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IS IRAN GOING NUCLEAR?

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Introduction

As far as international peace and stability are concerned, the Middle East is one of the most volatile regions in the world. Two principal reasons of tension can be stated as the geo-strategic significance of the region particularly due to its vitally important mineral resources; and the indignation of the Muslim states in the region aroused from presence of the State of Israel since 1948 with its remarkable military might. In the vulnerable and complex socio-political structure of the Middle East there has been international efforts to save the region from the danger of the manufacture, stockpiling and the actual use of all kinds of weapons of mass destruction.[1] Nevertheless, there is good reason to believe that Israel has already stockpiled some 100 atomic bombs in the basement.[2] This has been one of the most serious obstacles to the settlement of disputes and the establishment of a long-lasting peace in the region. The Israeli nuclear weapons capability has also been one major justification for other influential states of the Middle East such as Libya, Algeria, Iraq, and Iran for "going nuclear".[3] However, the economic and technological embargo imposed on Libya, and the internal disturbances in Algeria caused serious setbacks in the nuclear programs of these countries. And, during the war in the Gulf in 1991 the capability of Iraq to manufacture weapons of mass destruction has been partially destroyed. More-

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over, with the UN Security Council Resolution 687, Iraq is being closely scrutinized since then by the inspecting teams of the International Atomic Energy Agency[4] mandated with unearthing the undeclared (clandestine) nuclear weapons capability of that country. Apparently, only Iran remains problematique. There are serious allegations that Iran is seeking to acquire nuclear weapons capability. These allegations are not new, and Iran's nuclear engagements have been steadily 'reported' in various books and journals since the early 1970s. But, allegations are intensified both in number and gravity since the recent Russia-Iran secret nuclear deal became public.

This paper will thus focus on Iran's nuclear program in general, and will assess the nature and the orientation of the recent developments in its nuclear industry, in particular. Before proceeding further, however, several important points worth noting at this stage so as to prepare the ground for a more to the point discussion in the following paragraphs. First, Iran is party to the Nuclear Non-Proliferation Treaty[5] ever since its entry into force, and is subject to the safeguards provisions of the IAEA.[6] Therefore, Iran, at least on paper, has sworn not to seek assistance to divert nuclear energy from peaceful to military purposes, that is to manufacture nuclear explosive devices.[7] Any further move of Iran in making nuclear weapons would thus mean a violation of its obligations under the NPT. Second, regarding the recent agreement with Russia, Iranian authorities declared that they were pursuing solely peaceful purposes in their attempt to complete their nuclear power plants in Bushehr which were damaged during the Iran-Iraq war.[8] And, finally, even the US Central Intelligence Agency could not provide the international community with undeniable strong evidence that would indisputably condemn Iran for its illegal occupation with nuclear energy.[9] Given these facts, the significance of Iran's nuclear engagements as regards the usual process of acquiring nuclear weapons capability should be addressed first. Because, without full-fledged evidences or assurances, relying solely on others' judgements (pros and cons) on whether Iran is pursuing a veiled nuclear weapons program, or on the contrary, aims at generating huge amounts of energy for its economic development, can be misleading.[10] A second

emphasis should be on the basic undertakings of Iran under the NPT. Since, Iran's illegal occupation with nuclear energy in its safeguarded installations which are declared to the IAEA is likely to be detected.[11]

Nuclear program of Iran: a résumé

As far as the nuclear engagements of Iran are concerned, one should refer back to the year 1958 when the United States agreed to sell a small size (5 MW) nuclear research reactor to be installed in the Tehran University. Iran's Atomic Energy Organization (AEOI) was founded only a year before. However, both the capacity of the reactor and the lack of skilled personnel prohibited Iran's further research and developments in this field. Hence 'nothing wrong' was reported in the mass media. Notwitstanding, following the inflow of hard currency which started in the mid-1970s due to the drastic increases in the oil prices, Iran was then believed to have been involved in conducting a clandestine nuclear weapons program. However, with the entry into force of the NPT, Iran had become a state party to the Treaty, thus had to forgo such ambitions. Even though its NPT status did not change in the aftermath of the Revolution, Iran was still believed to have had ambitions to assemble a nuclear explosive device under the Khumeini regime.[12] However, neither during the routine IAEA safeguards inspections, nor in the most recent 'special' inspections of February 1992 and November 1993, IAEA inspectors could come up with evidence that would accuse Iran for violating the terms of the NPT. Nevertheless, the fears arising from Iran's recent engagements in the nuclear field, particularly those with Russia and China, have not been alleviated.

