let the sun shine
Together For a Nuclear Free Middle East

AN OVERVIEW OF NUCLEAR FACILITIES IN IRAN, ISRAEL AND TURKEY

A GREENPEACE BRIEFING

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CONTENTS

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INTRODUCTION

The Middle East is at a nuclear crossroads and the road taken will shape the region for decades to come. The trajectory of the nuclear road is clear, and threatens to create a region in which nuclear technology is common place and carries with it a host of inherent dangers: from routine radioactive discharges to the problem of how to isolate long lived deadly radioactive wastes from the environment over timescales beyond human or technical imagination. It also carries with it fear and suspicion; the fear and suspicion that the interchangeable 'dual-use' technologies of so-called peaceful nuclear power will be perverted to the purpose of war, into the development of nuclear weapons.

Whilst nuclear activities and developments in the region have been largely dominated over the last three decades by Israel's undeclared activities, the scale of Iran's nuclear ambitions have focused international attention more closely on the region. The debate over the right to so-called peaceful uses of nuclear technology has contributed to decisions by many other states in the region to pursue their own nuclear energy programmes: it is no coincidence that Saudi Arabia UAE, Kuwait, Qatar, Bahrain and Oman[1], Yemen[2], and Egypt[3] have all announced, in the last twelve months, plans to establish or revive nuclear programmes. Also, it must not be forgotten that 90 US/NATO nuclear weapons loom over the region from the Incirlik Airbase in Turkey.

Civil nuclear developments as we can see in the Middle East today create 'virtual proliferation' which in turn can give way to real nuclear weapons proliferation. However, regardless of the military threat and the intentions of nascent nuclear nations, nuclear power is a tragic mistake of the second half of the twentieth century. Nations of the Middle East would be well advised to leap frog the errors of the West and instead embrace non-nuclear energy futures based on energy efficiency, energy conservation and peaceful renewable energy sources.

This review of nuclear developments in the Middle East focuses on Turkey, Israel and Iran, but contains lessons and warnings for all countries in the region. In each country the report outlines some of the possible risks to the environment and human health as a consequence of continuing to operate and/or commission nuclear facilities such as nuclear power plants, research reactors and uranium enrichment facilities.

DISCLAIMER: Due to the highly secretive nature of the Israeli nuclear programme and the complete lack of official information the chapter on Israeli nuclear facilities was written based upon the best available informative yet unofficial sources.

IRAN

Development of Iran's Nuclear Programme

Iranian Nuclear activities began in the late 1960s with the establishment of the Atomic Centre of the Tehran University and the construction of 5Mw research reactor, by American company AMF.

The Atomic Energy Organization of Iran (AEOI) was established in 1974 and Iran entered into a safeguards agreement with the International Atomic Energy Agency (IAEA) on 15 May 1974. The AEOI was mandated to plan for and work on the complete fuel cycle including the production of 23000Mw electricity by nuclear power plants. The AEOI took over the Atomic Centre including its 5Mw research reactor, which had begun operation in 1968. The Centre then became known as the Nuclear Research Centre (NRC).

In 1974, construction of two 1,200 Mw(e) Pressurised Water Reactors (PWR) began at Bushehr by German company KraftWerk Union, a subsidiary of Siemens. However, following the Islamic Revolution in 1979, the construction programme was suspended.

Iran resumed its nuclear power programme in 1991 under a bilateral agreement with China for the supply of two 300 Mw(e) VVER units. The agreement was confirmed in 1993 but never realized.

In 1994, the Ministry of Atomic Energy of the Russian Federation and the AEOI agreed on the scope of work for completing the Bushehr nuclear power plant unit 1 with a 1000 Mw(e) VVER[6]. The contract was signed in 1995 and construction completed in 2006.

In September 2002 Iran announced a considerable expansion of its nuclear programme, with plans to construct a total capacity of 6000Mw within two decades.[7] At the same time Iran was asked to confirm whether it was building a large underground nuclear facility at Natanz and a heavy water production plant at Arak, as reported in the media in August 2002.

This was confirmed in February 2003, when Iran informed the IAEA[8] of its uranium enrichment programme at Natanz[9] and confirmed that a heavy water production plant was under construction in Arak. In May 2003 Iran further informed the IAEA of its intention to construct a heavy water research reactor at Arak[10], as well as a fuel manufacturing plant at Isfahan.[11]

At this time, Iran also acknowledged the receipt in 1991 of natural uranium, which had not been previously reported to the Agency[12] and that it had successfully converted most of the UF4 into uranium metal in 2000.

International Treaty issues

Iran signed the Nuclear Non-Proliferation Treaty (NPT) in 1968, ratified it in 1970 and subsequently signed the Additional Protocol in 2003 but has not yet ratified it.

In co-operation with Egypt, Iran introduced a proposal for a Middle East Nuclear-Weapon-Free-Zone (MENWFZ) in the United Nations General Assembly in 1974, which has since then adopted an annual resolution supporting the goal of such a zone. Since 1980 the resolution has been supported by all the states of the region and to this day it continues to be adopted annually by consensus.[5]

Development of Iran's Nuclear Programme

Military or not...

A significant international dispute has emerged over Iran's nuclear programme. Iran insists that its nuclear endeavours are intended only to guarantee an independent nuclear energy capacity and further argues that there is no substantive evidence of a nuclear weapons programme; it stoutly denies that its nuclear programme is directed towards the acquisition of fissile materials. Despite these assurances however, the IAEA remains concerned about the scale and persistence of Iran's nuclear venture.

There have been problems with the transparency of Iran's nuclear programme.[4] Since 2002 Iran has itself revealed a number of previously unknown facilities and activities to the IAEA. And a number of these, including the development of the facility at Natanz and attempts to purchase nuclear materials and equipment, have lead to doubts about the past purpose of Iran's nuclear programme.

Fears are now that with sanctions and continued threats of military action that the Iranian nuclear programme will be driven back underground and international inspections by the IAEA will be halted.

However whether or not Iran intends to develop a weapons programme, this dispute highlights the *essential* problem with any nuclear programme. The pathway to a bomb is the same as the pathway to nuclear energy; there is no such thing as a proliferation resistant nuclear programme. And this is the same for any nuclear programme anywhere in the world. Should a current or future government decide it wanted to do so, it's 'easy'. The only way to actually achieve a world free of nuclear weapons is to achieve a world free of all nuclear technology.

