A.Q. Khan, Urenco and the proliferation of nuclear weapons technology: - The symbiotic relation between nuclear energy and nuclear weapons

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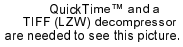

LAKA V.I.C.

PREFACE

Greenpeace International has commissioned this report to provide some insight into how one particular country, Pakistan, procured the technology to start its nuclear programme.

Through the history of the Khan network and its links to Urenco, the report highlights how easily civil nuclear technology can be acquired then put to military use. The report also shows how easily the international and domestic export controls system for civil nuclear technology can be circumvented to obtain the materials necessary to manufacture nuclear weapons.

As the authors of this report state:

"The role played by Urenco in the proliferation of nuclear technology as described in this paper illustrates clearly that the use of this technology for peaceful or military purposes cannot be separated. Furthermore, the existing international treaty obligations, which call for free access to nuclear technology for all member countries and for applying safeguards to nuclear materials, have in fact obfuscated an extremely important fact: the development of nuclear power as a source of energy makes it possible to create the basis of a nuclear weapons program."

Controlling who can have access to what types of nuclear technology through Article IV of the nuclear Non-Proliferation Treaty – as many are suggesting - is not the answer. The road to stopping countries acquiring the technology is not through saying some can have it and some can't. As past history has taught us, if countries cannot acquire this technology through legal means they will acquire it illegally, if they have political will, determination and enough money to pay for it.

If the international community is serious about tackling the threat of poliferation, there is an urgent need to agree and implement a comprehensive fissile material treaty that bans the production and possession of plutonium and highly enriched uranium.

Ultimately, only by ending the nuclear age will the threat of a nuclear breakout be curtailed.

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It is now well known that the 'father' of Pakistan's nuclear weapons programme, Abdul Qadeer (AQ) Khan, had his scientific roots in the Netherlands in the 1960's and 70's. At that time he had access to what was supposed to be highly secret uranium enrichment technology: the Urenco ultra centrifuge project. Thanks to security problems, as well as deliberate and unwitting help from former teachers and colleagues, he was able to build a global nuclear information network and business. From Pakistan, ultracentrifuge technology, knowledge and materials, were exported to Libya, Iran and North Korea. A mixture of legal and illegal transactions, involving businessmen from all over the world as well as individuals in the higher circles of the military and political elite in Pakistan allowed nuclear proliferation to proceed much faster than even those most familiar with the issue expected.

The Urenco Connection

Urenco, founded in 1970, is one of the world's leading uranium enrichment companies.[1] A Dutch/German/British consortium, Urenco uses the ultracentrifuge (UC) method to separate the useable fissionable uranium from the non-fissionable uranium. The advanced ultracentrifuge technology developed by Urenco uses significantly less electricity than gas diffusion,[2] which makes it much cheaper. Moreover, a UC enrichment plant can be built in modules, in contrast with gas diffusion plants which tend to be large football field sized facilities. Given the commercial advantages of the UC method of enrichment over gaseous diffusion methods, it is becoming the technology of choice around the world and eleven countries now have UC plants.[3]

After many years of denying accusations in that direction, the IAEA and Dutch authorities have recently confirmed that this very technology seems to have made its way to Iran, Libya and North Korea as well as Pakistan.[4] Moreover, it appears that until very recently Khan used the 'Dutch branch' of his international network of suppliers and middlemen for Pakistan's nuclear programme. And one Dutchman is now under investigation for having dealt with one of the other countries as well.[5]

The Risk of Proliferation

There are two steps in the civil nuclear chain which are most vulnerable with regard to nuclear proliferation: the export of technology for uranium enrichment and the reprocessing of spent nuclear fuel. The vulnerability of Urenco's security measures certainly goes a long way to explaining how interested states and non-state parties could obtain a nuclear arsenal via civil nuclear technology.

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[1] Boer, Joop; Uranium enrichment: No capacity growth in 20 years. WISE News Communique 499/500, Oct. 16, 1998. http://www.antenna.nl/wise/499-500/4932.html

[2] NEA/OECD, Trends in the Nuclear Fuel Cycle – Economic, Environmental and Social Aspects, OECD, 2001. p.10: http://www1.oecd.org/publications/e-book/6602011e.pdf

[3] Brazil, China, Germany, India, Iran, Israel, Japan, the Netherlands, Pakistan, Russia and the UK. In 2003, Louisiana Energy Services (LES) – a partnership of several major nuclear energy companies, including Urenco, Inc (a wholly owned subsidiary of Urenco Ltd) Westinghouse and US energy companies Duke Power, Entergy and Exelon – announced plans for a National Enrichment Facility (NEF) to be located near Eunice, New Mexico. The French enrichment company Eurodif announced in December 2003 it will acquire a fifty percent stake in Urenco's enrichment technology company and starting construction of a new UC plant at Tricastin in 2005.

[4] "Beantwoording kamervragen van het lid Wilders (VVD) over het ontwerp van de ultracentrifuges in Iran", 20 january 2004, at www.minbuza.nl.

[5] Alberts and Knip, "OM onderzoekt partner Khan", NRC Handelsblad, 17 February 2004. The link with Libya was earlier made by Matt Kelley, "Pakistan, nuclear black market linked", AP, 11 February 2004.

The Future?

US President Bush is currently using the Khan disclosures as justification for prohibiting the further export of technology for uranium enrichment and reprocessing of spent nuclear fuel to countries which do not yet have this technology at a commerical level. This may yet be an important step in diminishing further global nuclear proliferation.[6] The nuclear weapons and advanced civil nuclear states however, already occupy a privileged position in the nuclear Non-Proliferation Treaty (NPT) regime compared to other states. This discrimination, simply increases the risk of proliferation, as it cannot prevent vertical proliferation[7] by the nuclear weapons states. The development of new nuclear weapons currently taking place in the US for example, increases the risk of a renewed nuclear arms race among the existing nuclear weapons states. The worldwide abolition of uranium enrichment and reprocessing of spent nuclear fuel, through a comprehensive fissile material treaty is the only real answer to diminishing the risk of nuclear proliferation.

And of course, such measures must be accompanied by the abolition of nuclear weapons.

[6] Bush sees nuke crackdown. CBS News, Feb.11, 2004. http://www.cbsnews.com/stories/2004/02/11/politics/main599704.shtml

[7] Vertical proliferation refers to nuclear proliferation within Nuclear Weapon States, ie production of more or new nuclear weapons by those states who already have them; compared with horizontal proliferation which refers to states who currently don't have nuclear weapons acquiring them.

INTRODUCTION

More than 50 years ago US President Dwight D. Eisenhower presented his "Atoms for Peace" speech before the UN General Assembly.[8] He called on the United States and the Soviet Union "to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international Atomic Energy Agency" and then "devise methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind." His speech was the starting shot for the world-wide development and spread of nuclear energy, the civilian by-product of the manufacture of nuclear weapons;.[9] this was really a campaign to make the nuclear idea acceptable.[10]

Because of the risks inherent in the spread of nuclear technology, knowledge and fissile material, a global nuclear watchdog, the International Atomic Energy Agency (IAEA) was esablished in 1957 and in 1970, the nuclear Non-Proliferation Treaty (NPT) entered into force.[11] Under the NPT, the IAEA was given the powers of safeguards and inspection for the non-nuclear weapons states. To facilitate the peaceful use of nuclear energy, US legislation was also amended to reduce nuclear secrecy, allowing nuclear technology, material and knowledge to be exported to friendly states, approved and authorised by what was then the Atomic Energy Commission, now the Nuclear Regulatory Commission.[12]

The history of the IAEA and the NPT demonstrates that the promotion of the peaceful use of nuclear energy is a myth. In fact it has accelerated nuclear proliferation for military purposes. The recent disclosures on the nuclear network emanating from Pakistan and the history of the British-Dutch-German uranium enrichment consortium Urenco support this.

This paper attempts to detail the extent of the proliferation of Urenco enrichment technology over three decades. Chapters I and II provide a detailed reconstruction of Khan's nuclear network which began with him illicitly acquiring detailed knowledge and documentation from Urenco. Chapter III describes the origin and history of Urenco and Chapter IV its share in world-wide nuclear proliferation. Finally in conclusion the authors present recommendations necessary, in their view, to reduce the threat posed by the proliferation of enrichment technology.

[8] Atoms for Peace Address by Dwight D. Eisenhower President of the United States of America. Given to the 470th Plenary Meeting of the United Nations General Assembly on Tuesday, 8 December 1953.
http://www.ifpaenergyconference.com/pdf/speech.pdf
[9] Weiss, Leonard; Atoms for Peace. The Bulletin of the Atomic Scientists. November/December 2003, Vol. 59, No. 6, p.39.
http://www.thebulletin.org/issues/2003/nd03/nd03weiss.html
[10] Kollert, Roland; Latenten Proliferation
[11] http://www.fas.org/nuke/control/npt/back.htm
[12] Weiss; pp.40-41

CHAPTER I: KHAN'S DUTCH CONNECTION

Making a career

Born in the Indian town of Bhopal in 1936, AQ Khan and his family moved to Pakistan in 1952 and in 1961 Khan started his scientific tour through Europe in West-Berlin, studying at the *Technische Universität*. He continued at the *Technische Hogeschool* (now *Universiteit*) Delft in the Netherlands from 1963, where his mentor was the internationally renowned physicist prof. dr. W.G. Burgers. Khan received his MSc degree in metallurgical engineering there in 1967. Later he stated: "I got the best engineer's study in Delft, one of the best universities in the world".[13] Under the wings of prof. dr. Martin J. Brabers (himself a former pupil of Burgers) he received a Ph.D. in metallurgy from the Catholic University of Leuven (Belgium) in 1971 with a study on the elasticity of metal alloys.[14] Brabers and Khan co-edited "Topics in Physical Metallurgy", published in August 1972.

In May 1972 Khan started work at FDO[15], a subsidiary of VMF[16] in Amsterdam, highly recommended by the engineer A. Langstraat, an old friend from his time in Delft.[17] Security clearance for this sensitive job, from the Dutch Internal Security Service BVD (now the AIVD), was necessary because FDO was a major subcontractor for ultra centrifuge (UC) related work at Urenco's subsidiary UCN[18] in Almelo. Khan got the clearance without problems. VMF-Werkspoor was the place where in 1954 Jacob Kistemaker, the Dutch father of the UC-technology, built his first centrifuges for enriching uranium.[19]

Though Khan was supposed to work with material that was ultimately labelled "confidential", he soon found himself amidst all kinds of secret information, both at FDO, FMA[20] and UCN. He was even allowed to take home complete dossiers from FDO[21]. He visited UCN for the first time on 8 and 9 May 1972 and in 1974 spent 16 days in the "brainbox" (a temporary building) in Almelo, translating secret German reports on new developments in ultracentrifuge technology into Dutch.[22] Although at one stage he was seen taking notes in Urdu, his explanation that he was writing a personal letter was accepted.[23] According to the governmental report on the Khan case there was "an open atmosphere" within the group of technicians in the brainbox. Also during these days, he was free to enter the (classified) UC-plant itself, as the canteen and sanitary facilities were there. Nobody seemed to be bothered, as everybody had good faith in Khan.[24]

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[13] Harm Ede Botje and Ko Colijn, "De vader van de islamitische bom verklaart zich nader", Vrij Nederland, 18 July 1998. As for the rest of this article, all translations from Dutch-language sources are the author's.
[14] See e.g. David McMullin, "TU Delft's Dr. Strangelove", Delta, vol.34, nr. 26, 2002, at www.delta.tudelft.nl. Also Jan Pijper and Hugo Schneider, "Wat Khan kon, kon Khan nooit alleen"", de Volkskrant, 14 March 1981.
[15] Fysisch Dynamisch Onderzoekslaboratorium, or Physical Dynamic Research laboratory, founded as in-house laboratory in 1971.
[16] Werkspoor and Stork merged in 1954 into VMF (Verenigde Machinefabrieken), which in 1992 became Stork again. Throughout the literature VMF is also often called VMF-Werkspoor and VMF-Stork, sometimes referring to their former name.
[17] Pijper and Schneider, de Volkskrant, 14 March 1981. Though the government report on Khan claims that it was a normal application procedure, the vacancy was not advertised ("Onderzoek, zaak-Khan", Tweede Kamer, vergaderjaar 1979-1980, 16082, nrs. 1-2, p.17).
[18] Ultra-Centrifuge Nederland, which was set up in 1969..
[19] Henk Tolsma, "Nieuwe Helden", Technisch Weekblad, 16 January 2004.
[20] Fijn Mechanische Afdeling, another VMF department that produced and assembled engine parts for the Dutch ultracentrifuges.
[21] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.18.
[22] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.18; Frits Veerman and Jacques Ros, "Atoomspionage", Center Boek, Weesp, 1988, p.39.
[23] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.18.
[24] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.19.

Khan continued to work at FDO until late 1975, using the opportunities to expand his knowledge of the network of Urenco subcontractors and other companies. Suspicion arose in his last year in the Netherlands, after a number of incidents attracted the attention of the authorities,[25] and he was 'promoted' in October 1975 to a different function in the company to keep him away from uranium enrichment work. No formal investigation was launched as there seemed to be no hard evidence for any wrong-doing, despite signals to the contrary from a whistleblower.