Iran's nuclear deal with Russia and P.R. China

The Russia-Iran agreement came after several years of negotiations, and the two countries signed a $ 1 billion worth protocol on January 8, 1995.[13] Accordingly, Russia agreed to complete two partially constructed nuclear power reactors at Bushehr (750 km south of Tehran). The two 1300 MWe light-water reactors were originally built by

KraftWerk Union (KWU) of Germany starting in 1976. But, completion was halted after the Revolution.[14] Russia also agreed to provide Iran with enriched uranium fuel for these reactors. The protocol outlined a wide range of assistance including the training of approximately 500 Iranian technicians as well as some 20 AEOI graduate students and PhD's annually at Russian academic institutions.[15] The protocol pledged each government to instruct the appropriate agencies to prepare and sign contracts for the supply Iran with a 30 -50 MWth light-water research reactor, and 2,000 metric tons of natural uranium, and also called for cooperation in building low power research reactors for instructional purposes, and the construction of an Iranian desalination plant. Both sides agreed to prepare and sign a contract for the construction of a shaft for a uranium mine, after which negotiations would be conducted for the construction of a gas centrifuge plant.[16]

The P.R. China, on the other hand, has been Iran's chief supplier of nuclear-related technologies since the mid-1980s despite the US efforts to stop China from supplying Iran. China has reportedly supplied three subcritical and zero-power reactors and a small electromagnetic isotope separation (EMIS) machine as well as a very small 30 KWth research reactor. None of these hardware is believed to be capable of producing more than minute quantities of nuclear weapons material. But the small research reactors might be useful for training personnel. China also helped Iran create nuclear fuel facilities for uranium mining, fuel fabrication, uranium purification, and zirconium tube production. And, it is highly likely for China to supply Iran with facilities to produce uranium metal and uranium hexafluoride. In 1992, China signed a "preliminary agreement" to supply Iran with two 300 MWe light-water reactors.[17]

Manufacturing nuclear weapons: a technical briefing

This résumé of the nuclear program of Iran, compiled from different reliable sources, may make sense, regarding Iran's intentions, if filtered through a technical information about the usual process of manufacturing nuclear weapons. The first issue to be noted is that, a nuclear

weapon is a device in which most or all of the explosive energy is derived from either fission, or fusion, or a combination of the two nuclear processes. The basic nuclear weapon is the fission weapon which relies entirely on a fission chain reaction to produce a very large amount of energy in a very short time.[18] Nuclear fission occurs when a neutron enters the nucleus of an atom.[19] In a reactor, a neutron which is fired at a U-235, attaches itself to the atom, increasing its instability, which in turn causes the atom to split and release energy.[20] Neutrons which are normally too fast, can hardly attach themselves to U-235 isotopes to split them. To overcome such obstacles, several methods are available for slowing down the neutrons. In a nuclear reactor this is done by means of moderators which are materials such as either light-water, heavy-water, or graphite, that surrounds the nuclear fuel in the reactor core.[21] To make use of light water, the proportion of U-235 in the reactor should be higher in order to increase the likelihood of a successful chain reaction. Therefore, in light-water reactors, uranium used must be enriched in U-235. Another important event in the reactor core that increases the chances of successful fission is the transforming action of attacking neutrons. Neutrons that are unsuccessful in splitting U-235 atoms are mostly absorbed by U-238, and serve to convert the non fissile U-238 into plutonium Pu-239 which is also a fissile material.

Hence, a nation seeking to manufacture nuclear weapons must complete a number of extremely demanding steps in order to generate nuclear energy and divert it to non-peaceful purposes. The major technical barrier to making a nuclear explosive device is obtaining the fissile material. Weapons-grade uranium (highly enriched uranium HEU) or plutonium are such materials usable for nuclear weapons core. How much would be needed for a nuclear weapon depends on the technical capabilities of the country involved and the size of the weapon it seeks to produce.[22] The diversion of natural uranium into HEU requires several steps, which is usually called the nuclear fuel cycle. In the basic cycle, uranium is mined, refined, processed into an appropriate chemical form, converted into fuel rods, fissioned (burned) in a reactor, and stored as waste.[23] Uranium ore is found in places close to the earth's surface, and must be mined like any other mineral.[24] Excavated uranium ore is milled to separate uranium from foreign matter. Uranium is then processed into a chemical form U_3O_8 called yellowcake. At the conversion stage, the processed natural uranium is converted to a form usable in a nuclear reactor. If the material is intended for use in a heavy-water reactor which burns natural (non-enriched) uranium, it is converted to uranium metal or uranium dioxide (UO_2). Uranium destined for light-water reactors is converted to uranium hexafluoride which is a gas suitable for the enrichment process. To make a weapon from uranium, the U-235 isotope of uranium must be used. Since natural uranium is extremely poor in U-235, and while nuclear weapons require 90% or more of U-235, the percentage of natural uranium must be upgraded at an enrichment plant to achieve this concentration.[25] Since, U-235 and U-238 are chemically identical, it is necessary to use a physical method to separate and enrich them.