Amid international concern about the scope of Iran's activities, in October 2003, Iran announced under an agreement with UK, France and Germany, that it would voluntarily suspend all enrichment related activities, negotiate an additional protocol with the IAEA. Further, in November 2004 the "Paris Agreement" was signed between these countries and Iran. Iran agreed to continue its voluntary suspension of nuclear activities whilst negotiations aimed at a longer term agreement continued.

In February 2005, Russia and Iran agreed on nuclear fuel deliveries for the Bushehr reactor, signing an agreement for the return of spent nuclear fuel, which Russia would take back five years after unloading from the reactor. The first delivery is expected in early 2007.

In July 2005 Iran announced that the "Paris Agreement" negotiations were going nowhere and that it would be resuming enrichment activities at Isfahan in August. The so-called EU3 presented Iran in August with a "take it or leave it" proposal to fulfil the terms of the Paris Agreement which Iran rejected.

In September 2005 Iran was found to be in non-compliance with its Nuclear Non-Proliferation Treaty (NPT) safeguards agreement by the IAEA. However, it was not until January 2006 that Iran announced it would "resume those research and development (R&D) activities on the peaceful nuclear energy programme which has been suspended as part of its expanded voluntary and non-legally binding suspension."[13]

In February 2006, the IAEA resolved to report Iran to the UN Security Council if Iran did not fall into line.[14] Iran subsequently withdrew cooperation with the IAEA under the additional protocol.

In March 2006 the IAEA reported Iran to the Security Council and it quickly took up the case, issuing a Presidential Statement calling upon Iran to re-suspend all enrichment-related and reprocessing activities, and submit to inspections by the IAEA in order to "build confidence in the exclusively peaceful purpose of its nuclear programme"[15]. This resolution[16] gave Iran a further thirty days to comply or expect sanctions.

However, Iran resolved to continue developing its nuclear power and nuclear fuel cycle facilities and in December the Security Council imposed non military sanctions related directly to Iran's programme[17]. The IAEA must report to the Security Council in late February 2007 on implementation of the resolution.

Known Nuclear facilities in Iran

A) Tehran Nuclear Research Centre
Consists of:
- Tehran 5Mwe Nuclear Research Reactor[18]
- A Radioisotope Production Facility
- Jabr Ibn Hayan Multipurpose Laboratories[19]
- A radioactive waste Handling Facility
- Comprehensive Separation Laboratory for work with uranium
- Laser Separation Laboratory for experiments into enrichment of uranium by lasers

B) Kelaye Electric Company - Tehran
Consists of:
- Company belonging to the Atomic Energy Organisation of Iran
- P-1 centrifuges assembled and tested here 1997 – 2002, before work moved to Natanz[20].

C) Isfahan Nuclear Technology Centre
Consists of:
- 30kW Miniature Neutron Source Reactor[21]
- Light Water Sub-Critical Reactor
- 100W Heavy Water Zero Power Reactor[22]
- Graphite Sub-Critical Reactor (decommissioned)
- Uranium Conversion Facility Nuclear
- Fuel Manufacturing Plant
- Fuel Fabrication Laboratory
- Uranium Chemistry Laboratory (closed down as of Nov 2004)
- Zirconium Production

D) Bushehr Nuclear Power Plant
Consists of:
- 1000 Mwe VVER-1000 Reactor
- Spent storage pool
- New fuel store

E) Natanz
Consists of:
- Operational pilot scale uranium enrichment facility (planned to have 1000 centrifuges)[23]
- Commercial scale plant under construction (planned to have 50,000 centrifuges)[24]

F) Karaj Nuclear Research Centre
Consists of:
- Enrichment equipment storage
- Nuclear waste store

G) Lashkarabad
Consists of:
- Pilot uranium laser enrichment plant (now dismantled)

H) Arak
Consists of:
- Iran 40 Mw(th) Heavy Water Nuclear Research Reactor IR-40
- Heavy Water Production Plant
- Hot cell facility for production of isotopes (abandoned)

I) Anarak
Consists of:
- Nuclear waste storage site

J) Gachin
Consists of:
- Uranium mine
- Raw uranium ore to yellowcake conversion facility

K) Saghand
Consists of:
- Uranium mine

L) Farayand Technique
Consists of:
- Centrifuge assembly and quality control plant[25]

M) Pars Trash
Consists of:
- centrifuge assembly plan[26]

Other sites:

N) Kolahdouz Industrial Complex In Tehran
- A military industrial complex alleged to have been involved in enrichment activities. The IAEA were allowed to visit but found nothing[27]

O) Lavizan-Shian Physics Research Centre
- Suspected of being used for experiments in enriching uranium it has now been turned into a municipal park[28]

P) Parchin Military Complex
- Suspected site of high explosives research which could be used in nuclear devices. IAEA Inspectors were given access in 2005 but found no evidence of any nuclear related work

Q) Ardkan
- Uranium ore conversion plant for turning ore into yellowcake for feeding into the uranium conversion facility at Isfahan

Main Nuclear Facilities in Iran

Potential Hazards of Iranian Nuclear Facilities

As with all nuclear programmes around the world, there are a range of environmental and human health risks associated with Iran's nuclear facilities.

As the development of Iran's nuclear programme matures and facilities are completed/commissioned, risk of incident grows. In addition, there is serious concern about the likelihood of a military strike to 'take out' Iran's nuclear programme[29]. Attention must also be given to the potential impact of sanctions on the ability of Iran to source the best technology, safety equipment etc to manage its nuclear programme. Further, Iran is an area of seismic risk, with the likelihood of earthquakes in the region creating additional risks for its nuclear programme[30].

HAZARD 1:
Tehran Nuclear Research Centre

Location

The TNRC is located in a residential part of Tehran, approximately 5km north of the centre. The Centre includes the Tehran Nuclear Research Reactor, a radioisotope production facility and a radioactive waste handling facility.

Potential Hazards

The dominant known hazard on the site comes from the research reactor core, and the older 'used' nuclear reactor core also stored on the site.