Khan, his wife Hendrina[26] and daughters Dina and Aysha left for Islamabad for holidays on 15 December 1975. A case of yellow fever kept him there for at least two months according to a letter that his wife wrote to friends.[27] Some time later Khan himself sent his resignation letter to FDO, where his job formally ended on 1 March 1976.

In those three and a half years at FDO Khan collected and copied the most important documents needed to enable his country to build its own centrifuges for uranium enrichment - essential for 'Project 706', the creation of Pakistan's nuclear capability. His home country highly appreciated his Dutch work and AQ Khan became the main architect of Pakistan's nuclear weapons programme.

Building a European network

In July 1975, S.A. Butt - a physicist-turned-diplomat - was posted at the Pakistani embassy in Brussels, Belgium, in charge of buying the necessary tools, parts and materials (mostly special steel and aluminium) in Europe.[28] Later he was joined by Ikram ul-Haq Khan (no relation), with whom he worked at Watchberg-Pech, near Bonn in Germany. A.Q. Khan himself returned to Belgium in 1976 for negotiations with Belgo Nuclear for purchasing so-called glove boxes, that protect against radiation.[29] Export controls were easily bypassed, as trusted, mostly western intermediaries placed the orders. Though the CIA (and other intelligence services) were supposedly aware of Pakistan's purchases, all went smoothly until 1978, when it became apparent that the British subsidiary of Emerson Electric sold to Pakistan 'high-frequency inverters', with the same specifications as those used by British Nuclear Fuel Ltd. to enrich uranium. Before long an investigation was launched and elsewhere in Europe alarm bells started ringing.[30]

The Pakistan pipeline

Even before Khan left the Netherlands, companies were approached with lists of components needed for Pakistan's UC-project. One company that was particularly eager to make a profit was Van Doorne's Transmissie (VDT) in Tilburg. In the late 70's VDT worked on a deal to supply 6,500 maraging steel tubes for the centrifuges, ordered by S.A. Butt.[31] During what may have been his first trip back to the Netherlands after his return to Pakistan, Khan visited VDT in

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[25] One of them is an order that a Dutch company received from the Pakistani embassy in Brussels for special foil, which existence could almost certainly only be known through Khan. A deal never materialised. See also "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.19-20.
[26] Henny Donkers by birth, according to one source she is the daughter of a Dutch diplomat who worked many years in Africa and because of that she has a British, South African and Dutch passport (Groene Amsterdammer, 21 February 2004).
[27] Frits Veerman and Jacques Ros, "Atoomspionage", Center Boek, Weesp, 1988, p. 41.
[28] Though the Dutch connection is emphasized here, a host of European companies were more than eager to supply whatever Pakistan's wish list contained. To mention a few, Swiss companies Vakkuum Apparate Technik (now again in the spotlight as Urs Tanner, the son of the then director Friedrich Tanner, turns out to have been working for the Malaysian company SCOPE, which built parts for Libya's ultra-centrifuge programme) and Cora Engineering; Albrecht Migule's CES Kalthoff GmbH in Germany; Team Industries (Leonberg, Germany) served as suppliers for the Pakistani nuclear programme at least during the late 1970's.
[29] Pijper and Schneider, de Volkskrant, 14 March 1981.
[30] Veerman and Ros, p. 45-6.
[31] Butt's involvement is mentioned by Jaco Alberts and Karel Knip, "De vriend van een atoomspion", NRC Handelsblad, 21 February 2004.

1977.[32] Within the company the order was commonly known as the 'Pakistan pipeline'. The tubes were exported between 2 November 1976 and 10 September 1979. On this later date a shipment of 300 tubes was stopped at Schiphol Airport.[33] Though the Ministry of Economic Affairs was well aware of the deal and had even warned VDT several times not to deliver, VDT simply went ahead and was stopped only years later. At first the company claimed that the materials were for agricultural purposes. But in court it turned out that in 1977 it had admitted to officials that it knew the order was for Khan as orders had come from the Pakistani embassy in Bonn, Germany. However, director Hamstra Pik successfully claimed that no licence was needed for the exports.[34] Though the Dutch parliamentary commission on the Khan affair concluded that the tubes were "essential for the set-up of a U.C.project"[35], Dutch law was on VDT's side. As the tubes were not "specifically developed" for use in gas centrifuges, no export licence was needed, revealing a major loophole in the export law. The case was particularly embarrassing for the Dutch authorities as they had a large share in VDT and had spent millions of dollars to subsidise what was supposed to be the company's main business, the development of variable transmission systems for cars.

A gift from heaven

FDO also appeared in court as a consequence of the government's investigation into the Khan case. It was revealed that in 1977 it allowed the sale to Pakistan of specially designed measuring instruments, originally made for Urenco. When Urenco dropped the order, Pakistan's interest came like "a gift from heaven".[36] In 1983 FDO's director and sales manager were indicted for not having obtained an export licence. A year later both were acquitted - the court rejected the argument that because the embedded restricted devices needed a licence, the complete machine needed one too.

C.M. Kuys, FDO sales manager from 1976-1977, travelled to Pakistan in 1977 for the deal, worth 45,000 euro and stayed at Khan's house. To a Dutch journalist he stated in early 2004 that he had also visited Khan in 1976, in cooperation with the Dutch security service BVD, to make clear that he "should not bother us any more", asking former colleagues for help with sensitive information.[37] The reason that he made a sales visit to Khan the next year was because "that measuring equipment was innocent, we could deliver that to him." Soon though it became apparent that it did have something to do with "the affair".

Offset policy: Dutch components for Pakistan's nuclear delivery systems

Often overlooked are the legal, government-sanctioned sales of numerous components by Dutch companies[38] for the 40 Pakistani F-16s that were ordered in 1980, the year of the Khan report. Though Norway (a partner in the F-16 project) raised objections to the sale, the Dutch government gave the go-ahead, despite the common knowledge that F-16s are capable of nuclear tasks[39] and that Pakistan was moving ahead on the road towards nuclearisation. A new batch of 71 fighter-planes was ordered in 1989, but cancelled in October 1990, when the US government

[32] Pijper and Schneider, de Volkskrant, 14 March 1981.
[33] Ko Colijn en Paul Rusman, chapter 8.1 in "Het Nederlandse wapenexportbeleid 1963-1988", Nijgh & Van Ditmar Universitair, The Hague, 1989. Clemens Graafsma, "Van Doorne leverde omstreden materiaal", de Volkskrant, 12 September 1980.
[34] "Vrijspraak voor Van Doorne's Transmissie", de Volkskrant, 7 September 1984.
[35] Quoted in Colijn and Rusman, p. 407.
[36] Leonard S. Spector, "The new nuclear nations" (Vintage Books/Random House, New York, 1985), p.24.
[37] GPD (Harald Doornbos), "Stork deed ook na vermoeden van atoomspionage nog zaken met Khan", Haarlems Dagblad, 5 February 2004.
[38] E.g. Fokker (now Stork Aerospace), HSA (now Thales Nederland), Daf SP (now SP Aerospace & Vehicle Systems).
[39] As they are for the NATO nuclear task, by the Dutch Air Force at Volkel AB in the Netherlands.

decided that an arms embargo to Pakistan was needed, in response to its progress towards a nuclear bomb.[40] Also their F-16s were allegedly modified with the means of carrying and delivering a nuclear weapon.[41] Only weeks before the American embargo the Dutch government claimed that "the relation between Pakistani F-16 planes and nuclear weapons is not correct".[42] Today Pakistani authorities are again in talks with the Americans to renegotiate a batch of F-16s, new or second-hand, and to refurbish the current Pakistani F-16s, now the US has lifted its sanctions.[43] Even though its missile programme has progressed much over the last years and dependency on aircraft as nuclear delivery systems has diminished, additional F-16s could still prove to be an important tool in Pakistan's nuclear inventory.

A Dutch inquiry

Only at the end of March 1979, after a German television programme[44] revealed that Pakistan - through Khan - had access to Urenco UC technology, did the Dutch launch an investigation into the matter. Because new reports in early June of that year revealed that centrifuges identical to the Dutch ones were already working in Pakistan, the authorities "intensified" their investigation[45].

From the beginning, the Dutch authorities downplayed questions and accusations with regard to the value of the knowledge Khan had gained, and concerning the many failures on the security side. First it was said to be all rumours, then it was said that if any knowledge had been compromised, it would have been "only an insignificant part of the ultra-centrifuge technology"[46]. Some months later it was acknowledged that "serious doubts exist on Khan's innocence"[47]. Finally in the 1980 official report 'Onderzoek zaak-Khan' the government concluded "that it is likely that Pakistan through Khan has been able to acquire sensitive knowledge concerning the enrichment technology" but that the "real contribution of Khan to a Pakistani UC-project regarding the input of knowledge is hard to measure".[48]

The general picture the government tried to uphold throughout was one of a regrettable accident, due to laxity by a couple of people. Some extra safeguards were installed to prevent a recurrence in the future, and cases against Khan and two guilty companies were prepared.[49] Though the government came under fire several times for its handling of the case, there were no further political consequences.

It was another four years before Khan was finally tried and prosecuted. The case against him was not very strong: all that could be used against Khan were two letters from him - written after his

[40] Intelligence information reaching US authorities indicated that Pakistan was actively working on a nuclear bomb. It supposedly had received a design for a bomb from China, had tested a nuclear trigger, and was actively producing weapons-grade uranium. See http://www.f16falcon.com/facts/f16_17.html.
[41] http://www.f16falcon.com/facts/f16_17.html
[42] Quoted in Ko Colijn and Paul Rusman, "Pakistaanse atoombom onder F-16's van Fokker?", Vrij Nederland, 2 June 1990.
[43] The possibility of refurbishment was mentioned most recently in March 2004 when Pakistan's major non-NATO ally (MNNA) status was announced.(Gopal Ratnam and Vivek Raghuvanshi, "Subcontinental Tightrope - U.S. Nod To Pakistan Angers India", Defense News, 29 March 29 2004). In October 2003 Belgium was said to be a possible source of surplus F-16s for Pakistan ("Pakistan may get 60 helicopters from the US", The Press Trust of India, 4 October 2003; See also: "Pakistan to get $341 mil. worth of U.S. armaments: official", Japan Economic Newswire, 30 September 2003).
[44] ZDF, 28 March 1979; see: "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.9.
[45] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p.9.
[46] Economic Affairs minister Van Aardenne, as quoted in Veerman and Ros, p. 47.
[47] Van Aardenne, Wiegel (Interior minister) and Van der Klauw (Foreign Affairs), as quoted in Veerman and Ros, p. 47.
[48] "De zaak-Khan", Tweede Kamer, 1979-1980, 16082, nrs 1-2, p. 1-2.
[49] For example, 126 Dutch subcontractors of UCN are notified 24 July 1979 of the existing legislation. Ibid. p.32.

return to Pakistan - to his former colleague Veerman, in which he had asked for 'classified'[50] information about 'bottom-bearings' and 'pivots', critical UC-parts. For the illegal copying of secret documents with UC-technology and relevant details of its suppliers he could not be prosecuted, because proof was lacking. If he had been caught it could only have been for espionage, not for illegally exporting materials. At that time no export licence was needed for the transfer of technology.[51] After an initial sentence - *in absentia* - of 4 years imprisonment, Khan was acquitted 28 March 1985 by an appeals court due to a 'technicality', as the summons had not been delivered properly.

Though he was declared *persona non grata*, Khan continued to visit the Netherlands for years, both for business and family affairs, by way of the Belgian border, which was quite porous. He was only caught once, in December 1988, when he was put on a plane back to Pakistan. On at least three later occasions he was even officially allowed to enter the country, on "humanitarian grounds".[52]

Tem years later, and within days of Pakistan crossing the nuclear threshold - 28th May 1998 - Dutch Foreign minister Hans van Mierlo announced an embargo on arms exports to the country, as he had against India a few days earlier in response to its nuclear tests. When A.Q. Khan's Dutch background re-emerged in the media, Urenco spokesman Willem van der Elst claimed that "many of those stories were very, very exaggerated. As far as we know he has never been able to get hold of any information".[53] That claim became more ludicrous every day.

The Dutch authorities themselves have now admitted that Urenco technology apparently has made its way via Pakistan to countries that some governments have labelled 'countries of concern', or even part of an 'axis of evil'.[54] In a written statement - that was mentioned in relation to Khan's public confession of having leaked nuclear technology on 4 February 2004 - Khan himself is said to have confessed to selling nuclear technology to Iran, Libya and North Korea.[55]

What role for the Pakistani government?