Uranium enrichment is a highly complex process and requires considerable investment. Several methods have been developed for enriching uranium, all of which ultimately rely on differentiating among the isotopes of uranium and isolating the material with increased concentrations of U-235. The most widely used enrichment method is *gaseous diffusion*.[26] Gaseous diffusion is a technically complex process that requires massive amounts of electricity, therefore it makes clandestine acquisition of a gaseous diffusion plant difficult. The ultra-centrifuge or gas centrifuge method, on the other hand, uses centrifugal force to draw U-238 atoms away from the desired U-235 atoms.[27] The relatively low power requirements of the gas centrifuge method of enrichment, coupled with its relative efficiency, make it an enrichment process of high proliferation concern. Enriched uranium (or plutonium) must be fabricated into fuel rods before it can be used in a nuclear reactor.[28] Enriched uranium can then be used as a fuel in naval propulsion reactors or nuclear power reactors.[29] Production of plutonium also entails many steps and advanced installations and capabilities such as a research or a power reactor moderated by heavy-water or graphite; a heavy-water production plant or a reactor grade graphite production plant; and a reprocessing plant.[30] The plutonium obtained from the reprocessing operation can be converted to

a form usable for nuclear weapons. The separated plutonium and uranium are virtually inaccessible during this operation, hence, unsafeguarded material in a reprocessing plant can easily be diverted to a nuclear weapon.

Iran's nuclear program: two real concerns for scholars and policy-makers

The résumé of Iran's nuclear program, when reconsidered within the framework of the brief technical information about the usual process of manufacturing nuclear weapons, may give an insight about the intentions of the Iranian leadership. In this regard, one may safely state that it is highly likely for Iran to acquire nuclear weapons capability with its existing nuclear infra-structure which will attain a much more advanced level with the Russian (and to some extent Chinese) assistance in the years ahead. However, acquiring the nuclear weapons capability does not necessarily mean that Iran will definitely be able to manufacture nuclear weapons clandestinely in the installations that will be constructed by Russia or China. Because, these installations and the related nuclear materials that will be transferred to Iran, within the context of the recent protocols, will be under the IAEA safeguards. And, during the routine or non-routine inspections in these sites the IAEA inspectors will most probably detect any attempt to divert nuclear energy from civilian to military purposes. Therefore, any account for the likely outcomes of particularly these nuclear installations may still be subject to speculation. In such a circumstance, for those scholars and the policy-makers who fear a nuclear Iran the real concern should rather be the technical skill that the Iranian personnel will incur during the construction and the operation of the nuclear plants while in close collaboration and training with their Russian and Chinese counter-parts. Withstanding this, scholars and policy-makers should also be seriously concerned with the loopholes and shortcomings in the terms of the bilateral safeguards agreements concluded between the states and the IAEA which also regulate the inspection procedures. Because, the deficiencies in the application of safeguards inspections emanate from the terms of the Non-Proliferation Treaty and of the model safeguards document INFCIRC/153.[31]