Likelihood of Incident

As a major nuclear research facility in Iran and one of their main centres of nuclear expertise it might be considered a politically worthy target for any military strike. Iran has already officially expressed its concern to the IAEA about the threat of armed attack on its nuclear programme[31].

Consequences of incident

Being a relatively low-energy reactor, an *accident* involving an explosion of sufficient force to release fission product particles into the air is unlikely. However, a release of some of the radioisotopes being produced in the reactor could occur, in which case sheltering and even evacuation from an area several kilometres from the plant would be necessary.

In the case of *military attack*, the severity of damage could be extreme, with severe results for the near-by residential areas, definitely requiring countermeasures such as potassium iodate tablet provision, sheltering and evacuation. The scale of such countermeasures would depend on the exact conditions on the day of the accident but given the location of TNRC it is likely to have a significant impact on the population of Tehran.[32]

Potential Hazards of Iranian Nuclear Facilities

HAZARD 2: Isfahan Nuclear Technology Centre

Location

The Nuclear Technology Research Centre in Isfahan is Iran's largest nuclear research center, and is said to employ as many as 3,000 scientists. 41 kilometres south of Tehran this world-famous city of approx 1.5 million people is one of the most significant tourist attractions in Iran. It is also home to four research reactors, the Fuel Manufacturing Plant that will fabricate fuel assemblies for the reactors in Arak and Bushehr and the Uranium Conversion Facility, creating UF_6 for enrichment at Natanz.

Potential Hazards

The dominant radiological hazards on the site are the small research reactor cores. A greater risk comes from the uranium ore and UF_6 gas used and produced at the facility. Recent reports from Iran indicate that 250 tonnes of UF_6 gas is being stored in tunnels below the facility[33].

Likelihood of incident

The chances of a military strike is high, due to Isfahan's importance within the Iranian nuclear programme. Iran has officially expressed its concern to the IAEA about the threat of armed attack on its nuclear programme[34].

Accidents have occurred in enrichment facilities around the world. For example in 1986 an accident occurred at the Sequoyah Fuels enrichment facility in Oklahoma USA. One worker died and 42 other workers and 100 nearby residents were hospitalized with evidence of kidney damage from uranium exposure. The site was eventually closed in 1992 as a result of contamination to soil and groundwater[35].

Consequences of incident

Being very low energy reactors, the worst case accident is unlikely to involve an explosion of sufficient force to release fission particles. Of greater concern is an accident and or military strike releasing UF_6 into the atmosphere. Upon contact with air, UF_6 breaks down to form uranyl fluoride and hydrogen fluoride, the latter is a highly corrosive chemical, which can be hazardous if inhaled in sufficient quantities or cause severe burns on contact with the skin[36]. An explosion resulting in the dispersal of the uranium stored on the site, would also be highly toxic to populations around the facility causing damage to internal organs, particularly the kidneys as well as increasing the risk of cancer and other genetic defects in affected populations.

HAZARD 3: Bushehr Nuclear Reactor

Location

The Bushehr nuclear reactor is only 12km from Bushehr which has a population of 165,000. It is one of two reactors that will eventually be built on the site. The IAEA has now completed final safety checks and if all goes to schedule, Russian fabricated un-irradiated uranium fuel will be delivered around March 2007 according to the President of Russia's Atom Stroi Export Company who are supplying it. Under the agreement signed with the Russian Federation, plant commissioning is to commence in late 2007, with first power generation expected by the end of 2007[37].

Potential Hazards

Until the start up of the reactor, the 80 tonnes of uranium fuel delivered will provide a significant chemical, and more limited radiological risk. Once commissioned and operational, Bushehr will be the largest single source of radioactivity in the region. This risk will reach its maximum after three years' operation, which should mean the end of 2010 according to the schedule.

A considerable risk is also presented by the spent fuel storage pool. Reactor accidents can be the trigger for fuel pool accidents and vice versa, leading to increased radioactive releases. It has been suggested that fuel should be returned to the Russian Federation in batches after about five years of post core cooling. But the transfer of irradiated fuel from the fuel storage pond has not yet been arranged. If the return of spent fuels is delayed, for example for up to fifteen years, the radioactive hazard from the fuel accumulating in the storage pond will exceed that of the active fuel core of the reactor.

Risk of Incident

A significant risk of *military attack* exists prior to commissioning from an intention to interrupt Iran's nuclear programme. Iran has officially expressed its concern to the IAEA about the threat of armed attack on its nuclear programme[38].

Potential Hazards of Iranian Nuclear Facilities

HAZARD 3:
Bushehr Nuclear Reactor (continued)

The reactors being built at Bushehr have a high-energy output, operating at a higher temperature and pressure, accelerating corrosion of components. Failure in the steam generators is a notorious weak point[39], which can lead to radioactive releases outside the containment and in worst cases to severe accidents. Similarly cracks appear frequently in the cap on the reactor vessel[40]. And, as the system involves hydrogen production, hydrogen explosions can occur in the course of an accident if the integrity of the reactor pressure vessel is compromised, considerably increasing the severity of the accident. Furthermore, in two-unit plants, an accident in one reactor can affect the safety of the other.

This type of reactor also depends more heavily than other types on a complicated safety system, reliant upon a continuous electricity supply. Emergency systems, and particularly back up power supplies must be exceptionally reliable (and often are not) especially with respect to their ability to stand up to natural hazards like earthquakes, floods and storms[41].

The transport of fuel from and particularly the transport of the spent fuel back to Russia also involves significant risks to human health and the environment.

Whilst the IAEA has drafted standards for the safe transport of nuclear material, the reality is that these standards simply do not reflect accident conditions. Spent fuel casks for example are required to survive drops of only 9 metres and to resist temperatures of 800° C for up to 30 minutes. Studies, including those commissioned by Greenpeace, have shown that in real accidents, for example at sea or in tunnels, fires often burn at temperatures exceeding 800° C and for considerably longer than 30 minutes. Any air transport crash will undoubtedly involve a drop of more than 9 metres.

Waste storage will continue to present high levels of risk as the plant will be the largest single source of radioactive wastes in Iran. It is claimed that the waste produced[42] can be stored and/or discharged to the environment within authorised limits.