One of the most implausible aspects of the Khan story ar the claims that Khan was leading a multi-million dollar nuclear trading business on his own.[56] Given his high position within the Pakistani establishment and his close contacts with presidents and prime ministers since the mid-seventies, it is highly unlikely that they did not know about his activities. Moreover, as most stories on the North Korean-Pakistani nuclear relations confirm, the barter trade of missile technology for uranium enrichment technology directly benefited Pakistan's nuclear missile

[50] According to former lawyer Frank Bakker, Khan would have walked free anyway, as his lawyer, the late Mario den Drijver, had succesfully proven that at least for the pivot, blueprints were publicly available (Ed Croonenberg, "Nucleair gidsland", HP De Tijd, 20 February 2004).
[51] A direct consequence of Khan's case is the creation of an additional category for the transfer of technology for which a licence is needed. Excluded though is technology that is already available in open sources.
[52] The mother of Khan's wife re-married a former transport worker, who Khan was allowed to visit on humanitarian grounds, because of his critical condition. "Atoomspion Khan kreeg toestemming voor ziekenbezoek", de Volkskrant, 11 July 1992; Hans van Zon, "Dr. Abdul Qadeer Khan heeft nergens spijt van", Algemeen Dagblad, 27 June 1998.
[53] "Rol spion overdreven", Trouw, 29 May 1998.
[54] "Beantwoording kamervragen van het lid Wilders (VVD) over het ontwerp van de ultracentrifuges in Iran", 20 January 2004 and "Kamerbrief inzake bij de regering aanwezige kennis over de betrokkenheid van Urenco Nederland BV bij de ontwikkeling van nucleaire wapens in een aantal landen waaronder Pakistan", 5 April 2004, both at www.minbuza.nl.
[55] See e.g.: "Pakistani nuclear hero admits selling secrets", AP, 4 February 2004.
[56] According to the Bush administration Khan's business with Libya alone netted $100 million. David E. Sanger and William J. Broad, "Pakistani's Nuclear Earnings: $100 Million", The New York Times, 15 March 2004.

programme.[57] That Khan had set up such deals without permission from the authorities is simply beyond imagination. Most analysts therefore agree that Khan's confession and the subsequent pardon was directly linked to the knowledge that starting a court case would not only automatically create a perfect case for a coup, but also certainly implicate president Musharraf and many others. With top Al Qaeda leaders supposedly hiding in the remote border region with Afghanistan, and Pakistan's willingness to assist the US military in their hunt just across the border, Pakistan is too important in the war against terrorism to sacrifice. In fact it is so important that despite the allegations on Pakistan's role in proliferating nuclear technology, on 18 March 2004, when US Secretary of State Collin Powell visited Musharraf, it was announced that Pakistan would get the status of "major non-NATO ally".[58] As in the past, short-term foreign policy aims effectively undermined attempts to stop the proliferation of nuclear technology.

If recent rumours prove to be true, the case may come full circle, taking a bizarre step back to the Netherlands. According to the British paper The Daily Telegraph, in 2003, AQ Khan sent his daughter Dina abroad with "potentially incriminating documents" and a tape-recorded statement.[59] Khan is said to claim that all the chiefs of army staff since 1977, including general Musharraf, knew of his actions. Khan's pardon is said to be directly linked to his possession of these documents. Ziauddin Sardar writes in the New Statesman that he knows where they are: Khan sent his daughter to the Netherlands in December 2003, with "truckloads of incriminating documents".[60] He says that confidential contacts with people within the Pakistani military are his source.[61] If true, Khan has given the Dutch government another major headache.

Official silence again

The recent questions on Khan and Urenco have caused serious unease in The Hague. But rather than revealing the answers in public, the government appears to be trying to maintain as much secrecy about the case as possible. For as long as no court case takes place it is only investigative journalism that provides new insights. Most disappointing in this respect is the long-expected letter from the government on the recent Urenco revelations. Announced in January 2004, it was finally sent to parliament in early April. The one-page letter "on the available knowledge with the government on the involvement of Urenco Nederland BV with the development of nuclear weapons in a number of countries, among which Pakistan", goes no further than stating that Urenco itself has never been involved as such in the development of nuclear weapons by these countries. That Khan stole information on the "earliest Urenco-technology" is nevertheless regretted. Then the letter concludes that 24 years later there is nothing to add to the Khan report, concerning the Khan affair and Urenco. The finding of "centrifuges of the old Urenco-design" in Libya and Iran only reinforces the "serious suspicion" that A.Q. Khan has stolen these blueprints.[62] In that respect, too, not much has changed since the 1980 report "De zaak-Khan".

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[57] A 20-member North Korean delegation was even present at Pakistan's nuclear tests. See for example: Paul Watson and Mubashir Zaidi, "Death of N. Korean Woman Offers Clues to Pakistani Nuclear Deals", Los Angeles Times, 1 March 2004.
[58] "US To Designate Pakistan A Major Non-NATO Ally", AFP, 18 March 2004, at www.spacedaily.com.
[59] Massoud Ansari and Victoria Schofield, "Father of the Islamic bomb barters papers for his future", Telegraph, Internet-edition, 15 February 2004.
[60] Ziauddin Sardar, ""Traitor" will get a rich retirement", New Statesman, 9 February 2004.
[61] Aart Brouwer, "Waar zijn de Khan-papers?", Groene Amsterdammer, 21 February 2004.
[62] "Kamerbrief inzake bij de regering aanwezige kennis over de betrokkenheid van Urenco Nederland BV bij de ontwikkeling van nucleaire wapens in een aantal landen waaronder Pakistan", 5 April 2004, at www.minbuza.nl.

CHAPTER II: KHAN'S SUPPORT NETWORK

Khan befriended several top Dutch scientists during his time in the Neherlands as well as colleagues and former co-students, who later visited either Khan or his nuclear connections. Though Khan's charming, friendly personality is often quoted as a reason why he could win people to work with him, he obviously had more to offer, including free trips to Pakistan, paid for by the Pakistani government. One of these colleagues, Henk Slebos, may well have earned most of his income over the last decades with business deals from Khan.

A moral duty

In the first years after Khan's departure for Pakistan in 1975 at least three prominent Dutch scientists are said to have visited Pakistan: Brabers, Burgers and Barendregt[63]. The only one who has never denied this is Brabers, Khan's professor in Leuven. He is quoted as having said that it was his "moral duty" to help former students whenever asked, but has also said: "I don't help them to make an atomic bomb."[64] Brabers admits to having been in Islamabad "several times" in the years 1976-1977. In those years he also met Munir Ahmad Khan, then chairman of the Pakistan Atomic Energy Commission (PAEC) and the country's representative at the IAEA. Munir Khan was AQ Khan's boss for a short while in 1976, until 'AQ' founded the Engineering Research Laboratories (ERL, later KRL).[65] According to Brabers he never wanted money, but he did get tickets for free or half-price, as a guest of the Pakistani government.[66]

After President Bhutto openly started the quest for Pakistan's nuclear bomb in 1974, restrictions were placed on Pakistani students at Dutch universities and laboratories. Concerns about these developments were not shared by everybody. As Brabers commented in 1981: "[P]ersonally I don't really care. Knowledge is not secret and UC-technology is nothing exotic. You can find it all back in the professional literature."[67]

In the early nineties Brabers was rector of the Gulam Ishaq Khan Institute of Engineering, Science and Technology, set up by AQ Khan in Topi, North West Frontier Province. The institute was on a June 1998 US government list of Pakistani entities which were said to be involved in nuclear or missile activities and therefore denied US items controlled for non-proliferation reasons. And as recently as last year he was a member of the international scientific committee of the 8th International Symposium on Advanced Materials (ISAM), held in September 2003 in Islamabad. ISAM is the most important international meeting of Khan Research Laboratories (KRL) (see below).

Before working at Leuven University, Brabers had worked at the atomic research centre in southern Norway where Dutch and Norwegian scientists worked together. Brabers' boss in Norway was another respected scientist, the mathematician and physicist dr. T. Barendregt. From 1959 Brabers and Barendregt also worked together in Mol, Belgium, where Barendregt became director of Eurochemie, the then European project to reprocess spent nuclear fuel. In the early '80's Brabers worked one day a week at the nuclear energy laboratory SCK, also in Mol. [68]

[63] Pijper and Schneider, de Volkskrant, 14 March 1981.
[64] Pijper and Schneider, de Volkskrant, 14 March 1981.
[65] http://nuclearweaponarchive.org/Pakistan/AQKhan.html
[66] Pijper and Schneider, de Volkskrant, 14 March 1981.
[67] Pijper and Schneider, de Volkskrant, 14 March 1981.
[68] Pijper and Schneider, de Volkskrant, 14 March 1981.

Barendregt was director of the Dutch engineering company Comprimo between 1976 and 1 October 1980.[69] Comprimo and Interatom, subsidiary of the German Siemens concern were together responsible for the design and supervision of the first two uranium enrichment factories in Almelo.[70] Barendregt's son confirmed to journalists in 1981 that his father had been to Pakistan "several times" in the period 1975-1977.[71] His father denied this to the same journalists, but admits to having been in Pakistan in 1974, to work on a deal for a fertilizer plant despite a Comprimo spokesperson stating that the company had not done any fertiliser related work for 25 years. Barendregt also denied that he had ever met A.Q. Khan, but Brabers claimed that he met Munir Ahmad Khan in late 1976 to get orders for Comprimo. After retiring in 1980 Barendregt became advisor of Nuclebras in Brazil.

The third scientist, professor Burgers, from Delft, has always denied having ever been in Pakistan, let alone having visited Khan there. Nevertheless, both professor Brabers and a Dutch friend of Mrs Khan claim that he was there there for six weeks in early 1977.[72] According to this Volkskrant article, Mrs Khan's friend has a letter from her, in which she complains of having to take care of the invalid Burgers. In the same article Burgers wife says that this letter must be a falsification.

Many years later, the Dutch seem to have become more sensitive to foreigners working at or visiting scientific institutions and related companies. In the summer of 2003, the security and intelligence service AIVD released a report in which it warned of possible infiltration by people from "countries of concern", most notably Iran, Libya, Syria, North Korea, Pakistan and India.[73]

Operation butter factory

The name of Henk Slebos has been mentioned many times during the last months in press reports on Khan's nuclear network. His name surfaced shortly after a Pakistani government spokesman stated at a press conference, that a Dutch businessman called "Hank" or "Hank S." was involved.[74]

Henk Slebos has known AQ Khan for more than forty years, since they both studied metallurgy in Delft in 1963. After his studies Slebos worked for five years for the Royal Navy, as 'troubleshooter' involved in buying components for submarines. Through his job he was in touch with the specialised welding firm Explosive Metal Works Holland (EMWH) - a Urenco subcontractor - where he became Commercial Director around 1974.

In 1976 Slebos flew to Pakistan for the first time. The Dutch daily NRC quotes him as saying on tape: "I delivered him (...) the whole lot, the whole range from electronics to the construction materials, all kinds of things that were not forbidden to deal in."[75] And according to the court that

[69] Then a joint company of RSV (the then shipyard conglomerate, which went bankrupt a couple of years later), VMF (Stork), Shell and SHV (a former coal company owned by one of the richest Dutch families - de Fentener van Vlissingen).
[70] And probably the third, see: "Comprimo werkt aan UCN-project", de Volkskrant, 15 June 1978.
[71] Pijper and Schneider, de Volkskrant, 14 March 1981.
[72] Pijper and Schneider, de Volkskrant, 14 March 1981.
[73] "Proliferatie van massavernietigingswapens - Risico's voor bedrijven en wetenschappelijke instellingen", AIVD, July 2003.
[74] David Rohde and David E. Sanger, "Key Pakistani Is Said To Admit Atom Transfers", New York Times, 2 February 2004.
[75] Albert and Knip, NRC Handelsblad, 21 February 2004.

sentenced him in 1985, he admitted to Dutch export control authorities that he was well aware of the nuclear destination of his export activities, (see also below).[76]

Slebos - who started his own business Slebos Research BV in 1978 - is mentioned in different cases from the late 1970's onwards, though some claims are hard to verify. He is said to have been involved in the VDT (Pakistan Pipeline) deal as a middleman.[77] And according to German broadcasting corporation ZDF, Slebos met the head of the Special Works Organisation, Amid Ali Said, in the Netherlands in 1980.[78]

By accident[79], Slebos was caught illegally exporting a US-made Tektronix oscilloscope on 23 October 1983 and was sentenced to one year imprisonment in July 1985. During the trial it turned out that Slebos had been warned by the Dutch government export control department (ECD) in 1980, for three suspicious transactions.[80] For unknown reasons he never served his prison term.[81] According to another German broadcaster, in 1985 and 1986 Slebos received around 340,000 Euro's from the Pakistani embassy in Bonn in his German Commerzbank account. In that same TV programme he was said to be involved in a deal for Khan with German steel company Arbed Saarstaal. Interviewed by the Germans, Slebos explained that financial problems were the reason for his activities. He is quoted as having codenamed his business with Pakistan "Operation Butter factory".[82]

On 24 December 1988 Khan was caught in a car, near his wife's family home in Bergen op Zoom, apparently as a result of security service monitoring on Slebos, who was travelling with him.[83] Khan was put on a plane back to Pakistan. According to the WDR (German broadcasting corporation) journalists, the two had also met in the Netherlands in July of that year. [84] On both trips Khan is said to have been looking for European suppliers of measuring equipment to register nuclear test explosions.[85]