Basic undertakings of Iran under the NPT: a reminder

According to the terms of the safeguards agreements, states have to declare to the IAEA the exact locations of their nuclear related sites and their initial inventory of the nuclear material contained within. Hence, the IAEA is bound to rely on the information supplied by the member-states for scheduling and implementing its safeguards inspections.[32] This clearly means that the IAEA can be deceived by any state determined to manufacture nuclear weapons clandestinely, simply by not supplying the Agency with accurate information.[33] The strict reliance liability of the IAEA on the states' declarations is therefore one major deficiency of the safeguards agreements. Only in rare instances the Board of Governors of the IAEA may call a state for conducting special (non-routine) inspections which are however normally limited to the declared sites.[34] Nevertheless, Iran once let the IAEA to carry out inspections whenever and wherever the Agency would prefer. But, as noted earlier, since Iran's nuclear infra-structure is presently still at a rudimentary stage, nothing wrong was reported by the IAEA inspectors. A second difficulty with regard to conducting safeguards inspections properly is that, even if a state which concludes bilateral safeguards agreement with the IAEA does accurately accommodate an initial declaration to the Agency, that state may then create frictions for obstructing the timely and effective implementation of safeguards inspections of the Agency in order to gain a considerable time prior to inspections.[35] The principle of sovereignty and the sensitivity of the states to their domestic jurisdiction gave way to such defects in the above noted internationally agreed documents.[36] Having said these, the importance of close observation of the suspected states is obvious as the jurisdictional and technical limitations of the IAEA are taken into consideration. Because, unless any state like Iran which unambiguously display the determination of acquiring an advanced level of nuclear infra-structure is not closely scrutinized, the nuclear technological capacity that can be used to generate huge amounts of electricity, can also very well be used to manufacture nuclear weapons indigenously in non-declared sites away from the declared ones.

The significance of acquiring technical skill: the crux of the matter

Bearing in mind the possibility of any state to conduct a clandestine nuclear weapons program given that the political will and financial resources exist, the weapon can thus be acquired basically through two ways. One is procuring a 'turn-key' nuclear weapon by any means. This option is the most difficult of all to effectuate, and requires an intelligence vacuum.[37] The second option is to assemble a nuclear explosive device indigenously at 'home' as did Israel, India, Pakistan, South Africa, and as almost did Iraq. This option as well requires an intelligence vacuum and the fulfilment of enduring steps by the states. In the case of Iran, given the very fact that the scientists and technicians of this country will soon acquire the basic scientific knowledge and technical skills, the second option is presumably more feasible. Hence, when allegations about Iran regarding its illegal attempts to procure weapons-usable material through various channels are considered, it becomes more apparent that there does exist an unequivocal danger of further spread of nuclear weapons in the Middle East. Much of these allegations go back several years. Western intelligence officials have often reported that Iranian agents have travelled throughout the former Soviet republics in search of nuclear materials, know-how and scientists. In 1992, for example, Iranians reportedly visited the Ulba Metallurgical Plant in Kazakhstan. That plant produces reactor fuel, and manufactures specialized metal components for the aerospace, electronics, and other defence industries. The plant is also said to have more than 600 kilograms of HEU which the Iranians may have tried to buy. Another piece of information released to public was when the US Secretary of State Warren Christopher said on May 1, 1995 that, for years Iran has been trying to purchase heavy-water research reactors that are best suited to producing weapons-grade plutonium, not electricity. Similarly, according to a senior US government official, Iran is concentrating on centrifuge designs and looking toward a pilot plant, possibly large enough to produce enough HEU for nuclear weapons, with hundreds or thousands of centrifuges connected together in cascades. Moreover, US officials refer to a long list of Iranian procurement attempts in Europe and elsewhere that potentially relate to centrifuges.[38] These and other allegations concerning Iran are worth noting as far as the dual character of advanced nuclear industry remains and its output depends on the decision of the leaderships whether to generate electricity or to manufacture weapons with the nuclear yield gained.

Conclusion

The sources referred to throughout this study which aimed at assessing the threat posed by the recent developments in the nuclear program of Iran supplied basically two categories of information and/or judgements: Iran was either determined to acquire nuclear weapons in the facilities now under construction or, on the contrary, it was pursuing solely peaceful uses of nuclear energy by seeking assistance to resume construction of the facilities. However, the real concern of this study was to emphasize the importance of acquiring legitimately the necessary technological capabilities and skills which can later be used illegitimately in secret nuclear facilities endowed with nuclear material procured clandestinely. This is concluded to be the real threat that the recent developments in Iran pose. To overcome such a threat, however, the shortcomings of the safeguards provisions of the IAEA should be alleviated so as to pave way to frequent inspections in suspected states like Iran. Nevertheless, this is a matter of international cooperation, and needs overhauling at least the safeguards documents of the IAEA.[39] Secondly, the international cooperation in preventing the supply of the suspect states with weapons-usable sensitive materials should be strengthened. The existing norms of the London based Nuclear Suppliers Group[40] should become much more operational, and must be supported with reliable intelligence gathering. All in all, regarding these difficulties, states like Iran which deny any accusation about its intentions, should give permision to international safeguards inspections to be conducted whenever and wherever the IAEA would prefer regardless of whether the safeguards agreement in force warrants such a right to the Agency.[41] By behaving this way states may assure the international community about their peaceful intentions.

