Nuclear Program. Iran Watch. September 2004. www.iranwatch.org

^{xii} For instance, Israel's Dimona or India's Cirus reactor.

^{xiii} Iran's Strategic Weapons Programmes. A net assessment. IISS. 2005.

^{xiv} Iran's oil reserves: roughly 10% of world total, second in the world. Natural oil reserves: 15,5% world total, also second in the world.

^{xv} Iran and IAEA Agree on Action Plan; U.S., Europeans Not Satisfied. By Paul Kerr. *Arms Control Today* Arms Control Association May 2004

^{xvi} Secret services say Iran is trying to assemble a nuclear missile. The Guardian. Ian Cobain and Ian Traynor. Wednesday January 4, 2006

^{xvii} Iran's Space Launch Program May Put US at Nuclear Risk. By Julie Stahl. CNSNews.com Jerusalem Bureau Chief. December 09, 2005

^{xviii} Being technically precise, one can also mention 0.0055% of U-234 isotope.

^{xix} *In situ* leaching, also known as solution mining, is the method to extract uranium from underground ore bodies in place (in other words, *in situ*) using liquids, which are pumped, through the ore to recover the minerals out of the ore by leaching. After the *in situ* leaching, uranium does not need to go through the milling process.

^{xx} There is also another, less prevalent type of conversion: the 'yellowcake' is converted to unenriched uranium dioxide (UO₂) which can also be used in some types of research or power reactors that