A decade later Slebos' name resurfaced in the media. Some weeks after Pakistan's nuclear tests, in May 1998, journalists of the weekly Vrij Nederland discovered that three Slebos packages were being held at Schiphol airport, and two more in Austria and Belgium.[86] Besides Slebos Research, Bodmerhof BV, another Slebos company, was also involved. Though the goods normally would not need an export licence, a special 'catch-all' provision was applied, because of their suspected Pakistani destination.[87] Asked about the case in an interview, Khan stated: "I

[76] Alberts and Knip, NRC Handelsblad, 21 February 2004.
[77] See Pijper and Schneider, de Volkskrant, 14 March 1981.
[78] ZDF, 17 February 1981, as quoted in Pijper and Schneider, de Volkskrant, 14 March 1981. The Special Works Organisation was set up under the Defence ministry by prime minister Zulfikar Ali Bhutto in the mid-seventies, to control nuclear activities. Former Finance minster Ghulam Ishaq Khan was appointed as its first coordinator.
[79] Because of a work-to rule action by the unions, personnel at the airport were checking every single package.
[80] "Vriend Khan hoort 15 maanden eisen", Reformatorisch Dagblad, 19 June 1985.
[81] College van Beroep voor het Bedrijfsleven, "LJN-nummer: A00900 Zaaknr: AWB 02/595", 29 October 2003.
[82] WDR (Westdeutsche Rundfunk) programme as quoted in: Theo Jongendijk and Walter Samuels, "Nederlander verdacht van hoofdrol in Pakistaans atoom-spionageschandaal", Telegraaf, 11 January 1989.
[83] "BVD volgt zakenvriend van atoomspion Kahn", NRC Handelsblad, 11 January 1989.
[84] Jongendijk and Samuels, Telegraaf, 11 January 1989.
[85] Jongendijk and Samuels, Telegraaf, 11 January 1989.
[86] Ko Colijn and Paul Rusman, "Khan bestelt nog steeds uitrusting in Nederland", Vrij Nederland, 6 June 1998.
[87] If there is suspicion that certain non-strategic goods may be used in relation with weapons of mass destruction this special provision is used. From its coming into force in 1996 it has been used about twenty times in total (see “Beantwoording vragen van het lid Karimi over het (nucleaire) smokkelwerk van Khan en Nederlandse connecties”, 9 March 2004, at www.minbuza.nl).

know Slebos as a righteous Dutch citizen, who takes all precautions to obey laws and rules. Before he delivers something to Pakistan, he always checks everything again and again".[88]

The legal battle continued until late 2003. Slebos sold part of the equipment - an LMF[89] made compressor, type V 17 5518 L, 40-K - to a company called V-I in Schiedam, which unsuccessfully applied for an export licence to Pakistan in May 1999. V-I did not accept that decision and went to court in 2000. The firm claimed that the compressor was meant for an ordinary company, the People's Steel Mill in Karachi, despite Slebos having previously given the Institute for Industrial Automation (part of Khan's KRL) as the final destination. Intelligence and export control authorities, however, claimed that the compressor was "very suitable for use with the Ghauri missiles, as used in the Pakistani missile programme"[90]. In October 2003 the Ministry of Economic Affairs finally won the case - it was right to refuse an export licence for the compressor.[91] What happened with the other Slebos equipment impounded in 1998 is still unclear.

According to Vrij Nederland journalist Ko Colijn, Henk Slebos has recently been involved in much more business with Pakistan. In particular he is said to have been involved in trading large amounts of graphite and magnesium straight from China to Pakistan. The magnesium was of a quality grade specified on the list of the Nuclear Suppliers Group and therefore subject to Dutch export control.[92] Sources within the Justice Department say they think that the graphite was suitable for use in ultracentrifuges.[93]

In addition American intelligence sources claim that "a company in North-Holland" - where Slebos' firm is based - ordered so-called Baratron pressure meters from a German daughter of an unidentified American company.[94] These meters can be used to measure pressure in fuel tanks of missiles. Though an export licence is required, the "North-Holland" company had sold them to - again - the Institute of Industrial Automation. This case may be the same as the one mentioned in other media, namely an investigation by the court in Haarlem into illegal export of dual-use goods, supposedly by Slebos and supposedly with final destination Libya.[95]

The answers provided by the Dutch government to a series of written parliamentary questions about Slebos' role, by GreenLeft MP Farah Karimi, are meagre, but do provide some additional information.[96] According to the government, "S." (read Slebos) did not get any Dutch export permits for the export of *dual-use goods* to Pakistan, Libya, Iran or North Korea during the last four years. In "a number of cases" it has applied the catch-all clause to Slebos, requiring an export permit for goods that normally do not need a permit. Details on these catch-all cases have

[88] Harm Ede Botje and Ko Colijn, "De vader van de islamitische bom verklaart zich nader", Vrij Nederland, 18 July 1998.
[89] Leoberdorfer Maschinenfabrik AG, Austria.
[90] Ko Colijn, "Explosieve handel tussen Montfoort en Islamabad", Vrij Nederland, 21 February 2004.
[91] College van Beroep voor het Bedrijfsleven [Court of Appeal for Trade and Industry], "LJN-nummer: A00900 Zaaknr: AWB 02/595", 29 October 2003; and "LJN-nummer: AB3001 Zaaknr: AWB 00/128", 27 June 2001.
[92] Regulation regarding trilateral trading relations ("driehoekshandel"): "If a Dutch resident engages in a financial action with regard to strategic goods which are outside the Community [meaning the European Union, Frank S.], [...] , a licence Financial Traffic Strategic goods ("vergunning Financieel Verkeer Strategische goederen" or FVS) is required."
[93] Colijn, Vrij Nederland, 21 February 2004.
[94] Colijn, Vrij Nederland, 21 February 2004.
[95] Alberts and Knip, "OM onderzoekt partner Khan", NRC Handelsblad, 17 February 2004. The link with Libya was earlier made by Matt Kelley, "Pakistan, nuclear black market linked", AP, 11 February 2004.
[96] "Beantwoording kamervragen over mogelijke verdenking door de Pakistaanse regering van het leveren van nucleaire technologie aan Iran, Lybië en Noord-Korea", 9 March 2004; Beantwoording kamervragen over het nucleaire smokkelwerk van Khan en Nederlandse connecties", 9 March 2004; "Beantwoording kamervragen Karimi over exportvergunning aan Henk S.", 30 March 2004. All at: www.minbuza.nl.

been provided to MPs on a confidential basis.[97] “Relevant investigation services” check whether Slebos has observed these export rulings. Pakistan has been asked to inform the Dutch government if any details about the possible involvement of “a Dutch national” emerge from their investigation into Khan’s nuclear network.

Many questions remain, too, about Slebos’ involvement as a middleman in proliferation-prone transactions that have never touched Dutch soil. Most recently, Slebos name has appeared in conjunction with the well-publicised case of the German owned 'BBC China' ship. The 'BBC China', laden with nuclear equipment and on its way to Libya, was caught by American inspectors in Italy on 4 October 2003.[98] The catch revealed a host of information on persons and companies, which were supplying Libya with nuclear-related materials. Implicated were not only Sri Lankan businessman Bukhari Sayed Abu Tahir (allegedly "the network's chief financial officer and money-launderer"), the Malaysian company Scomi Precision Engineering[99], and the Dubai-based Gulf Technical Industries (GTI) of UK citizen Peter Griffin. Also on board were aluminium castings and dynamos from the Turkish company ETI Elektroteknik[100] in which Slebos has a 15 percent share.[101]

All this fits very well with Slebos’ business profile. "We find hard-to-get objects for customers all over the world. We have delivered machine parts of sawing machines, grinding wheels, fixings, iron and metal alloys, laboratories and testing equipment, software and much more", he writes on his website www.slebos.com. On the site he also advertises an anti-fouling system, of interest to the Royal Dutch Navy.[102] His businesses seem to come and go - a year ago his website also mentioned "Technical Troubleshooting", "Prefab Buildings", "Technical purchasing", "Technical Engineering" and even "Wine Import" - but not anymore.[103]

No boys' choir

The most explicit recent proof of Slebos' dealings with Pakistan became known in late 2003, when the Dutch Campaign Against Arms Trade revealed that Slebos Research was one of the sponsors of ISAM 2003, the International Symposium on Advanced Materials in Islamabad and KRL's main international scientific event.[104] Though both companies deliver almost identical technical services, another Dutch company Gemco denied having anything to do with another ISAM sponsor, Gemco Pakistan (Pvt.) Ltd. No longer chief of KRL, AQ Khan was still ISAM's main host, as "patron" of the organising committee. The "international scientific committee" consisted, among others, of Khan's former tutor, emeritus professor Brabers (see above).

In response to a number of questions from parliamentarians on the Dutch content of the meeting and its relation to Dutch non-proliferation policy, then Foreign Minister De Hoop Scheffer

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[97] This confidential note contains information on all (around twenty) catch-all cases since the creation of this ad hoc licensing legislation in 1996. Early April 2004 Ms. Karimi asked to (partly) declassify this information. At the time of writing no governmental answer was available yet.
[98] See for example William J. Broad, David E. Sanger and Raymond Bonner, "A tale of nuclear proliferation: How Pakistani built his network", New York Times, 12 February 2004.
[99] Plus some foreigners working for the company, like the Tanner brothers from Switzerland.
[100] Alberts and Knip, "Atoomhandel ging via Turkije", NRC Handelsblad, 27 February 2004.
[101] Alberts and Knip, "Atoomhandel ging via Turkije", NRC Handelsblad, 27 February 2004.
[102] "KNRM test vinding omstreden techneut", de Volkskrant, 24 February 2004. The system is made by SRAF Nederland BV, an acronym for Slebos Research Anti-Fouling.
[103] Other known companies in which Slebos was involved are: Sleedoorn Styling (home and office furnishing, bankrupt in 1989); RA Products (solar energy, dead 1996); Milieu- en Energiesystemen (energy, 34% share) (source: Alberts and Knip, "Pakistan verdenkt Nederlander 'Hanks'", NRC Handelsblad, 7 February 2004).
[104] Press Release Campagne tegen Wapenhandel, 3 September 2003, see www.stoparmstrade.org.

admitted that KRL is part of Pakistan's nuclear weapons industry, and that - though the government did not have information that ISAM was set up to further develop that industry - it was "not fully possible to exclude that the exchange of knowledge and information during the symposium directly or indirectly contributes to that development".[105]

Curiously, one Dutch participant, professor Das of ECN[106], afterwards admitted that he had been there in the pay of the Dutch intelligence service AIVD. Furthermore he had worked for them frequently, for many years and in many countries. At ISAM 2001 he had even visited Khan at home and met president Musharraf.[107]

Asked about ISAM, Slebos answered a journalist: "I do business in all of Asia, but not in Pakistan. I have nothing to hide and I don't even go to the symposium myself. I have only sponsored it. That is nothing peculiar though? [...] If I subsidise the boys' choir of St. Pancras, you also don't ask strange questions, do you?"[108]

[105] "Beantwoording kamervragen van het lid Van Velzen (SP) over mogelijke Nederlandse bedrijven en personen bij symposium van Pakistaans kernwapenlaboratorium", 2 October 2003 at www.minbuza.nl.
[106] Energieonderzoek Centrum Nederland - Energy Research Centre of the Netherlands.
[107] Aart Brouwer, "De offerkoeien van een kernmacht", De Groene Amsterdammer, 14 February 2004 and KRO Radio1, 10 February 2004.
[108] Aart Brouwer, "Nucleaire verkenners", Groene Amsterdammer, 3 September 2003.

CHAPTER III URENCO 1970 - 2004

Urenco Ltd is a consortium of British company INFL[109], the Dutch firm UCN BV and the German Uranit GmbH.[110] Founded in 1970, it is one of the world's leading uranium enrichment companies.[111],[112] It's origin and history is closely linked to the research and development of ultracentrifuge technology. Together with gas diffusion technology it is the most commonly used method of uranium enrichment. During the 60's and 70's there were high expectations of the growth of nuclear energy for power production, with a consequent need for uranium enrichment capacity. The supposition was that all or most nuclear reactors would need enriched uranium as nuclear fuel; hence the founding of Urenco.

Keeping the weapons options open

The history of Urenco is also closely linked to Western Europe's desire to be independent from the US with regard to nuclear reactors and enriched uranium. The US had a veto on the reprocessing of all nuclear fuel enriched in the US or burned in US-supplied or -licensed nuclear reactors. However, Germany, the UK and France wanted to reprocess used nuclear fuel to produce plutonium. Officially they wanted to use the plutonium in Fast Breeder Reactors, such as Kalkar in Germany or Phenix in France, which would breed more plutonium than they used. This was justified once again by an expected shortage of uranium and unrealistic prognoses of nuclear energy growth.[113] By enriching their uranium themselves, West European states were free to reprocess the used nuclear fuel and also free to develop their own industrial plutonium infrastructure, keeping their nuclear weapons options open.

Urenco's intention was to build a plant to manufacture ultracentrifuges and an enrichment plant in each of the three countries. Germany, however, was until 1985 not allowed by the US to build an enrichment plant, in order to prevent it from producing nuclear weapons materials. So, instead the German enrichment plant was constructed at the Dutch Urenco plant in Almelo. But Germany was allowed to manufacture ultracentrifuges, which took place at a plant in Jülich, owned by the German Urenco partner Uranit GmbH. In the UK the manufacturing plants were constructed at Capenhurst, next to the gas diffusion plant.