End Notes:

1 For a compilation of the documents and scholarly works concerning these efforts See, Mustafa Kibaroñlu, "Verification Provisions of a Nuclear-Weapons-Free Zone in the Middle East with Special Reference to EURATOM and ABACC, The Turkish Yearbook of International Relations, Ankara University Press, (forthcoming); See also, Mustafa Kibaroñlu, "EURATOM and ABACC: Recipes for a NWFZ in the Middle East ?" in James F. Leonard and Jan Prawitz (eds.), The Mobarek Plan: A Zone Free of Weapons of Mass Destruction in the Middle East, UNIDIR Research Report, (forthcoming)

2 Yet, the official stance of the Israeli authorities against such allegations is neither the denial nor the acknowledgement of the existence of nuclear weapons in their arsenal. This strategy is called the policy of ambiguity or opaqueness. See in this regard, Benjamin Frankel (ed.), Opaque Nuclear Proliferation, London, Frank Cass, 1991; See also, Etel Solingen, "The Domestic Sources of Regional Regimes: The Evolution of Nuclear Ambiguity in the Middle East", International Studies Quarterly, June 1994, No:38, pp:305-337. For an analysis of Israel's ambiguity policy see, Shai Feldman, Israeli Nuclear Deterrence: A Strategy for the 1980s, Columbia University Press, New York, 1982.

3 The term "going nuclear" is part of the nuclear (non-)proliferation terminology which is often used to denote threshold states that are strongly believed to have chosen the nuclear path for developing lethal weapons. It also stands as the name of a book of one of the most quoted scholars in the field namely, Leonard S. Spector, Going Nuclear, Cambridge, Mass., Ballinger Publishing Co., 1987.

4 The Vienna based International Atomic Energy Agency (IAEA) was established in 1957 and mandated with the verification of the compliance of the states with their obligations under the terms of their bilateral nuclear safeguards agreements with the Agency.

5 The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) of 1968, which entered into force in 1970, was drafted with the principal purpose of controlling the development as well as preventing the diversion of nuclear energy from peaceful (civilian) to military uses.

6 The Iranian leadership officially denounced nuclear weapons, unlike some other Middle Eastern leadership as that of Libya, by staying in the NPT even after the Islamic Revolution of 1979

7 A nuclear explosive device does not necessarily mean a nuclear weapon. However, particularly in the Treaty on the Non-Proliferation of Nuclear Weapons, any request of or offer for assistance in the manufacture of nuclear explosive devices, whether or not intended for peaceful purposes, are prohibited. The purpose behind such a restriction was the clear cut understanding that there was indeed no distinction between the two devices (a peaceful device or a weapon) based on the destructive effect they could produce in case they would be used for military purposes. Only slight modifications would be needed to transform any nuclear explosive device into a nuclear weapon.

8 In addition to formal declarations, in personal conversations with the Iranian authorities during an international conference in Sweden in June 1995, Dr. HadjiHusseini of the Tehran based Institute for Political and International Studies (IPIS) told the author that Iran is undergoing a serious economic crisis since the drastic falls in the oil prices, and also suffers a considerable decline in the generation of electrical energy. Hence, Iran, according to Dr. Hadjihusseini, has no other option but to revitalize its already $ 4

billions spent Bushehr project initiated by the Germans but not completed.

9 The former CIA Director James Woolsey stated in September 1994, that they paid particular attention to Iran's efforts to acquire nuclear and missile technology from the West in order to enable it to build its own nuclear weapons. Woolsey also noted that Iran is 8 to 10 years away from building such weapons and that help from outside will be critical in reaching this timetable. According to Woolsey, Iran has been particularly active in trying to purchase nuclear materials or technology from Russian sources, as well as looking to purchase fully fabricated nuclear weapons in order to accelerate sharply its timetable. See, "Challenges to Peace in the Middle East," Address of R. James Woolsey to the Washington Institute for Near East Policy, Wye Plantation, MD, September 23, 1994, quoted in Leonard S. Spector, Mark G. McDonough with Evan S. Medeiros, Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1995, Carnegie Endowment for International Peace, Washington D.C., 1995. p. 119.