Consequences of an incident

Although the radiological consequences prior to reactor fuelling and start up are minimal, the chemical/toxic risk from dispersal of uranium into the atmosphere is significant. As in the case of an incident at Isfahan, an explosion resulting in the dispersal of the uranium stored on the site would also be highly toxic to populations around the facility causing damage to internal organs, particularly the kidneys as well as increasing the risk of cancer.

Post start up, Bushehr will be the single greatest source of radioactive releases in the region, with the potential for a release associated with a severe accident comparable to or even higher than the releases from the Chernobyl accident. This is possible from about the third year of operation. In case of a large scale incident, adjacent States, including Qatar, Saudi Arabia, Kuwait and the United Arab Emirates would probably be required to implement measures to safeguard their population from radiation exposure and uptake.

Potential Hazards of Iranian Nuclear Facilities

HAZARD 4:
Natanz – uranium enrichment plant

Uranium Enrichment

The term "enrichment" refers specifically to increasing the concentration by weight of U^{235} in a sample of uranium. Feeding natural uranium into an enrichment plant produces two streams of uranium – enriched uranium, so called because it is enriched in U^{235} and depleted uranium, so-called because it is depleted in U^{235}.

Highly enriched uranium (HEU) has a greater than 20% concentration of U^{235}. Nuclear weapons usually contain greater than 85% U although even 20% is considered 'weapons-useable'.

Low-enriched uranium (LEU) has a lower than 20% concentration of U^{235}. For use in commercial power reactors, uranium is usually enriched to 3 to 5% U^{235}.

HEU and LEU can be produced in the same facility. In the case of the centrifuge facility at Natanz, HEU production would simply involve longer periods in the centrifuges than the production of LEU.

Location

Natanz is located between Isfahan and Kashan in central Iran. The facility is reportedly 100 miles north of Isfahan, and is located in old Kashan-Natanz, near a village called Deh-Zireh, itself some 25 miles southeast of Kashan.

IAEA inspections have documented two enrichment plants at Natanz – a pilot-scale facility planned to have 1000 centrifuges and a commercial-scale plant (intended to have 50,000) under construction. The pilot plant, started up in June 2003, shut down in December 2003 when Iran voluntarily suspended enrichment activities. Since February 2006 when Iran resumed enrichment related activities, Iran has tested small cascades under IAEA safeguards[43]. Construction on the commercial scale plant was also suspended in 2003, but in April 2006, Iran announced plans to install 3000 centrifuges.[44]

Potential Hazards

The dominant hazard comes from the uranium hexafluoride gas and enriched and depleted uranium used and produced at the facility.

Likelihood of incident

The importance of the pilot plant, and subsequently the commercial plant to Iran's long term plans for self sufficiency in enriched uranium, put this facility high on the list of those at risk of military attack. Iran has officially expressed its concern to the IAEA about the threat of armed attack on its nuclear programme[45].

Consequences of incident

As with the Nuclear Technology Research Centre at Isfahan the main consequence would be the dispersal of the UF_6, enriched and depleted uranium on the site. Dispersal of uranium would be highly toxic to populations around the facility causing damage to internal organs, particularly the kidneys, increasing the risk of cancer and genetic defects in the affected population.

Potential Hazards of Iranian Nuclear Facilities

HAZARD 5:
Arak heavy water production plant and heavy water reactor

Location

These facilities are located at Khondab, a village of some 6,000 people in central Iran, approximately 52km from Arak. Arak is one of Iran's main industrial cities, with a population of just over 500,000.

The heavy water production plant was commissioned in mid-2006. The plant has an initial production capacity of around 8 to 10t/year, expanding to about 15t/y.

The construction of the associated heavy water moderated RD-40 reactor commenced around 2004, with an expected completion date of around 2014[46].

Potential Hazards

Until the reactor is fuelled and commissioned in or about 2010, there should be no significant radiological hazard at Arak. Once the natural uranium oxide fuel arrives on site, prior to reactor start up, the radiological risk will remain small, but the chemical risk increases considerably, with the risk that the uranium oxide fuel could be particulated and dispersed into the atmosphere. Further, once the reactor is commissioned the reactor core will present a significant radiological risk, with the highest risk after 3-4 years of operation.

Plutonium Production

Iranian officials have stated that Iran after trying unsuccessfully to acquire from abroad a research reactor suitable for medical and industrial isotope production and for R&D to replace the old research reactor in Tehran. Iranian officials concluded, that the only alternative was a heavy water reactor, which could use the UO_2 produced in Esfahan. To meet the isotope production requirements, such a reactor would require power on the order of 30–40 Mw(th) when using natural UO_2 fuel.

However all nuclear reactors can have a dual use, and this type of reactor in particular is of a type often associated with production of plutonium for nuclear weapons programs. As such this facility certainly increases Iran's technological options for the production of nuclear weapons should it chose to do so, with the reactor having the capacity to yield 9-12.5kg of plutonium each year, enough for 2-3 nuclear bombs per annum.

ISRAEL

Development of Israel's Nuclear Programme

Israel's interest in a nuclear programme dates back to the founding of the state in 1948. The newly established Weizmann Institute of Science began supporting nuclear research in 1949 under the guidance of Ernst David Bergmann, a scientist and personal friend of the then Prime Minister David Ben-Gurion. Bergmann went on to become the first chairman of the secretly created Israel Atomic Energy Commission in 1952. Both Ben-Gurion and Bergmann believed that the nuclear option was essential for survival.

Since the beginning, Israel has maintained a posture of nuclear ambiguity, also described as nuclear opacity. Little is officially confirmed, therefore, about the nature and scale of its nuclear programme. Most assessments, like this one, are based on foreign sources.

Nuclear cooperation during the early 1950s and negotiations with France led to a 1957 agreement on the creation of a large-scale nuclear facility in Dimona. This agreement called upon France to build a 24Mwt reactor (although it is claimed that cooling systems and waste facilities were designed to handle three times that power and also in protocols that were not committed to paper, a chemical reprocessing plant[48])

The reactor went online in 1964[49] and during the early-1970s it is believed that the reactor was significantly upgraded in thermal power, with its design output grow from 24Mwt to three or four times that. The associated plutonium extraction plant is believed to have commenced operations shortly after the reactor came on line.[50] The reprocessing plant has an estimated capacity of 20-40 kg of weapons grade plutonium each year – enough to manufacture between 5 and 10 warheads annually. Dimona has always operated outside international safeguards.