The E21 plant was the first gas centrifuge facility at Capenhurst. It began operations in 1976. The next generation gas centrifuge plant, the Capenhurst E22 plant, was completed in 1982. The E23 plant began operations in 1997.[114] The E21 was operated until 1991 and was subsequently decommissioned, just a few years after the closure and the beginning of decommissioning of the gas diffusion plant.[115] Two years after the completion of the E22 plant a separate centrifuge

[109] INFL is a full subsidiary of British Nuclear Fuel Ltd (BNFL), owned by the UK government
[110] Shareholders of UCN BV are: Dutch government (98.9%) and Shell, Philips, DSM, VMF-Stork (1.1%). Shareholders from Uranit GmbH are: NUKEM GmbH (50%) and E.ON AG (50%). More information on http://www.antenna.nl/wise/uranium/ecure.html
[111] Boer, Joop; Uranium enrichment: No capacity growth in 20 years. WISE News Communique 499/500, Oct. 16, 1998. http://www.antenna.nl/wise/499-500/4932.html
[112] Further information about Urenco's corporate structure is contained in ANNEX I
[113] Kollert, R.; Die Politik der latenten Proliferation, 1994, DUV, p.127
[114] Johnson, Timothy C.; Internal memo NMSS: Foreign trip meeting summary: Louisiana Energy Services Technical Meeting and Site Visits; 26 July 2002. http://www.nrc.gov/materials/fuel-cycle-fac/ml022100265.pdf
[115] "Capenhurst, near Chester, was home to the gas diffusion uranium enrichment plants. Decommissioning of these huge structures began in 1989 and was complete by 1994." http://www.bnfl.com/index.aspx?page=572 ; Financial Times, 03 Nov. 1987: "Britain has just begun to dismantle an obsolete uranium enrichment factory at Capenhurst."

enrichment plant, Capenhurst A3, [116] was built for military purposes and from 1993 the plant operated for civil purposes.[117]

In the Netherlands, the enrichment plant was built southeast of the town of Almelo near the German border. Since the opening of the pilot plant in 1971, despite many actions and legal suits by local opponents, the plant has been substantially expanded.[118] The same is true of the plants in Gronau (Germany), only a few dozen kilometres from the Dutch Urenco factory in Almelo, and Capenhurst.

But by the time Urenco had built its first small enrichment plants, around 1980 it had become clear that far fewer nuclear power plants would be constructed than had been expected only a decade before. Instead of a shortage of enriched uranium, demand was only one-half of the combined production capacity at that time.[119] The US had huge stockpiles of HEU by then, and Russia also had an enormous overcapacity of enrichment plants and huge stockpiles of HEU, offering enriched uranium to the Western countries at low prices[120]. Russia had also developed and constructed LWR's in Russia and several Warsaw Pact countries.

Because of this oversupply and the low prices asked by the US and Russia for enrichment, Urenco made no profits, only losses, for fifteen years.[121] A large part of the money needed for research, development, construction and operation was paid for by the three governments involved. [122]

Plans for the future

Urenco is now expanding fast. Its management intends to double its production capacity at each of its three sites: Capenhurst (UK), Gronau (BRD) and Almelo (NL) and is trying to get permission to build a large enrichment plant at Lea County, New Mexico, US.[123] In this case Urenco works together with US nuclear firms in the Louisianna Energy Services (LES) consortium.

Urenco tried unsuccessfully to build a UC enrichment plant in the US in the 90's, also as major partner of the LES consortium, but abandoned the effort in the face of significant oppostion. Now Urenco is again trying to get a license to build a plant in the US, by far the largest market for enriched uranium. A centrifuge plant in the US will help Urenco to protect itself against the risks of an unfavourable dollar/euro exchange rate. It will also enable Urenco to compete with the US privatised enrichment company USEC, which is world leader in the enrichment business.

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[116] Currently, this gas centrifuge plant in Capenhurst has a capacity of 2,438 ton SWU/yr (SWU = Separative Work Unit: unit for the capacity of uranium enrichment).
Source: http://www.antenna.nl/wise/uranium/efac.html#ENRC

[117] Capenhurst A3 was bult for the purpose of producing enriched uranium for the military, using Urenco technology. However the plant never produced HEU. After it was started in 1984-85 it produced intermediate enriched uranium, it is above 5 percent uranium-235, for export to the US either for further enrichment to HEU, or in exchange for an equivalent amount of HEU. [Nuclear FuelVol.22, No.9, 05.05.1997, p.12 and: British Nuclear Facilities: http://nuclearweaponarchive.org/Uk/UKFacility.html]

[118] Currently Urenco Nederland B.V. has a license for a capacity of 2500 ton SWU/yr. The pilot plant in Almelo (SP1) had a capacity of 25 tSWU ('73); the demonstration plant (SP2): 200 tSWU ('75); and the commercial SP3 ('86): 1,000 tSW. In 1995 the capacity is expanded to 1,400 tSW. Currently the capacity is 1,950 tSWU (see source in note 108).

[119] Atomic Energy in Australia, July 1983, p.36

[120] Nuclear Fuel 05.10.1987, p.2

[121] UCN Annual Report 1986, p.13

[122] UCN Annual Report 1978,p.

[123] Nuclear Fuel, 29.03.2004, p.23

Currently USEC operates a gas diffusion enrichment plant in Paducah, Kentucky. It took over two gas diffusion enrichment plants from its predecessor, the Department of Energy, DOE, in 1993.[124] but the second facility in Portsmouth, Ohio, is kept in cold standby.[125],[126] USEC attempted to gain entry into Urenco but failed.[127] To stay competitive, USEC has to change from enrichment by the gas diffusion method to the ultracentrifuge technology.

In the 80's USEC predecessor, DOE, developed ultracentrifuges, but stopped this program before commercialisation could take place. Now USEC has resumed this centrifuge development program. In 2000 USEC signed an agreement with DOE on centrifuge development.[128] On 12 January 2004, USEC announced that it has chosen Piketon, Ohio as the site for its so-called "American Centrifuge" commercial uranium enrichment plant project.[129] On 12 February 2003, USEC submitted a license application for a gas centrifuge uranium enrichment test facility or "lead cascade".[130] In 2005, USEC expects to begin operating the American Centrifuge Demonstration Facility.[131] The demonstration facility, to be sited in Portsmouth, will contain a lead cascade of up to 240 full-size centrifuge.[132] A lead cascade is the basic building block of a commercial enrichment plant.[133] The USEC centrifuges have an eightfold larger output than the Urenco ultracentrifuges and are claimed to have a 100-year operating lifetime.[134]

Within a decade it is likely that centrifuge technology will be the dominant technique for uranium enrichment. Many countries have done research on laser enrichment, but the technology is not yet commercially viable. The three Urenco countries, France, Japan, the USA and others spent large sums of money on laser research in the nineties. The Urenco countries alone spent $300 million on laser research until 1994.[135] USEC suspended work on AVLIS in 1999 having spent US$2 billion over the project's lifetime.[136] The Japanese Laser-J research was ended in 2001, having cost billion of yens from 1980 onwards.[137] And in 2003 France's Commissariat à l'Energie Atomique (CEA) ended research into laser enrichment too, having spent over € 1 billion on the project.[138]

Until recently only the USEC funded Silex Systems research in Australia was left. USEC stopped funding it from April 2003.[139] Silex Systems is now looking for a new partner for the commercialisation of the SILEX uranium enrichment technology.[140]

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[124] Nuclear Fuel, 07.07.2003,p.18
[125] USEC press release, 18 May 2001; The Courier-Journal, 29 May 2001
[126] Nuclear Fuel , 05.01. 2004, p.3
[127] Nuclear Fuel, 15.09.2003,p.16
[128] Nuclear Fuel, 07.07.2003, p.1,17-20
[129] Nuclear Fuel, 19.01.04
[130] U.S. Enrichment Corporation Gas Centrifuge Facility: http://www.nrc.gov/materials/fuel-cycle-fac/usecfacility.html
[131] USEC Annual Report 2003, p.3.: http://www.usec.com/v2001_02/Content/Investors/2003pdf/USEC2003AnnualReport-Narrative.pdf
[132] Nuclear Fuel, 10.11. 2003, p.7
[133] http://www.antenna.nl/wise/uranium/epusec.html
[134] Nuclear Fuel, 29.03.2004,p.21,22
[135] Lenders, Maurice; Uranium Enrichment by gaseous Centrifuge, p.7, 16 May 2001, Dresden.
[136] Lenders, Maurice; Uranium Enrichment by Gaseous Centrifuge; 16 May 2001, Dresden
http://www.urenco.com/pdf/atomforum_May_2001.pdf
[137] http://www.etceteraweb.com/IYNC/10-04-01.laser-enrichment.pdf
http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20011004c2.htm
[138] Nuclear Fuel, 19 January 2004, 11; http://www.world-nuclear.org/news/2004/wd_jan23.htm
[139] Uranium Enrichment; Nuclear Issues Briefing Paper 33; June 2003; http://www.uic.com.au/nip33.htm
[140] SILEX – USEC settlement, 7 April 2004:
http://www.asx.com.au/asx/statistics/AnnHeadersForIssuer.jsp?ASXCode=slx&TimeFrame=past_year&from_year=1998&from_month=0&to_year=1998&to_month=0&x=11&y=9

Astonishingly, Iran has built a pilot laser enrichment plant, which actually produced small quantities of enriched uranium. The IAEA is studying this program[141].

CHAPTER IV URENCO AND PROLIFERATION

Although Urenco denies being responsible for proliferating its enrichment technology to other countries, in at least the case of Brazil, Urenco has acknowledged that its technology has ended up in Iraq, Pakistan and via Pakistan in North Korea, Iran, and Libya.[142] And as will be demonstrated below, there are certainly cases where problems with security have facilitated the theft of this technology.

A delivery for Brazil

On 2 April 1977 the first big demonstration against Urenco Almelo took place, with around 100,000 people protesting against the expansion of the enrichment plant. Expansion was necessary as Germany had agreed to export to Brazil 8 nuclear power plants, including the enriched uranium needed for the whole lifetime of the reactors, as well as nuclear fuel production plants, reprocessing and enrichment plants[143]. Because of the limitations on it enriching uranium, West Germany could not supply enriched uranium to Brazil if the Dutch Urenco plant did not deliver. Although the Dutch government had promised parliament it would have a say in approving the export from the Netherlands, this proved to be unnecessary, as in 1981 it became clear that the British Urenco plant in Capenhurst had exported enriched uranium to Brazil instead.[144]

At the time, Brazil had not signed the non-proliferation treaty (NPT) , the reason cited by the US in opposing delivery of low enriched uranium (LEU)[145] to Brazil. It was feared by the international community[146] that the transfer of sensitive nuclear technology, especially enrichment and reprocessing technology by German firms to Brazil, would result in Brazil making nuclear weapons by itself, or by using Urenco deliveries of enriched uranium. In 1978 Brazil started a nuclear weapons program, code-named “Solimoes”, managed by the state-owned Brazilian Nuclear Corporation 'Nuclebras'.[147] This was based on the commercial nuclear energy program, which was under trilateral IAEA safeguards, because Germany was an NPT member.

In 1978 the Dutch Urenco partner, UCN, had also been importing uranium for more than four years from the Rössing mine of the British multinational Rio Tinto Zinc in Namibia, occupied by South Africa. According to the United Nations 1974 decree nr. 1 the export of raw material from Namibia was forbidden. The Dutch state was taken to court on the grounds of receiving plundered minerals. In 1985 The UN Steering Group for Namibia decided to take Urenco to court[148].

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[142] Nuclear Fuel, 20.01.2003, p.15; 07.07.2003, p.2024.11.2003, p.8,9; 15.03.2004, p.7-9; Nuclear Europe Worldscan, 11-12/1991,p.53.
[143] http://www.laka.org/teksten/verzet/1960-2001.PDF
[144] Sublette, Carey, Nuclear Weapons Frequently Asked Questions: Ch. 7: Nuclear Weapon Nations and Arsenals. http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html By 1997 it was reported that the Brazilian Isotopic Enrichment Facility (LEI) housed 725 centrifuges, which could produce enough HEU for one or two nuclear bombs a year. Currently there are plans to expand the capacity to 200,000 SWU/yr. Brazil apparently has the capability to produce HEU, but it is not known to have done so. Brazil plans to build nuclear submarines which use HEU as a nuclear fuel in their nuclear reactors.
[145] Light Enriched Uranium [LEU]: up to 20 percent Uranium-235; High Enriched Uranium [HEU]: more than 20 percent U-235
[146] Specter, Leonard S., The New Nuclear Nations, 1985, p.197-200; Vintage, NY.
[147] De La Court, T., ea, De Nuclear Fix,p.33-35, 1982, WISE Amsterdam.
[148] Twentse Courant 04.05.1985

Prolems with security

There are at least two *known* cases where secret ultracentrifuge technology has leaked from Urenco enrichment facilities. The most well known involving AQ Khan is detailed in Chapter I and II. The lesser-known case involved the Urenco plant at Gronau.