10 Because, it should be underlined that, from the technological point of view, in any nuclear industry operating either for manufacturing nuclear weapons or for generating electrical energy, the phases that must be accomplished are identical. The difference can be in the political intentions of the states about how to make use of their existing nuclear infra-structure.

11 On the one hand, the safeguards provisions of the IAEA under the NPT are far from being perfect, and thus the IAEA and the terms of the NPT were seriously criticized for not having detected the nuclear weapons program of Iraq throughout the 1980s. But, on the other hand, in the first half of the 1990s, the Agency gained experiences in Iraq and during the North Korean dispute. Therefore, the Agency is becoming more capable to fulfil its political objective which is expressed as to deter against possible diversion

through the risk of early detection. To complement this, the technical objective of the IAEA's safeguards procedures is the timely detection of diversion of significant quantities of nuclear material into a bomb.

12 Detailed discussions on Iran's allegedly secret nuclear deals with countries such as South Africa, Pakistan, Argentina, W. Germany, France, Spain, China and the Soviet Union, exist in, Zalmay Khalilzad, Iran: The Nuclear Option, Los Angeles, Pan Heuristics, 1977; Leonard S. Spector, Nuclear Proliferation Today, New York, Vintage Books, 1984; L. S. Spector, The New Nuclear Nations, New York, Vintage Books, 1985; Akbar Etemad, "Iran," in Harald Müller (ed.), European Non-Proliferation Policy, Oxford, Oxford University Press, 1987. See also L. S. Spector, Nuclear Ambitions: The Spread of Nuclear Weapons 1989-1990, Boulder, Colorado, Westview Press for Carnegie Endowment for International Peace, 1990. Despite the reported initiatives of Iran, most of the authors of recent books agree that Iran's nuclear program, at present, is at a rudimentary stage.

13 Indeed, several Russian nuclear specialists have been active in Iran since April 1994 performing preliminary studies of the coastal site, and some 150 Russian technicians are currently at the site and this number will soon be quadrupled. See, Leonard S. Spector et al, ibid., p. 120.

14 Approximately 85 % of the civil work on Bushehr I was complete, and the work in Bushehr II was also partially finished when construction stopped in 1979. In the intervening years, both reactors were damaged during bombing raids in the Iran-Iraq war, and Iran was subsequently unsuccessful at convincing the German firm to complete construction, largely due to the pressure from the United States. For details see, Leonard S. Spector et al, ibid., pp: 119-124. And, on an account for German nuclear export policy, and on how the German government put an end to KWU's deal in Iran,

see Harald Müller (ed.), A Survey of European Nuclear Policy, 1985-87, MacMillan, London, 1989.

15 David Albright, "The Russian-Iranian Reactor Deal", The Nonproliferation Review, Center for Nonproliferation Studies, Monterey Institute of International Studies, Spring-Summer 1995, Vol. 2, No: 3, pp: 49-51

16 Although Russia has reportedly cancelled the centrifuge plant, it still intends to build the mine shaft. For a detailed exposé of the Russia-Iran agreement see, David Albright, "An Iranian Bomb ?", The Bulletin of the Atomic Scientists, July/August 1995, pp: 21-26.

17 But it is unclear if the reactors will ever be supplied. Head of the AEOI Amrollahi told the New York times in May 1995 that Iran made a down payment on the reactors, and China had started to draw up blueprints and engineering reports for a site in southern Iran. D. Albright, op. cit., p. 25.

18 Frank Barnaby, How Nuclear Weapons Spread: Nuclear-Weapon Proliferation in the 1990s, Routledge, London and New York, 1993, p. 27.

19 Atoms consist of protons, neutrons, and electrons. Protons and neutrons bond together strongly to form a nucleus, and electrons orbit around them. Atoms of the same family are called isotopes. The uranium isotope U-235 is made up of 92 protons and 143 neutrons, whereas the isotope U-238 has 92 protons and 146 neutrons. Uranium isotope U-235 is rare in nature, whereas the U-238 isotope is 140 times more common in natural uranium than the U-235 isotope (0.7%).

20 The same neutron directed at a more stable U-238 atom would

likely be absorbed without fissioning (i.e., without causing split). In a reactor, many neutrons are intercepted by U-238 atoms, and others are absorbed by the atoms of other materials in the reactor.

21 When neutrons collide with the heavy water or graphite atoms, they decelerate to a speed that improves their chances of attaching to a U-235 atom and causing it to break apart. Hence, in reactors moderated by these materials, no other adjustments are necessary to make fission possible. When light (ordinary) water is used as a moderator some neutrons are slowed, but others are absorbed by the light-water itself. Because ordinary water is plentiful and cheap when compared to heavy-water which is costly and very difficult to make, light-water is the preferred moderating material.