In 1955 the Nahal Soreq Nuclear Research Centre near Beersheba, south of Tel Aviv, was opened, with the construction of its 5Mwt research reactor being completed in 1960; unlike the Dimona facility this reactor is under the IAEA safeguard regime.[51]

According to foreign sources, Israel's nuclear infrastructure also consists of several other strategic weapons plants or facilities, Tirosh and Eliabun, nuclear storage facilities; Rafael, the Ministry of Defence's high-tech weapons research and development organization, which produces missiles and warheads; and the Bor ("hole"), an underground command post beneath the Ministry of Defence, where Israeli officials gather during a crisis and from where they can command a war.

Israel's nuclear programme and international organizations

Israel has not signed the Nuclear Non-Proliferation Treaty[47] or the Biological Weapons Convention, and signed but hasn't yet ratified either the Chemical Weapons Convention or the Comprehensive Test Ban Treaty.

Israel is a member of the IAEA, and participates in its annual meetings. For the past 14 years Israel has been joining the consensus regarding "Application of IAEA safeguards in the Middle East", but in the 2006 general conference, diplomatic pressure towards action on "Israeli Nuclear Capabilities and Threats" has resulted in Israel not joining the "safeguards" consensus.

In the UN General Assembly, Israel, since 1980, has been joining the annual consensus resolution supporting "The establishment of a nuclear-weapon-free zone in the Middle East". However, Israel votes against the resolution regarding "The risk of nuclear proliferation in the Middle East.".

Missile facilities are located at Hirbat Zekharya, where approximately 100 Jericho-I and Jericho-II missiles, in equal numbers, are or can be deployed according to recent satellite photos, and at Be'er Yaakov, Israel's main missile production facility, where Jericho and Arrow missiles, as well as the Shavit launch vehicle, are assembled. The Palmakhim air base is the Israel Defence Force's main research and development facility, where missiles and rockets are assembled and tested. A large air base, Tel Nof, houses nuclear capable aircraft and is located only a few miles from Tirosh, the nuclear weapons storage facility, and from Hirbat Zekharya, the missile base. It is believed that several aircraft on the base are kept on 24 hour alert.

Development of Israel's Nuclear Programme

Military aspects of Israel's nuclear program

Although the Israeli Government has never officially acknowledged a nuclear weapons programme, the international community has recognised the military nature of the Israeli nuclear programme since the 1960s.[52] With the exception of the research reactor at the Nahal Soreq Nuclear Research Centre the Israeli programme is entirely military; it has no nuclear energy programme. Dimona is considered the centre piece of the military programme: with the reactor providing the irradiated/spent fuel from which plutonium is extracted/separated in the co-located reprocessing facility and then turned into plutonium metal required to make the pit components for a nuclear weapon. If changes to the reactor in the 1970s did increase design output to 75Mwt, then plutonium breeding rates would have increased to about 15 to 20kg or greater per year of operation[53], According to estimates based on Vanunu's revelations, the average weekly production is 1.2 kilograms of pure plutonium, enough for 4-12 nuclear weapons per year.

In 1981 the International Atomic Energy Agency (IAEA) asked Israel to submit its nuclear facilities to IAEA inspection but was refused[54] and the Dimona facility (reactor and plutonium reprocessing facility) remain unchecked.

Today, Israel's nuclear weapons arsenal is supposed to be quite diverse in terms of yield delivery systems, although the actual size and composition of Israel's nuclear stockpile is uncertain. By the late 1990s the U.S. Intelligence Community estimated that Israel possessed between 75-130 weapons, based on production estimates.

The principle rationale for going down the nuclear weapons path was to have a weapon of "last resort". In 1966, the Israeli defence establishment began systematic defence planning, which gave rise to the concept of four "red lines". If these lines were crossed then Israel would consider using nuclear weapons. These were:

- A successful Arab military penetration into populated areas within Israel's post-1949 borders;
- The destruction of the Israeli Air Force;
- Massive and devastating air attacks against Israel or the use of chemical or biological weapons; and
- The use of nuclear weapons against Israel.

By 1970 it was an open secret that Israel had nuclear weapons, and observers point to the 1973 war as the second time Israel went into nuclear alert. It has also been reported that Israel went on full-scale nuclear alert for the duration of Desert Storm in 1991 while the US was bombing Iraq and Iraq was sending SCUD missiles into Israel. But official Israeli nuclear policy has remained the same since the early 1960s: Israel will "not be the first to introduce nuclear weapons into the Middle East" although efforts to clarify both the term "introduce" and the term "nuclear weapons" in this context have been met with evasion. Israel's policy is supported by a consensus amongst decision makers and the public, and is linked to the continuing perception that a nuclear arsenal is essential if Israel is to survive as an independent nation.

Nuclear Facilities in Israel

Known Nuclear Facilities in Israel[55]

A) Nahal Soreq Nuclear Research Centre

Consists of:

- 5Mwt Research reactor IRR-1 fuelled with HEU[56] nuclear weapons research and design laboratory, possibly with additional fissile material on site

B) Negev Nuclear Research Centre [Dimona]

Consists of:

- Heavy Water plutonium/tritium production reactor, IRR-257
- Plutonium Reprocessing facility[58]
- Uranium processing and fuel production facility[59]
- Uranium enrichment facilities[60]
- Waste Treatment plant, High Level Waste Storage facility[61]

C) Eilabun

Consists of:

- Tactical nuclear weapon storage facility[62]

D) Haifa

Consists of:

- submarine base for 3 SSG and storage of warheads for sea launched cruise missiles (SLCMs); estimated to be 20 SLCMs

E) Yodefat

Consists of:

- Nuclear weapons assemblage facility[63];

F) Tirosh

Consists of:

- Nuclear weapons storage facility[64]

G) Kfar Zekharya

Consists of:

- Nuclear missile base and gravity bomb storage facility[65]

Potential Hazards from Israeli Nuclear Facilities

As with all nuclear programmes around the world, there are a range of environmental dangers and human health risks associated with all of Israel's nuclear facilities. Risks and hazards apply to fixed nuclear installations, particularly the reactor and reprocessing facilities at Dimona, and also to the transportation[66], handling and deployment of nuclear warheads, at land and at sea.