This case involved the theft, somewhere between 1985 and 1990, of blueprints with specifications of the then most modern UC, the TC11, and probably a list of subcontractors, by former workers of the company MAN, which was then a main shareholder of Uranit, the German Urenco firm. The ultracentrifuge experts, Bruno Stemmler and Schaab, still had old entry permits, allowing them to easily enter Uranit and copy the very secret blueprints, which they sold to Iraq.[149] Stemmler and another MAN expert, Walter Busse, stayed for months in Iraq during 1987 and 1988 to help the Iraqis solve technical problems they had with production and operating of ultracentrifuges.[150] The IAEA discovered the very advanced, carbon fiber reinforced TC11 ultracentrifuges in Iraq, after a top Iraqi official fled to Jordan, with a number of discriminating documents. [151]

There was also a case of a suspected theft 1984, which if conclusively proven would also demonstrate how easily nuclear proliferation can take place. The firm Leybold-Heraeus responded to tender from Uranit for delivery of cascade tubing, autoclaves for storage of natural UF6, UF6 containers and desublimators, for cooling of enriched UF6. To be able to test whether they could construct this technology, Leybold-Hereaus legally obtained the blueprints from Uranit. A Leybold employee, Gotthard Lerch, then ordered autoclaves, containers and desublimators from the Swiss firm MetalWerke Buchs, MWB, which produced them using the blueprints.[152],[153] A small part of the machinery produced was seized by Swiss customs, the largest part had already been shipped to Pakistan, via Dubai.[154] From the design of the equipment it was concluded that it was suitable for producing high-enriched uranium.[155]

In 1986 Uranit informed Aachen prosecutors that the blueprints, which it recovered from MWB, were copies for which it had copyright protection. Uranit said that Leybold-Hereaus got the blueprints from Urenco. In 1987 criminal prosecutors in Cologne concluded that two former Leybold employees, Otto Heiligbrunner and Lerch had stolen the Urenco know-how. In 1988 Leybold-Hereaus suggested that Lerch had had access to the blueprints, but in 1991 German prosecutors let it be known that the investigation of the accused had been terminated, because the Swiss authorities did not cooperate.[156]

Interestingly, in March 2004, Heiligbrunner, now 80, stated that Leybold-Hereaus had bought the rights to the know-how in the blueprints from Comprimo BV, a Dutch firm, located in Amsterdam. At the time, Comprimo had formed an architect/engineering partnership in the Urenco project with Interatom GmbH, itself a Siemens subsidiary, which was also a Urenco subcontractor for enrichment technology. According to Heiligbrunner, Comprimo developed the

[149] Nuclear Fuel 29.10.1990, p.10
[150] K.R.Timmerman, 1991, De Judaskus, Tirion, p.308,309
[151] Nucleonics Week 22.01.1996, Extra
[152] Die Stern 02.05.1987
[153] Nuclear Fuel 29.10.1990, p.10
[154] Nuclear Fuel 04.05.1987, Extra
[155] Nucleonics Week 18.05.1987,p.1,2
[156] Nuclear Fuel 28.11.1991,p.1

technology and had sold it later to Leybold-Hereaus, around 1978 or 1979. At that time the technology was not considered sensitive enough to be classified by the German government.[157] The director of Comprimo was the Dutch Professor, Barendregt, a nuclear scientist who knew A.Q.Khan and had visited Pakistan several times.

In February 2004, the Swiss started an inquiry into three suspects alleged by Malaysia to have been involved in the production of gas centrifuge parts for Libya by the Malaysian firm Machine Shop 1001. One of the suspects was again Gotthard Lerch. The Malaysian police alleged that Lerch tried to obtain supplies of pipes for this plant. A former Iranian official said Lerch had also been named by Iran as having been involved in Teheran's nuclear program.[158] The other two suspects are well known from other cases of nuclear smuggling: Friedrich Tinner and his son Urs. F. Tinner. Friedrich Tinner is currently president of the Swiss company Cetec, and is a former executive at the Swiss firm VAT, which supplied valves to Urenco since 1979[159] and also supplied valves for Leybold-Hereaus furnaces. Urs Tinner, the third suspect, was a consultant to the manager, B.S.A.Tahir, of the Malaysian company Machine Shop 1001, hired to set up the centrifuge parts factory until he left in Oct. 2003. Large quantities of aluminium and steel tubes were delivered to the Malaysian factory by a German subsidiary of the Singapore-based firm Bikar Metal Pte Ltd.[160]. The centrifuge parts made in Malaysia were made according to blueprints originating from Urenco designs, stolen by Kahn.[161]

It is remarkable that over such a long period the same individuals and companies are named repeatedly as being connected with cases of nuclear smuggling or brokering. Questions remain about how many other firms received blueprints from Uranit when they reacted to tender from the firm? It is also not known whether this was the normal way of ordering at the Urenco plants in the Netherlands and the UK. One thing is clear: a large firm like Urenco has many (former) subcontractors, which are much less controlled regarding their export of dual use goods or know-how than Urenco itself.

[157] Nuclear Fuel 01.03.2004
[158] Nuclear Fuel 01.02.2004
[159] Kollert, p.408
[160] Nuclear Fuel, 01.03.04
[161] IHT 21.02.2004; Guardian, 05.03.2004; LA Times, 22.02.2004; Nuclear Fuel, 01.02.2004.

CONCLUSION: THE NPT DILEMMA

The role played by Urenco in the proliferation of nuclear technology as described in this paper illustrates clearly that the use of this technology for peaceful or military purposes cannot be separated. Furthermore, the existing international treaty obligations, which call for free access to nuclear technology for all member countries and for applying safeguards to nuclear materials, have in fact obfuscated an extremely important fact: the development of nuclear power as a source of energy makes it possible to create the basis of a nuclear weapons program. A key part of this is the nuclear enrichment technology developed so successfully by Urenco.

Black market excuses

The production of the Pakistani and indeed any nuclear weapons depend on the import of technology, equipment and materials as well as the development of know-how. The case we have described clarifies how this can work in practice. Existing legal arrangements and guidelines for stopping or controlling the export of the technology from the Netherlands have failed on many occasions. The widely held explanation of this failure is based on an analysis in which this exporting process is largely seen as a problem of illegality. Hence the constant use of the term 'black market'. The use of this terminology in itself suggests that the solution to the proliferation problem needs only be sought in the tightening up of the laws and export regulations. President Bush's recent speech on the proliferation issue was a clear illustration of this. He stated:

"*Second, I call on all nations to strengthen the laws and international controls that govern proliferation. At the U.N. last fall, I proposed a new Security Council resolution requiring all states to criminalize proliferation, enact strict export controls, and secure all sensitive materials within their borders. The Security Council should pass this proposal quickly. And when they do, America stands ready to help other governments to draft and enforce the new laws that will help us deal with proliferation."* [162]

However, the companies involved were largely operating perfectly legally. Either they exported licence-free products, which could be used to build key parts of the uranium enrichment chain; or they exported dual use goods as permitted under existing legislation. Alternatively and more controversially, key items were exported to third countries from where they were redirected to the final destination. It is, however, misleading to describe this solely as a gigantic black market operation that avoided the scrutiny of various law enforcement agencies. It is more accurate to describe this as a collection of particular transactions, which were not looked at too closely because of the prevailing political winds.

We believe that the post facto reconstruction of the events as a kind of sophisticated bank robbery is misleading and will in fact result in further mistakes being made in developing effective anti-proliferation policies.

The development of Urenco technology and its dissemination took place within an international policy framework, which allowed such a process to take place. Short-term opportunistic foreign policy was unfortunately aided by the nature of the Non-Proliferation Treaty itself, which in

[162] "Remarks by the President on weapons of mass destruction proliferation", Fort Lesley J. McNair - National Defense University, Washington, D.C., 11 February 2004.

article 4 states the following*: "Nothing in this Treaty shall be interpreted as affecting the inalienable right of all Parties to the Treaty to develop, research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with Articles I and II of this Treaty."*

It therefore acknowledges the rights of all member countries to use nuclear technology for peaceful purposes, as a quid pro quo for not building nuclear weapons.

Strategic blindness

In the 'seventies and 'eighties Pakistan was a frontline state in the East-West confrontation. It was not in the interests of the West to confront Pakistan on the preparations it was making for its nuclear weapon programme, let alone the import of the basic elements of the enrichment technology. The country's strategic position made it an important strategic asset for the US as a counter to post-revolutionary Iran, communist China and in the 'eighties supporting the Afghan revolt against the Soviet occupation.

Similarly, Iraq was given maximum leeway in arming itself for the 1980-88 war with Iran. The US government countered the growing Iranian influence in the region by supporting Iraq in its invasion and subsequent long war against Iran. This support extended to the export of sophisticate weaponry to Iraq, including the technology that country needed for its nuclear weapons program.

Today Pakistan is an American ally in its war on terrorism. Since this involves the close co-operation of the present military ruler of Pakistan for military operations and, indeed, all aspects of US power projection into central Asia, it would be entirely contrary to US interests to weaken his power. That is why there have been no overt sanctions or reprisals against the state of Pakistan in response to the development of its nuclear weapons and the export of the related technology. Instead, all blame and responsibility has been placed squarely on the shoulders of the famous Mr. Khan. It is entirely beyond the bounds of belief that the Pakistani government itself was not involved in the various exchanges of nuclear technology with North Korea, Iran and Libya.[163]

There are some indications that the US government is playing a role in the custody of the Pakistani nuclear forces. There is also a possible political adjunct to this: UK foreign minister Jack Straw suggested that "the international community' was examining the feasibility of accepting Pakistan as an official NWS…."[164]

The political implication is very clear: if a state has made itself into a key ally of the most powerful state in the world, then it has a powerful lever to pursue its own interests, even if these ultimately run counter to those of that state.

There are other examples of close cooperation between the nuclear weapons states and their allies in the area of nuclear technology.

[163] "Musharraf Named in Nuclear Probe", Washington Post, 3 February 2004.
[164] Nucleonics Week, 11 March 2004.

Russia, for example, has in the last decade provided Iran with nuclear reactors and the necessary technical expertise to run them. Iranian technicians were also trained in this. A large, modern LWR needs more know-how and therefore training to run than a relatively simple dual-use reactor. Once these programmes are initiated the receiving country can develop them further. In Iran an enrichment programme was also set up without notifying the IAEA. Israel's nuclear programme was set up with French help, while India was supported by Canada.

The key point is that the so-called civilian help laid the foundations for the military nuclear programme.

Inherent contradictions

There is another built-in barrier to effective counter proliferation policy, and that is the obvious co-existence of two sets of rules: one for the nuclear weapon states, the other for the non-nuclear weapons states. We distinguish five categories of involvement:

1. The five nuclear weapon states recognised by the Non Proliferation Treaty: US, Russian Federation, China, France, United Kingdom
2. The three, possibly four nuclear weapon states which have not signed the NPT but have a substantial nuclear strike capability: Israel, India, Pakistan. Most public intelligence estimates give North Korea a small number of nuclear bombs.[165]
3. The states covered by a nuclear umbrella. This includes all the NATO (formal) non-nuclear weapons states, which are involved in NATO nuclear planning and doctrine. Six of these non-nuclear member states have tasked part of their air forces to carry out nuclear strikes with US nuclear weapons, in accordance with US nuclear doctrine.[166]
4. The states striving to gain nuclear weapons, either within or without the NPT framework, like Iran.[167]
5. The states with a civil nuclear programme, which gives them the ability to build nuclear weapons if they were to make the political choice to do so. This is a group of 44 countries, as defined in the Comprehensive Test Ban Treaty. They include states like Japan, Republic of Korea and Brazil.[168]

It is generally recognised that the NPT is an extremely important treaty for curbing the proliferation of nuclear weapons technology. However, as we have shown in our case study, it has a built-in contradiction that at least partially defeats its purpose. That is, it explicitly encourages (in art. 4) the proliferation of nuclear technology suitable for building weapons. The measures suggested by President Bush in his February 2004 speech: curbing the export of the enrichment part of the nuclear cycle and agreeing to more international inspections, sound reasonable but have a fatal flaw. They would not apply to a substantial group of industrialised states included in the categories described above. Instead, the great majority of the signatories of the NPT would be affected. It would, in short be another way of ensuring the continuation of the nuclear weapons status quo, with no attempt to comply with the other part of the NPT which is rarely mentioned by spokespersons of the nuclear weapons states (NWS): the obligation to strive for nuclear disarmament (art. 6).

