Analyse, inform and activate

LAKA

Analyseren, informeren, en activeren

Stichting Laka: Documentatie- en onderzoekscentrum kernenergie

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Dit is een pdf van één van de publicaties in de bibliotheek van Stichting Laka, het in Amsterdam gevestigde documentatie- en onderzoekscentrum kernenergie.

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Laka speelt met oa. haar informatie-voorziening een belangrijke rol in de Nederlandse anti-kernenergiebeweging.

The Laka-library

This is a PDF from one of the publications from the library of the Laka Foundation; the Amsterdam-based documentation and research centre on nuclear energy.

The Laka library consists of about 8,000 books (of which a part is available as PDF), thousands of newspaper clippings, hundreds of magazines, posters, video's and other material.
Laka digitizes books and magazines from the international movement against nuclear power.

The catalogue of the Laka-library can be found at our website. The collection also contains a large number of digitized magazines from the Dutch anti-nuclear power movement and a video-section.

Laka plays with, amongst others things, its information services, an important role in the Dutch anti-nuclear movement.

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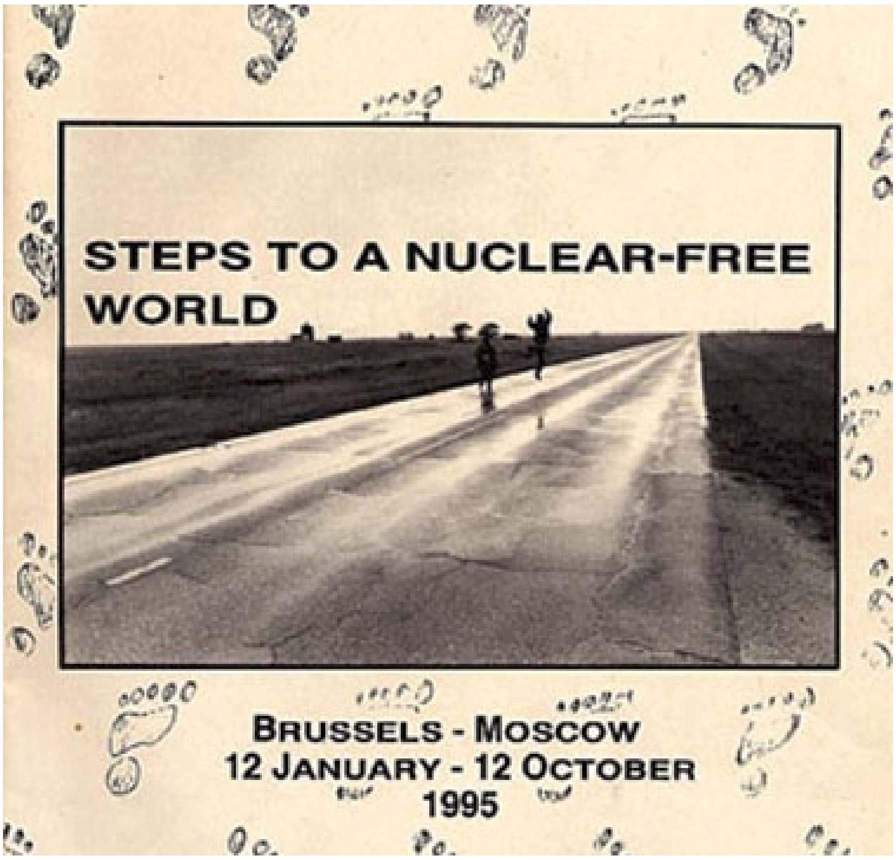

From January 12 to October 12 1995, hundreds of people plan to walk through a large part of Europe for a nuclear free world. The walk is being organised by For Mother Earth and starts in Brussels. It will go through Paris, London, Antwerp, Frankfurt, Prague, Vienna, Bratislava, Kiev, Chernobyl, Minsk and will end in Moscow.
From the start it was obvious that the walk would be, among other things, a good way to spread information on several nuclear issues which are currently relevant in many European countries and on international issues especially relevant in 1995.

* In 1995 it is exactly 50 years ago that the dawn of the nuclear age broke. On July 16, 1945, the first ever nuclear test explosion took place, followed two weeks later by the dropping of nuclear bombs on Hiroshima and Nagasaki.

* Exactly 25 years ago a treaty came into being, aimed at stopping the spread of nuclear weapons: the Non-Proliferation Treaty. In 1995 an extension conference will take place in New York.

* 40 years after the first call for a Comprehensive Test Ban Treaty (CTBT) by president Nehru of India, no such treaty has yet been accomplished. Talks have been going on in the Conference for Disarmament of the UN to achieve such a treaty in 1995.

* October 12, 1995 is the International Day for Solidarity with Indigenous People. For Mother Earth wishes to raise awareness on how nuclear developments continue to affect Indigenous People (i.e. nuclear testing, uranium mining and nuclear waste), thus violating these people's rights to self-determination.