The hazards associated with Israel's 3 major nuclear facilities are discussed below. Impacts of a military strike are also briefly considered, although the high level of air defences and other security would make a successful strike difficult[67].

HAZARD 1: Nahal Soreq Nuclear Research Centre

Location

The Nahal Soreq Nuclear Research Centre is near Yavne a town of 30,000 people 30km south of Tel Aviv. It shares a security zone with the Palmachim Air Base. The reactor has been in operation since 1960 and is safeguarded by the IAEA.

Potential Hazards

The dominant hazard on the site is the research reactor core, plus any additional fissile material that might be present on the site.

Likelihood of incident

An accident is the most likely scenario, particularly given the age of the facility. Whilst a military strike is unlikely, the Nahal Soreq Centre is known internationally as the centre of Israel's nuclear weapons research and development[68] and as such is a target for any military attack targeting Israel's nuclear programme.

Consequences of incident

Being a relatively low-energy reactor, an accident is unlikely to involve an explosion of sufficient force to release fission product particles into the air. But a release of any of the radioisotopes being produced in the reactor could occur. If any release of radioactive material occurs, people would be required to shelter within their homes, and possibly even be evacuated from an area several kilometres from the plant. Large scale provision of potassium iodate tablets to limit some of the long term impacts would also be required, although media reports indicated this has already occurred[69].

In the case of *military attack*, the severity of damage could be extreme, with quite severe results for the near-by residential areas, definitely requiring countermeasures such as potassium iodate tablet provision, sheltering and evacuation. The scale of such countermeasures would depend on the exact conditions on the day of an accident but the location, only 30km from Tel Aviv means that impacts on Tel Aviv populations must also be considered.

Potential Hazards from Israeli Nuclear Facilities

HAZARD 2:
Negev Nuclear Research Centre [Dimona]

Location
The Dimona Facility is located in the Negev Desert about 10 kilometres from the city of the same name, population approximately 34,000 and 40 kilometres from the Jordanian border.

According to international sources the purpose of the Dimona facility is the manufacturing of nuclear weapons, but the Israeli Government refuses to confirm or deny this publicly.

Potential Hazards
There are significant radiological and chemical hazards associated with Dimona. The most significant radiological hazard is presented by the reactor core, but the spent fuel, plutonium separated and stored on site, and the waste also represent significant environmental dangers. The enriched uranium manufactured on the site, as well as the natural uranium used for fuel, represent a significant chemical hazard if released to the environment.

Likelihood of incident
A reactor accident or leakage of nuclear waste from the facility appears the most likely scenario. In a front page story in the most popular daily newspaper, Uzi Even, a former senior scientist at Dimona, declared that the reactor is dangerous and unsafe, and that it should be closed. He noted that reactors of this age are usually decommissioned, and that the Dimona reactor had been operating at a higher capacity than intended, thus speeding up the ageing process[70].

Consequences of incident
The consequences of an incident involving an explosion large enough to disperse plutonium from either the reactor or the reprocessing facility would be the most serious type of accident that could occur. Dispersal would depend on wind conditions and direction on the day of the accident. Dispersal of the uranium from site would also be highly toxic to populations around the facility causing damage to internal organs, particularly the kidneys as well as increasing the risk of cancer and other genetic defects in affected populations. Perhaps more likely, but no less significant is an accident involving leakage of radioactive material from the site or a fire involving the highly pyrophoric plutonium stored on-site.

The age of the reactor is certainly causing concern; with studies indicating that a 'melt down' at Dimona could affect an area up to 400 aerial kilometres in radius, reaching Cyprus, Jordan and the Palestinian Territories[71]. A study conducted by the Jordanian authorities at the request of the Palestinian Environment Authority attributes increased rates of cancers amongst nearby populations, particularly those in Jordan's Tafila City, to radioactive material leaking from the Dimona reactor[72].

Workers from the plant and residents of Dimona have also raised concerns about contamination from the facility. Although lack of available information is an impediment, including workers' actual inability to discuss the full range of duties carried out in the course of their employment, and the types of chemicals and radioactive substances to which they were exposed due to security reasons[73], medical research shows that those workers with relatively lengthy work histories in technical and inspection jobs had a higher rate of leukemia, lyphoma and tumours of the stomach and the brain[74].

Certainly the authorities have been taking some measures to prevent impacts to the population in the event of an accident. In 2004 iodate radiation tablets were distributed to the people living around the reactor to be used in the event of an accident at the plant to counteract the effects of radioactive iodine released during an incident[75].

Potential Hazards from Israeli Nuclear Facilities

HAZARD 3: Haifa

Location

Haifa is the main Israeli naval base. Three Dolphin diesel powered German built submarines are based in Haifa Port[76]. The submarines are reportedly capable of firing cruise missiles armed with nuclear warheads. Hence Israel has a sea-based as well as air and land based nuclear capacity. Haifa, with a population of just over 1/4 million it is also a centre for chemical and petrochemical industries.

Potential Hazards

The main hazard, apart from the actual use of a nuclear weapons would be from maintenance transport or from an accident whilst the submarine was on patrol if it were to be carrying nuclear-tipped cruise missiles[77].

Likelihood of incident

Accidents certainly do happen, as the recent collision between a US nuclear powered submarine and an oil tanker in the Gulf shows[78]. The greatest risk remains from fire reaching the fissile material in the warhead. This danger can be exacerbated if the conventional high explosive in the warhead is detonated by the shock of an impact. In the case of a missile, the accident can be worsened by the burning of solid or liquid propellant.

Consequences of an incident

Plutonium is highly pyrophoric and burns easily in these conditions and could create a toxic radioactive plume of plutonium particles contaminating a wide area downwind. Nuclear weapons lost at sea also present long term environmental risk. Nuclear weapons breached under deep ocean pressures can rapidly release their radioactive contents. At best, long term corrosion will cause a gradual release, emitting radioactivity into the marine food chains which can ultimately have a measurable effect on human populations.