[165] http://www.fas.org/nuke/
[166] "Questions of Command and Control", PENN (Project on European Nuclear Non-Proliferation) Research Report 2000.1.
[167] http://www.fas.org/nuke/
[168] http://www.ctbto.org

At the same time the US government has engaged in a strategic policy shift, which openly declares that pre-emptive warfare is legitimate. It reserves the right to wage nuclear war against states, which threaten to arm themselves with WMD.[169] In so doing the 'negative security assurances', promises made by the nuclear weapons states in 1995 not to attack the signatories of the NPT with nuclear weapons, are violated.[170]

The NPT review conferences (which are held every five years), are meant to review the effectiveness of the NPT: i.e. the degree to which the signatories have adhered to their treaty commitments. In 2000, all state parties except France (which abstained) recommitted themselves to nuclear disarmament. In 2005 these commitments will again be reviewed. There will obviously be sharp disagreements between the nuclear weapons states and those countries, which agreed in 1995 to the unlimited extension of the NPT. The former (most clearly the US) will be seen to have largely ignored their commitments, while at the same time developing coalitions of the willing (like the Nuclear Suppliers Group, the Proliferation Security Initiative) to counter horizontal proliferation, while ignoring vertical proliferation. Moreover, the US continues to develop new nuclear weapons systems and means of deploying them.[171]

It is entirely logical that countries that see themselves threatened by US pre-empting policies (or by those of other nuclear weapons states) will strive to develop weapons which will effectively defend them against possible attack. And of course, in so doing, they will be giving a reason for being attacked. This is a deadly spiral, which should be avoided.

The argument made by President Bush about the need to change the NPT is well taken. But it is of course an attack on the principle of free trade, on the article 4 right to nuclear technology. It would create a de facto oligopoly of nuclear suppliers, which would in turn give rise to strong opposition from existing and potential NPT signatories. In fact it is more logical to agree and implement a comprehensive fissile material treaty that bans all reprocessing and uranium plants, capable of producing pure plutonium and enriched uranium.

Director ElBaradei of the IAEA agreed with President Bush to some degree: but he added the extremely relevant comment:
"*Of course, a fundamental part of the non-proliferation bargain is the commitment of the five nuclear States recognized under the non-proliferation treaty — Britain, China, France, Russia and the United States — to move toward disarmament. Recent agreements between Russia and the United States are commendable, but they should be verifiable and irreversible. A clear road map for nuclear disarmament should be established — starting with a major reduction in the 30,000 nuclear warheads still in existence, and bringing into force the long-awaited Comprehensive Nuclear Test Ban Treaty."*[172]

[169] "Nuclear Posture Review Leaks; Outlines Targets, Contingencies", Arms Control Today, April 2002, http://www.armscontrol.org/act/2002_04/nprapril02.asp; "Bush Administration Releases Strategy on WMD Threat", Arms Control Today, January/February 2003, http://www.armscontrol.org/act/2003_01-02/wmdstrategy_janfeb03.asp.
[170] "U.S. Nuclear Policy: "Negative Security Assurances"", http://www.armscontrol.org/factsheets/negsec.asp
[171] See: http://www.armscontrol.org/act/2004_03/EnergyDepartment.asp
[172] IAEA Director General Dr. Mohamed ElBaradei, "Saving Ourselves From Self-Destruction", New York Times, 12 February 2004.

That is, the lack of verifiable and ireversible steps towards nuclear disarmament will make a stronger non-proliferation regime within a legal framework extremely difficult if not impossible to achieve.

Points for a policy debate
In view of the above developments we see a need for a fundamental debate along the following lines:

1. The NPT encourages the proliferation of nuclear technology. This in turn can be used by NPT signatories that want to develop nuclear weapons;

2. Certain changes are needed, in particular the prohibition on the production, transport and use of fissile materials in the nuclear fuel cycle;

3. This will run into strong opposition from NPT signatories who want to maintain maximum access to nuclear technology;

4. There is no sign at all that the NWS will abolish their nuclear weapons;

5. Unilateralist mechanisms (like the traditional arms export control agreements NSG, MTCR and now especially PSI) are being set up outside the NPT and other multilateral arms control mechanisms (CD) by the US, which is supported in this by a number of mainly Western (-oriented) industrialised countries. This means that the NPT is being undermined;

6. Pressure will logically be applied to change the NPT (along the lines suggested by Mr. ElBaradei and President Bush, undoubtedly with all kinds of variations on the theme): many signatories will likely resist this. Therefore a stalemate in 2005 seems very possible;

7. The threatening deadlock at the NPT review conference in 2005 makes a serious debate an urgent necessity. A key point that should be taken up is the connection between nuclear energy and nuclear weapons;

8. It would be wise to initiate this debate quickly, and not wait for a very likely deadlock in 2005. A possible point of action could be suggesting changes in the NPT. Either the treaty itself could be changed, or additional protocols added.

ANNEX I: URENCO CORPORATE STRUCTURE

In the Netherlands the state originally possessed 56% of the shares of Urenco Nederland, the private companies Philips, DSM, VMF-Werkspoor, RSV and Shell the rest. In 1980 a decision was made to construct new Dutch and German enrichment plants at Almelo. This decision was a consequence of a giant nuclear contract Germany had made with the military regime in Brazil. The Dutch Urenco private companies, however, were not prepared to invest as they did not expect to make a profit. Departing from the original intention of the government that the companies take over all their shares in the long term, the government – clearly under strong German pressure – decided to invest *f*470 million (€214 million) and to give loan guarantees. This larger financial involvement was translated into a larger state share from 1980: 98.9%, the companies were left with 1.1% of the shares.[173]

Until September 1993 Centec GmbH, located in Bensberg, West Germany, was an associate company of Urenco Ltd. As the technology holder, Centec co-ordinated the R&D programme for the entire Urenco Group. It had the same British and Dutch shareholders as Urenco Ltd, BNFL and UCN respectively. The German shareholder was Gesellschaft für nukleare Verfahrentechnik (GnV), which was jointly owned by Internationale Atomreaktorbau GmbH (Interatom) and MAN AG. UCN NV built the ultracentrifuges for Urenco Nederland BV and BNFL and GnV for the settlements in the UK and Germany.

Since the merger in September 1993 Urenco Ltd has taken over the enrichment plants of the Urenco Group and all related activities. The shareholders are Uranit, UCN and INFL, each for one third.

The activities of Urenco in the Netherlands are organised in Urenco Nederland BV. The Enrichment Division of the company operates the Dutch enrichment plant in Almelo, and the Manufacturing Division is responsible for the manufacturing of centrifuges for the whole group. In addition, Almelo is the centre of Urenco Aerospace. Urenco Nederland BV is a 100% subsidiary of Urenco Ltd.. The other two subsidiaries Urenco Deutschland GmbH and Urenco Ltd. operate the uranium enrichment plants.[174] The Dutch branch of Urenco was best known as Ultra-Centrifuge Netherlands (UCN). Currently, however, UCN is only the holding company of Urenco Nederland BV. In practice many people use the names Urenco or UCN for the operating plant.

The past bids on Urenco

In 1999, driven by orders of the European Commission to create a single market in electricity, holding companies for Preussenelektra AG, Germany's biggest nuclear power producer, and RWE Energie AG, the country's biggest utility, decided to sell their shares in Uranit.[175]
Since then, market sources reported, BNFL has likewise held talks with German and Dutch officials regarding the terms of sale of respectively Uranit and UCN to BNFL. As an existing shareholder, BNFL appeared to be in key position to acquire these shares. At the beginning of November 1999 it was expected that BNFL would take over Urenco.[176] Though not formally, Cogema countered the BNFL offer for Urenco.[177] During a meeting in Almelo on 10 November 1999, the German government laid down five points that it wanted to be fullfilled by BNFL or any other party that bought Uranit shares. It demanded a third of the proceeds of any sale of Uranit shares from Uranit's shareholders, Preussenelektra and RWE, through a change in ownership.[178] At the end of November 1999 BNFL reportedly pressed Urenco's German and Dutch shareholders to sell their shares of Uranit and UCN to the British company by 31 December 1999.[179] At the end of December 1999 Urenco's German utility owners made clear that they

[173] UCN, Annual Report 1992, p.45.
[174] Annual Reports Urenco 1976, '85, '92, '93
[175] NuclearFuel, 28 June 1999, 1.
[176] NuclearFuel, 1 November 1999, 14.
[177] NuclearFuel, 15 November 1999,1.
[178] NuclearFuel, 15 November 1999,11.
[179] NuclearFuel, 29 November 1999, 1 and 6.

firmly opposed plans by the German federal government to take a third of the proceeds and that BNFL had not come close to the amount that the two companies claimed the German Urenco shares were worth.[180] Shortly afterwards Cogema issued a formal bid for control of Urenco shares held by the Dutch and German shareholders. This bid was reported to be close to double the original BNFL bid. A meeting between Cogema and the German Ministry of Economics was taken as a sign that Germany was willing to accept the French company as a bidder.[181] In May 2000 Lauvergeon confirmed that Cogema had made an offer to buy all or part of the 66% of Urenco up for sale at that time. BNFL was reportedly seeking ways to increase its bid for Urenco, including a joint venture with USEC.[182] BNFL was aiming for control of 51% of the shares of Urenco. This majority ownership would ensure that BNFL would control Urenco's technology should it form a venture with USEC to build a centrifuge plant in the US. Because BNFL was joined by Cogema and USEC in the competition for the Urenco shares, the shareholders of Uranit considered starting the process again by formally soliciting official bids for the shares. This would no doubt have increased the price.[183] In September 2000 it was reported that Cogema was said to have been in talks with BNFL about a possible joint venture to buy the shares. The Canadian uranium mining company Cameco was also reported to be interested, and commentators speculated that the bidding process might lead to a number of joint venture options, as none of the interested parties "has enough money to buy up all the shares" at the asking price.[184]

Though there has not been a sale of the Dutch and German shares of Urenco, Cogema now has access to ultracentrifuge technology. Cogema's parent company Areva has made a first step to abandon uranium enrichment by gaseous diffusion. In a Memorandum of Understanding (2002) , Urenco and Areva have agreed to develop plans for working together in the field of centrifuge technology for uranium enrichment. The companies envisage a 50-50 joint venture to build a new centrifuge enrichment plant that would progessively replace the existing Tricastin plant capacity beginning from 2007.[185] The new enrichment plant will be named Georges Besse II. Actual construction is expected to get under way in early 2005, once government authorizations have been obtained and relevant international treaties have been modified allowing Areva to take an equity interest in Enrichment Technology Company (ETC). This is supposed to be done in the 4th quarter of 2004.

On 24 November 2003, Areva Group signed an agreement with Urenco shareholders, under which it will acquire a 50% equity interest in ETC. ETC comprises all of Urenco's centrifuge design and manufacturing activities as well as its R&D in the field of centrifuge equipment and installations for uranium enrichment to produce nuclear fuel.[186]

Of note is the fact that Iran still has a share in Eurodif.[187] [188]
In the 1970's the then ruling Shah of Iran planned to build 23 nuclear power plants throughout Iran by the mid-1990s. Consequently in 1974 Iran bought a 10% share of an enrichment facility being constructed in France by the Eurodif consortium and loaned US$1 billion to the French Atomic Energy Commission (CEA) toward the construction of a gaseous diffusion enrichment facility at Tricastin, France. These arrangements would have allowed Iran access to Eurodif enrichment technology and deliveries of the highly-enriched uranium (HEU) produced at the Tricastin plant.[189] Iran was expected to purchase 10% of

[180] NuclearFuel, 27 December 1999, 1 and 10.
[181] NF, 24 January 2000, 1 and 8.
[182] Uranium Institute News Briefing 00.22 | 24 - 30 May 2000:
http://www.world-nuclear.org/nb/nb00/nb0022.htm
[183] NF, 29 May 2000, 1 and 12.
[184] NF, 18 September, 2000, 1 and 13.
[185] Areva/Les Echos, Oct 9, 2002; http://www.antenna.nl/wise/uranium/epeur.html
[186] Areva Nov. 26, 2003.
[187] Haeri, Safa; IPS, Treated as a future head of state, Rohani ended visit to Paris, 16 Jan., 2004.
http://www.iran-press-service.com/articles_2004/Jan_04/france_iran_16104.html
[188] Scheinman, Lawrence; The Nuclear Fuel Cycle: A Challenge for Nonproliferation; Disarmament Diplomacy; Issue No. 76, March/April 2004;
http://www.acronym.org.uk/dd/dd76/76ls.htm
[189] Skootsky, Mark D.; US Nuclear Policy Toward Iran; 1 June 1995;

the 3%-enriched uranium fuel produced by Eurodif. In September 1986 France and Iran were near agreement on their dispute over the Eurodif enrichment plant. Iran wanted repayment of a US$1 billion loan to France's CEA for Iran's participation in Eurodif. France wanted compensation for the enrichment services allotted to Iran. The settlement with France might have included French participation in Iran's partially completed Bushehr nuclear units.[190] In 1991, the International Commerce Commission ruled that France must repay the loan and that Iran would keep a small share of Eurodif, but France stated that it would not sell enriched uranium to Iran.[191]