22 IAEA regulations assume that 25 kg of HEU or 8 kg of plutonium are the minimum amounts needed to manufacture a nuclear device with a yield of 20 Kilotons, roughly the size of the Nagazaki bomb. According to one recent estimate, a country possessing a low technical capability could build a 20 kilotons device with only 6 kg of plutonium or 16 kg of HEU. A state with high technical capability can potentially build such a device with as little as 5 kg of HEU or 3 kg of plutonium. Moreover, a 1 Kt device, which would require considerable sophistication to manufacture, might need only about half these amounts. See, Thomas B. Cochran and Christopher E. Paine, The Amount of Plutonium and Highly Enriched Uranium Needed for Pure Nuclear Weapons, Natural Resources Defense Council, Washington D.C., 1994.

23 The basic nuclear resources and facilities that would be needed to produce HEU indigenously thus include: uranium deposits; a uranium mine; a uranium mill for processing ore into uranium oxide concentrate, or yellowcake named for its amber color; a conversion plant for purifying yellowcake and converting it into uranium hexafluoride (UF6) or uranium tetrachloride (UCl4) to be processed in the enrichment plant; an enrichment plant for enriching the uranium hexafluoride gas or uranium tetrachloride in the isotope U-235; and a capability for converting the enriched uranium hexafluoride gas or uranium tetrachloride into solid uranium oxide or metal.

24 The world leaders in uranium mining and milling are Canada, the United States, Australia, France, Niger, Namibia, and South Africa. About 5,000 kilograms of natural uranium is needed to produce the 25 kg of weapons-grade uranium for one atomic bomb. See F. Barnaby, ibid., p. 4.

25 Indeed, technically a weapon could be made of uranium enriched to more than 20 percent. As a practical matter, material enriched to more than 90 percent is preferred. For instance, the bomb dropped on Hiroshima used uranium enriched to 80 percent. Similarly, S. Africa used material enriched to 80 percent for the first nuclear weapons and 90 percent for the remaining 5 weapons.

26 Uranium in a gaseous form, i.e., uranium hexafluoride, is forced through a series of membranes of a huge container. Each membrane allows the lighter U-235 atoms to pass through more easily than the heavier U-238 atoms. After penetrating each membrane, the gas is richer in U-235 than it was originally, but only slightly. Normally, 1,250 passes are needed to enrich the gas to 3 percent U-235, which is the enrichment level used in most light-water nuclear power plants. However, 4,000 passes are required to enrich the material to the weapons-grade of 90 percent U-235.

27 When uranium hexafluoride is spun in a centrifuge, the heavier U-238 atoms gravitate toward the outer walls, whereas the lighter U-235 atoms remain in the center. The centrifuge method requires only 35 repetitions to achieve weapons-grade uranium. A plant with 1,000 centrifuges can supply the uranium stock for several nuclear weapons per year.

28 The enriched uranium, plutonium, or natural uranium used in heavy-water reactors is shaped into cylindrical pellets, which are then stacked in tubes called fuel rods. The rods are then bundled together into fuel assemblies. Light-water reactor fuel assemblies each weigh from 200 to 500 kg. Approximately 180 fuel assemblies containing about 110 tons of low enriched uranium are needed to fuel a typical 1,000 MW light-water reactor for three years. See Mason Willrich and Theodore B. Taylor, Nuclear Theft: Risks and Safeguards, Ballinger Publishing Co., Cambridge, Mass., 1974.

29 A nuclear power reactor is basically a furnace where the heat produced by a controlled chain reaction is used to generate electricity. Typically, the heat used to turn water into steam issued to drive a turbine which generates electricity. Thus, a country can have entirely legitimate, non-weapons related reasons for developing uranium enrichment technology even though the same technology can be used to upgrade uranium enrichment level useful for weapons.

30 Uranium fuel, usually in the form of uranium-filled tubes (fuel rods) made of zirconium alloy (zircalloy) or aluminium, is placed in the reactor. As the reactor operates, the uranium fuel is partly transformed into plutonium. This is amalgamated in the fuel rods with unused uranium and highly radioactive waste products, and it must then be extracted. Using the Plutonium Uranium Recovery by Extraction (PUREX) method, more than 90% of the uranium and plutonium in the spent-fuel solution can be recovered. To do the extraction operation, the spent fuel rods are taken to a reprocessing plant where they are dissolved in nitric acid and the plutonium is separated from the solution in a series of chemical reprocessing steps.