Hazardous Materials in a Nuclear Weapon

Plutonium and Americium. When dispersed in an accident, plutonium is considered the most significant radiological hazard. The primary hazard results from inhalation and later deposition in the lungs. From the lung, plutonium enters the bloodstream and is deposited in the bone and liver. Bone deposition may lead to cancer and other possible genetic defects. Due to its extremely long physical and biological half-lives, plutonium is held within the body for a lifetime. The hazards from americium are comparable to those of plutonium.

Uranium is a heavy metal that occurs in nature in significant quantities. Three forms of uranium have been used in nuclear weapons: natural uranium, DU, and enriched uranium. Radiological hazards associated with any uranium isotope are usually less severe than those of plutonium. If uranium is taken internally, a type of heavy metal poisoning may occur affecting the functioning of the kidneys. Lung contamination due to inhalation may cause a long-term hazard and increase the risks of cancer and other genetic defects.

Tritium is a radioactive isotope of hydrogen and diffuses very rapidly in the air. Metals react with tritium in two ways: plating, the deposition of a thin film of tritium on the surface of the metal; or hydriding, the chemical combination with the metal. In either case, the surface of the metal becomes contaminated. In a fire, tritium combines spontaneously with oxygen in the air and also replaces ordinary hydrogen in water or other hydrogenous material (grease or oil), causing these materials to become radioactive. Metal tritides deposit in the lung. The tritium involved is bound with the metal. In its gaseous state, tritium is not absorbed by the skin to any significant degree. The hazardous nature of tritium is due to its ability to combine with other materials. HTO is readily absorbed by the body by inhalation and absorption through the skin. The radioactive water entering the body is chemically identical to ordinary water and is distributed throughout the body tissues. Tritium that has plated on a surface or combined chemically with a material is a contact hazard.

Thorium is a heavy, dense gray metal that is about three times as abundant as uranium. Thorium presents both a toxic and radiological hazard. Toxicologically, thorium causes heavy metal poisoning similar to lead or the uranium isotopes. Thorium accumulates in the skeletal system where it has a biological half-life of 200 years.

TURKEY

Development of Turkey's Nuclear Programme

Turkey's ambitions for nuclear energy began in 1967 with studies into the feasibility of a heavy water reactor and continue to the present day. Various proposals have come and gone in the mean time, including cooperation agreements with the Canadian[80] and Argentinean[81] Governments, German[82] and American companies[83] and a Korean research institute.[84] In July 2006, Turkish Prime Minister Recep Tayyip Erdogan outlined[85] a proposal to have three nuclear power plants in operation by 2015.[86]

Turkey also operates a small 5Mwt nuclear research reactor at the Cekmece Nuclear Research Centre. The first reactor on this site, a 1Mwt pool reactor TR-1, was commissioned in 1962 and shut down in 1977. It was replaced by a smaller 0.25Mwt reactor (TR-250) in 1979. And in 1982 the latter was in turn replaced by the current reactor. Turkey also has an operating pilot fuel production plant in CNAEM.

Turkey also hosts US/NATO nuclear weapons at Incirlik Airforce Base near Adana. Originally deployed in the 1960s, there are now 90 B-61 nuclear gravity bombs stored on the site. Nuclear weapons have also previously been stored at Akinci and Balikesir Air Bases. Each can store up to 24 nuclear weapons. Although these weapons were moved to Incirlik in the mid-1990s, Akinci and Balikesir are still on caretaker status, which means nuclear weapons can be redeployed in these bases anytime.

International Treaty Issues

Turkey signed the *Nuclear Non-Proliferation Treaty* (NPT) in 1969, ratified it date of deposit of ratification 17.04.1980 and subsequently ratified the *Additional Protocol* on 6 July 2000.

Turkey states its support on a WMD free zone in Middle East in international fora: "Turkey supports the establishment of Nuclear weapons Free Zones wherever practically feasible. Assurance of total absence of nuclear weapons and other WMD in a particular geographical area would have direct positive implications on the security concerns of the states in that specific region. In this context, Turkey supports the idea of creating a WMD Free Zone in Middle East and encourages all efforts for having a common regional understanding on this project with the participation of all parties concerned"[79]

Known Nuclear Facilities in Turkey

A) CEKMECE NUCLEAR RESEARCH CENTRE (CNRT)

- swimming pool type research reactor with 5Mw thermal power;[87]
- pilot fuel facility.[88]

B) INCIRLIK AIRBASE

- 90 NATO nuclear B61 gravity weapons held on site with a yield of between 0.3-170 kilotons, in 25 storage vaults
- 40 weapons hosted by Turkey - 50 weapons by US
- delivered by US F-16 C/D

Potential Hazards of Nuclear Facilities in Turkey

As with all nuclear programmes around the world, there are a range of environmental hazards and human health risks associated with Turkey's existing nuclear facilities.

If the Turkish Government goes ahead with planned new power plants the likelihood of an incident will increase particularly as Turkey is an area of seismic activity, and the likelihood of earthquakes creates additional hazards to any proposed additions to its nuclear programme.

The risks associated with two current nuclear facilities are discussed in detail below; the likely risks associated with the new power plants will be similar to those described elsewhere in this report.

HAZARD 1:
Cekmece Nuclear Research Centre (CNRT)

Location
The TR-2 5Mwt pool reactor at the Cekmece Nuclear Research Center is located in the Istanbul suburb of Halkali.

Potential Hazard
The dominant hazard on the site is the research reactor core.

Likelihood of incident
As the reactor is located in a seismic risk area and close to the international airport (Yesikoy), earthquake and aircraft crashes are the most obvious risks, with earthquake identified as the most likely to initiate an event with the potential for significant consequences.[89]

Consequences of incident
Being a relatively low-energy reactor, an accident is unlikely to involve an explosion of sufficient force to release fission product particles into the air. But a release of any of the radioisotopes being produced in the reactor could occur, in which case sheltering and even evacuation from an area several kilometres from the plant would be necessary. Large scale provision of potassium iodate tablets to limit some of the long term impacts could also be required.