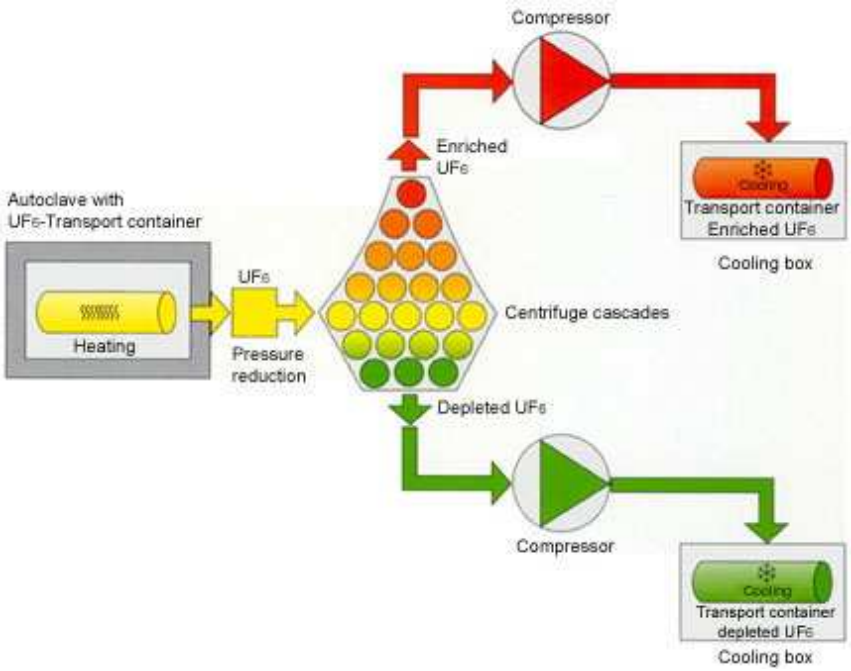
http://www.ai.mit.edu/people/boris/iran-nuke.text

[190] --"France and Iran may be nearing agreement," Nuclear News, September 1986, p. 90b.
http://www.nti.org/e_research/e1_iran_nch_1986.html

[191] http://cns.miis.edu/research/wmdme/flow/iran/enrich.htm

ANNEX II: URENCO AND THE ULTRCENTRIFUGE

The origin and history of Urenco is closely linked to the research and development of ultracentrifuge technology. Together with gas diffusion technology it is the most used method of uranium enrichment. Enrichment of uranium is part of the process which has to take place before the mined, purified and concentrated uranium enters the nuclear power plant in a nuclear fuel rod or becomes the explosive load of a nuclear weapon. The principle of an ultracentrifuge consists of high speed turning drums, which are coupled in a cascade and in which the heavier non-fissionable uranium 238 isotope is separated from the lighter usable fissionable uranium 235. In the seventies the Urenco ultracentrifuge was about one metre high. Currently the most modern Urenco UC's are around four meters high and are made from seven parts, connected by bellows.[192] At a certain number of revolutions per second, called the critical speed, the centrifuges tend to resonate like a string. Centrifuges which rotate at lower speeds are called sub-critical centrifuges. Centrifuges which rotate at higher speeds are called ultracentrifuges. Only special material can withstand the extreme centrifugal forces at which ultracentrifuges are subjected.[193] To lessen air resistance, the ultracentrifuges are built into castings, which are made vacuum. This enables higher speeds. As such this is highly sensitive technology, which the enrichment companies try to keep secret..



The first centrifuges for the separation of uranium isotopes[194] were used for the first time in the US[195] and further developed in Nazi Germany.[196] After World War II, the Russians took the leading centrifuge experts Zippe and Steenbeck with them.[197] Within eleven years they succeeded in developing such hi-tech centrifuges that the Russians were able to produce High Enriched Uranium (HEU) for the manufacture of

[192] Marx, Patrick, Verrijkt Uranium, Technisch Weekblad. http://www.technischweekblad.nl/include/techarti/proned20.htm
[193] Federation of American Scientist. Uranium Production. http://www.fas.org/nuke/intro/nuke/uranium.htm
[194] Whitley, Whitley; Review of the gas centrifuge until 1962. Part I: Principles of separation physics (abstract), BNFLtd, Capenhurst Works, Chester, England: http://prola.aps.org/abstract/RMP/v56/i1/p41_1
[195] David Albright and Mark Hibbs, Iraq's shop-till-you-drop nuclear program, The Bulletin of the Atomic Scientists, Vol. 48, No. 3, April 1992. http://www.thebulletin.org/issues/1992/a92/a92.albright.html
[196] Klinkenberg, Wim; De ultracentrifuge 1937-1970, Van Gennep & In den Toren, 1971
[197] Ibid. pp.15-16.

nuclear weapons. Germany, the UK and the Netherlands (re)started centrifuge research after WW II. The spiritual father of the Dutch ultracentrifuge project, prof. dr. J. Kistemaker, accused of collaboration with the Nazis[198], started preparations for electromagnetic and ultracentrifuge isotope separation in the "Zeeman Laboratorium Amsterdam" from 1947.[199] Progress was slow. As soon as the centrifuges were spinning fast, they started to explode. After a few meetings with Zippe in Germany, who returned from Russian captivity in 1956, he perceived that Zippe's centrifuge design was superior to the Dutch design and convinced his team to select the former as a basis for further development.[200]

After WW II most European countries made plans to develop a nuclear weapon program. France and the UK succeeded in developing a nuclear weapon capability. However, countries like Germany, Spain, Sweden, Switzerland, Norway and the Netherlands wanted at least to have the option open. In the Netherlands, Germany, France and the UK research was done to develop methods for enriching of uranium. France and the UK had built enrichment plants based on the gas diffusion technology, for military use. In 1957 Euratom was founded with the intention to construct a common European nuclear industry, including enrichment and reprocessing plants. However, the Euratom countries were divided on the choice of an enrichment technology. Finally, the two groups of countries chose different technologies. France, together with Belgium, Spain and Italy, decided to build a gas diffusion enrichment plant at Tricastin in France. This company is called Eurodif.[201] Germany and the Netherlands were close to forming a joint venture to build an ultracentrifuge enrichment plant, but after some pressure from the United States, they accepted the United Kingdom as a partner. By doing so US influence in the European consortortium was ensured . In 1970 this troika founded Urenco.[202] Another way of obtaining fissile material for the manufacture of nuclear weapons is to build reprocessing plants, in which plutonium is separated from spent nuclear fuel. In Belgium a joint European reprocessing plant was built at Mol. France and the UK built their own reprocessing plants, first for military production and afterwards to separate plutonium from commercial reactor spent fuel.

The first country ever to build an ultracentrifuge enrichment plant was the Soviet Union. Other countries which have constructed ultracentrifuge enrichment plants, in addition to the UK, the Netherlands and Germany are: Brazil, China, India, Iran, Japan, Pakistan and the US.

Urenco and the Light Water Reactor

During the 'sixties and 'seventies there were high expectations of the growth of nuclear energy for power production. It was consequently expected there would be a shortage of uranium enrichment capacity too. That was one of the basic ideas behind the founding of Urenco. The supposition was clearly that all or most nuclear reactors would need enriched uranium as nuclear fuel. However, until the seventies it was not clear at all that Light Water Reactors, (LWR's) would be the winning design. A LWR uses enriched uranium as nuclear fuel and normal or `light' water for cooling and for moderating the speed of fast neutrons, enabling them to split other uranium atoms. In Western Europe and elsewhere several different types of nuclear reactors were built. In Germany alone five different types of reactors were designed and constructed.

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[198] In 1937 the firm NV Cellastic was founded, which was in reality a scientific espionge department of the nazi intelligence service. Cellastic was financially close to the German Bank Rhodius Koenigs, dealing with espionage for atomic efforts of the Third Reich of which the ultracentrifuge was an important part. During World War II Kistemaker was a member of the staff of the Cellastic laboratory for nuclear physics in Paris under supervision of the German *Wehrmacht*. References: Goudsmit, Samuel A."ALSOS - the Failure in German Science" Londen 1947, p. 38-40; Bar-Zohar, Michel, "La Chasse aux Savants allemands (1944-1960)", Parijs 1965, p. 113; cited in 24.

[199] "De geschiedenis van het Nederlandse Ultracentrifuge Project", FOM, Institute for Atom and Molecule Physics, 1991.

[200] De Waarheid, "Al 13 jaar ultra-centrifuge in Nederland", 17 Nov. 1960. Klinkenberg, Wim; "Kistemaker en de Duitse A-bom", CPN, Nov. 1960.

[201] Salanave, Jean-Luc, et.al.; "Technological Transition With a Long-Term View", EURODIF Production, France, January-February 2003. http://npj.goinfo.com/NPJMain.nsf/0/d905c77d0dbfc2bb86256cdb006c3edc?OpenDocument&Click=

[202] Twentse Courant, "UC-Verdrag getekend", 4 March 1970; Keesings Historisch Archief, "Overeenkomst gas-ultracentrifugeprocédé ondertekend" (274/275), 8 May 1978.

During the 'fifties and 'sixties, the UK and France first constructed natural uranium reactors for their nuclear weapon programmes, which do not need enriched uranium. These reactors do not use light water for moderating, but heavy water or graphite and gas as a coolant, normal air or carbon dioxide.
They were especially designed to produce weapon-grade plutonium and electrical power at the same time, so-called 'dual use' reactors. That is what they were used for in the UK, France, Russia, China and later on in North Korea. The plutonium created in the reactor was afterwards separated from the used nuclear fuel. This happened in reprocessing plants, like those still functioning at la Hague in France, and at Sellafield in the UK. Natural uranium reactors have the relative advantage of not needing enriched uranium. Canada developed the CANDU reactor during the 'fifties which uses natural uranium and which is cooled and moderated by heavy water.

The majority of the early reactor types did not use enriched uranium. So why did the LWR become the dominant reactor type? [203]

There are four main reasons why this happened. The first is the fact that the USA Navy wanted to develop nuclear reactors for propulsion of their nuclear submarines, the advantage being that the subs could stay under water for months. They could not use a natural uranium reactor, because it needs at least a hundred tonnes of uranium as fuel. But if one uses enriched uranium, less nuclear fuel is needed. The more highly enriched the fuel is, the less fuel one needs. A 50 MegaWatt [MW] LWR reactor on board a nuclear submarine which uses HEU, enriched to 93% uranium-235, only needs about 50 kg HEU fuel. When a 50 MW reactor uses LEU, enriched to 4% U-235, as fuel, it needs about 1400 kg fuel.
Not surprisingly, the US Navy developed the LWR for the Nautilus, the first nuclear submarine built in 1954.

The second is that after the 'Atoms for Peace' speech of President Eisenhower in 1953, the US decided to declassify some nuclear know-how, so it could be used for 'peaceful' purposes to produce electrical power in civil nuclear reactors. But until then nuclear energy was only used for the military and no such civil nuclear reactor was developed in the USA. After the Atoms for Peace programme was announced, a commercial reactor had to be developed to make the message credible. The US was concerned that the USSR would be first in developing a commercial nuclear reactor and offer it to other countries. For the USA government that would be a political and economical disaster: It was therefore essential for it to develop a commercial reactor as soon as possible to offer to countries willing to sign up to the Atoms for Peace Program. Their military reactors were not found suitable for commercial use, they were not designed to produce power but to produce weapon-grade plutonium. The only reactor type available that could be developed in a short time for commercial use was the LWR. It could be built without major development costs, as the military had already paid for its initial development.

The third reason why the USA chose the LWR was based on its non-proliferation policy: it was not ideally suited to the production of weapons-grade plutonium.

And finally, the US had an overcapacity of uranium enrichment plants, which could now be used to produce LEU for the LWRs. The US thus created a monopoly: it was the only country that could guarantee the delivery of uranium and of enrichment services. Together with the UK, Canada and Australia they formed a uranium cartel.[204]

Although the Soviet Union built the first reactor that produced electrical power in 1954, the US followed in 1957 when the Shippingport LWR came into operation.[205] Once developed, the US civil nuclear reactor

[203] At the moment about 90% of all nuclear power plants are LWR's.
[204] Kollert, Die Politik der latenten Proliferation, 1994, DUV, p.137,450
[205] Kollert, p.65,78

industry was encouraged to build LWRs. The commercial breakthrough was reached in 1963, when a New Jersey energy company ordered the Oyster Creek LWR. By 1965 more than 30 nuclear power plants were ordered in the US.[206] The same development took place in the Soviet Union. It too used enriched uranium on board its nuclear submarines, developed and exported LWRs.

At that time the US Atomic Energy Commission had built three giant and very expensive uranium enrichment plants, using gas diffusion technology, one of which is still operating today. By 1964 two of them were put on standby, as they were no longer needed for the production of HEU for nuclear weapons. By this date there were huge stockpiles of HEU.[207]

From the industry's perspective, it was a logical and lucrative step to export LWRs and use the idled plants for the production of enriched uranium. The importing countries could buy LWRs from the US or get a license to build them themselves. The US guaranteed a life-long supply of enriched uranium. This had the deliberate side effect of giving the US control of the spent nuclear fuel and thereby also control over proliferation. Without permission from the US, the spent fuel could not be reprocessed to produce plutonium.[208]

In less than a decade most Western countries that went nuclear, chose the LWR. Almost the same happened in the Soviet Union and Eastern Europe: they too offered enrichment services for sale. The energy companies were to buy the uranium themselves and to ship it to the Soviet Union. Such was the expected demand for uranium enrichment services that many countries planned to build their own enrichment plants: Canada, Australia, Japan, France, Germany, the UK and the Netherlands.

[206] Kollert,p.78-80
[207] Bulletin of Atomic Scientists, April 1985,p.28
[208] Kollert, p.450

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