31 Information Circular (INFCIRC/...) is one of a series of unclassified, general purpose IAEA circulus used to bring to general notice the contents of an important document or an important decision or communication. Safeguards document circulated in this form

include the safeguards system and the safeguards agreement. Hence, INFCIRC/153 denotes "the structure and content of the agreement between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons." When the IAEA circulates such documents at the request of the state or states concerned, it takes no responsibility for the contents of the documents. However, the significance of the INFCIRC/153 within the nuclear non-proliferation regime comes from the fact that, these procedures constitute the sole legal basis for the verification mechanism of the regime.

32 Since, according to its Statute and the terms of the model agreement INFCIRC/153 (applicable to the states party to the NPT), the IAEA has no power to have access to the suspected sites in a state without the consent of the host state. Such enforcement measures are beyond its mandate.

33 This has been the case in Iraq. After the 1991 Gulf War, the IAEA inspectors unearthed the undeclared nuclear facilities and materials which were being used to manufacture nuclear weapons.

34 During the inspections the IAEA inspectors apply indeed simple material accountancy techniques to the nuclear material to determine whether any significant amount of nuclear material is missing, or not. Inspections are conducted in restricted areas within the facilities called material balance areas. Such and other restrictions further complicate the proper and effective implementation of inspections.

35 Either by objecting to the inspectors' nationalities or by not providing reliable escort services, and the like, states may seriously delay inspections, and the time gained may be significant from the military point of view. Based on the degree of suspicion, the IAEA may ask more frequent inspection from several states. But, the frequency of inspections is negotiated between the parties, hence no

unilateral encroachment is possible. In a protracted conflict, however, unlike the first difficulty mentioned above, in this case the IAEA is not totally powerless. Indicating such a circumstance, through its Board of Governors, ultimately to the UN Security Council, the IAEA may then take several measures for the fulfilment of its task, as it was the case in North Korea.

36 During the process of drafting these documents, the sovereignty principle was one of the most hotly debated issues in the international fora which undertook working out regulatory documents for controlling the development of nuclear energy world wide. Multilateral discussions in this respect have initially taken place right after World War II with the creation of the United Nations Atomic Energy Commission UNAEC in 1945. Despite the failure in this attempt, events led to the creation of the IAEA in 1957, the enactment of the NPT in 1968, and issuing of INFCIRC/153 in 1971.

37 By intelligence vacuum the author envisions a situation where the intelligence agencies may overlook or rather fail to disclose such 'giant deals' between the client and supplier states.

38 For a detailed discussion in these respects see, David Albright, ibid., pp: 22-26.

39 In the Review and Extension Conference of the NPT held in the UN headquarters in April/May 1995, it is decided that the NPT be extended unconditionally and indefinitely. This means that no adjustments or amendment can be made in the Treaty and its related safeguards document. See in these matters, John Simpson, "The Birth of a New Era ? The 1995 NPT Conference and the Politics of Nuclear Disarmament", Security Dialogue, Vol.26, No:3, September 1995, pp:247-256.

40 The Nuclear Supplier Group has reproduced a set of guidelines

that most of the suppliers of nuclear plants and materials agreed to in London on 21 September 1977. That's why this group is equally known as the London Club. This set of guidelines is also attached to communication addressed on 11 January 1978 to the Director-General of the IAEA. These guidelines for nuclear transfer are also labelled as INFCIRC/254. The initial signatories of the guidelines are; Belgium, Canada, Czechoslovakia, France, the former German Democratic Republic and the Federal Republic of Germany, Italy, Japan, the Netherlands, Poland, Sweden, Switzerland, UK, USA and the USSR. NSG restricted the supply of items that might be used to advance a non-peaceful nuclear program, and adopted a trigger list including heavy-water and heavy-water production plants. NSG also required export conditions stricter than those specified in the NPT. In April 1992, the twenty-eight NSG member states further tightened control over nuclear exports in response to revelations of Iraq's clandestine import of nuclear technology. The Group, thus expanded its trigger list to include more dual use items, and agreed to require full-scope (comprehensive) safeguards as a condition of export.

41 Of course, the IAEA, as stated in its Statute, should seriously take into consideration that such extra inspections may cause a competitive disadvantage to the host country.