In the case of *plane crash* or l*arge earthquake*, the severity of damage could be extreme, with severe results for the near-by residential areas, definitely requiring countermeasures such as potassium iodate provision, sheltering and evacuation. The scale of such countermeasures would depend on the exact conditions on the day of the accident but the location of the facility would mean a significant impact on the Istanbul population.

Potential Hazards of Nuclear Facilities in Turkey

HAZARD 2:
Incirlik Airforce Base

Location
Incirlik Airforce Base is located in south Turkey near the Syrian border. It can accommodate up to 100 nuclear weapons in 25 storage vaults and currently hosts 90 B61 nuclear gravity bombs. Whilst the base is collocated with the small town of Incirlik it lies only 8 km from Adana one of the biggest cities in Turkey with city centre (urban) population of 1.4 million. Together with the rural areas the city's population rises to 1.8 million.[90]

Potential Hazard
The main hazards, would be whilst the weapons are being transported to and from the United States for maintenance.

Likelihood of incident
Incirlik Base has been explicitly identified by the United States as a terrorist target[91] and media reports in 2006 revealed that Al Qaeda had been planning to attack the base, including with a human propelled and highly destructive missile, and in an apparent second plan with a hijacked plane[92].

And accidents can also happen. The greatest risk remains from an aircraft crashing whilst transporting nuclear weapons and igniting the fissile material in the warhead. This danger can be exacerbated if the conventional high explosive in the warhead is detonated independently by the shock of an impact.

Consequences of an incident
Plutonium will burn readily in these conditions and create a toxic radioactive plume of plutonium particles that can contaminate a wide area. An example, taken from a US military nuclear weapons accident response procedures manual, shows that if a nuclear weapon accident occurred in the early morning and under dry conditions, the radioactive core of the bomb could be widely dispersed with serious consequences: Up to 3 kilometres downwind people could receive up to 100 times the recommended radiation dose limit, requiring immediate evacuation. Up to 14 kilometres downwind contamination at the maximum dose limit could be received and that sheltering and/or evacuation could be necessary[93]. The town centre of Adana in Turkey, a city of 1.9 million people, is 15 km from Incirlik

CONCLUSION

No matter what the intent, military or peaceful, the presence of nuclear technology and facilities in the Middle East are a clear and present danger for the local population, both in the minor accident scenarios and in the worst cases the threats that could extend beyond national boundaries and threaten neighbouring populations.

The history of the nuclear industry is one of human errors and technical failure, accidents have happened in the past and will with certainty happen again in the future, the possible consequence are truly frightening justifying a full public discussion of the risks. Greenpeace is confident that no one who is "moderately wise will run the certain danger for a doubtful prize'.

For many observers around the world the Middle East has become synonymous with war and conflict, and for those concerned with the proliferation of weapons of mass destruction it is a "hot spot." For those living in the region, the reality of war and the fear of mass destruction are all too real. But, the Middle East is more than that. As the world watches with more than a little trepidation to see how the nuclear era will play itself out in this famously volatile region, there is still a choice that can be made by countries of the region, separately and collectively. That choice is between dirty, dangerous and outdated nuclear technology which deepens tensions and risks, or clean, modern renewable energy, opening a path to stability and peace.

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7 At the September 2002 regular session of the 46th IAEA General Conference, the then Iranian Vice-President H.E. Mr.R. Aghazadeh, http://www.iaea.org/About/Policy/GC/GC46/iran.pdf

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9 A pilot fuel enrichment plant (PFEP) nearing completion of construction and a large commercial-scale fuel enrichment plant (FEP) also under construction. These two facilities were declared to the Agency for the first time during that visit, at which time the Director General was able to visit both of them. In: Implementation of the NPT safeguards agreement in the Islamic Republic of Iran, report by the IAEA Director General, June 6th, 2003 http://www.iaea.org/Publications/Documents/Board/2003/gov2003-40.pdf

10 the 40 Mw(th) Iran Nuclear Research Reactor IR-40

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12 in the form of UF6 (1000 kg), UF4 (400 kg) and UO_2 (400 kg), see ibid.

13 mentioned in Implementation of the NPT safeguards agreement in the Islamic Republic of Iran, report by the IAEA Director General, 27th of February, 2006 http://www.iaea.org/Publications/Documents/Board/2006/gov2006-15.pdf, GOV_2006_11

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79 Statement by Mr. Mehmet Haluk Ilicak, Deputy Director General for OSCE, Disarmament and Arms Control to the 59th session of the General Assembly First Committee on Disarmament and International Security, 5 October 2004 originally here, but link disfunctional http://www.reachingcriticalwill.org/political/lcom/lcom04/statements/turkey.pdf, see http://www.reachingcriticalwill.org/about/pubs/Inventory/Turkey.pdf

80 655Mwe CANDU at Akkuyu

81 In 1988, Turkey signed a 15-year cooperation agreement with Argentina which included front-end nuclear fuel cycle development within IAEA safeguards82 and the installation of a 25Mwt research reactor twinned with a counterpart in Argentina. But this project was cancelled in 1991, as well as the order of a a 380Mwe Argos nuclear power plant, Argentina allegedly hoped for.

82 a Kraft-werk Union 990MWe PWR at Akkuyu,

83 General Electric 1,185Mwe BWR (Boiling Water Reactor) at Sinop on the Black Sea.

84 While the Argentina-Turkey cooperation agreement was effectively inactive, the Korean Energy Research Institute (KAERI) positioned itself in 1996 for the upcoming bid to supply a nuclear plant to Turkey. In this study KAERI examined the feasibility of renewing the Akkuyu project. After that, it was the Turkish government´s plan to accept bids for the construction of 1,200Mwe of nuclear capacity, either as a single or two 600Mwe units. However, this advanced project fell on stony ground when the Turkish government formally announced its abandonment in July 2000.

85 The Prime Minister said, 'As a country whose energy consumption is increasing rapidly, we want to benefit from nuclear energy as soon as possible'.

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86 In February 2006 Turkish energy officials were reported to be considering a nuclear plant sited at Sinop as part of a 5,000Mwe programme of nuclear plants for commissioning in 2012 with, although details are vague, the programme being led by a 100Mwe demonstration plant.

87 originally designed for a HEU core but this, by now, has most probably been replaced by a low-medium enriched fuel core in accord with the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program of United States (RERTR).

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