January 1995, For Mother Earth, Belgium
Writing, editing and lay-out: LAKA Foundation, Amsterdam, The Netherlands

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HISTORY OF 'FOR MOTHER EARTH'

At the end of 1989 some people gathered in Gent, Belgium to organise a Walk across America in 1992, 500 years after Columbus landed on the shores of Turtle Island, nowadays known as America.

The vision came from the non-profit 'European Peace Pilgrimage' from the Netherlands. They made an appeal to have several small bands of people walking from different points from the East coast of the USA to converge at the Nevada Nuclear Test Site on October 12th, 1992. In Nevada, the USA has tested over 800 nuclear weapons since 1951... according to the Treaty of Ruby Valley, on land belonging to the Western Shoshone Indian Tribe.

After an overwhelming response in Belgium, it was decided in 1991 to create an independent grassroots non-profit organization. William Rosse Sr., a Western Shoshone elder, whispered the name to us: FOR MOTHER EARTH. In July 1991 a second office of For Mother Earth opened in the USA.

On January 31st, 1992, around 100 people started an unusual journey across America. Walkers from Belgium, the USA and different Indian Nations walked together. They faced snow, rain and freezing cold, or the heat of the desert as they moved their feet slowly in their trail for human rights, the environment and disarmament.

It became a wonderful experience, where close to 500 people joined their 'feet' on their effort to raise consciousness around the violation of Indigenous People's land rights and nuclear developments worldwide. And when the walkers reached Nevada they could read in the newspaper that their effort was fruitful: on October 1st, 1992, President Bush had declared a moratorium on nuclear testing. On October 12th, 1992, over 2,000 people joined in a non-violent protest, and ever since it has been silent at the Nevada Test Site.

The walk had empowered people and created strong links. In 1993 it was decided to continue our walking. After 'shorter' walks across Belgium in 1993 and 1994, and non-violent direct actions, we will walk from Brussels to Moscow in 1995. Today there are also For Mother Earth groups in the Netherlands, Germany and Slovakia.

STATEMENT OF PURPOSE
WALK ACROSS EUROPE FOR A NUCLEAR-FREE WORLD 1995

STOP

#1 all nuclear testing immediately

#2 the mining of uranium

#3 the use of Indigenous People's land for nuclear activities

#4 the production of nuclear weapons

**#5 the Western nuclear lobby going East
and phase out all nuclear power plants immediately**

**#6 the promotional and technological functions
of the International Atomic Energy Agency (IAEA)**

START

**#1 the funding of a health and housing programme
for those affected by nuclear testing in the past**

#2 funding for correcting its environmental impact

**#3 immediate negotations with the traditional councils
for compensating aboriginal landclaims**

**#4 a peacefund for research and training on nonviolence and
destroy existing nuclear weapons as they are in violation with
international law. Treat nuclear warheads as waste**

**#5 funding the use of alternative energy sources
while implementing programmes energy efficiency/savings
and job conversions**

**#6 redirecting nuclear expertise and funding
to the finding of short and long term solutions to the problem of waste.
In the interim, store waste in above ground retrievable storage
near existing nuclear facilities**

**#7 using the IAEA as a purely nuclear control organization
that gives Non Goovernmental Organizations participation in policy-making
and create a new international Energy Agency under United Nations
for research and promotion of renewable energy**

A BRIEF HISTORY OF THE NUCLEAR AGE

In September 1933 in London, the Hungarian Leo Szilard, engineer, physicist and former student of Albert Einstein, was looking forward to hearing the nuclear pioneer Rutherford who was to deliver a public lecture at the British Associa-tion for the Advancement of Science. But on the morning of the lecture, Szilard awoke with a bad cold and stayed at home. The next day he read *The Times* for the story about the lecture. One of the things Rutherford had said was: *"Anyone who looked for a source of power in the transformation of the atoms was talking moonshine"*.

Leo Szilard found that paragraph *"rather irritating because how can anyone know what someone else might invent?"* In this same year he conceived of the idea of the chain reaction. Later he worked closely with Enrico Fermi, who directed the science team that actually built the first graphite-and-uranium chain reacting pile.

On August 2, 1939 Albert Einstein wrote a letter to his friend, President F.D.Roosevelt of the USA. In it he expressed his concerns about the recent developments of atomic research. He had recently talked to his former student Szilard and heared about the experimental data of the possibility of the chain reaction. *"Some recent work by E.Fermi and L.Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory"*.

This letter was the motive to install an Advisory Committee on Uranium and led to the tran-sition of atomic research to the development and production of a weapon. This was the so-called Manhattan Project.

Once the research was funded by the government, the US military's security apparatus took hold. In its search for enemy aliens, the army naturally eyed the emigrants Fermi and Szilard and compiled highly inaccurate reports on them. Had the army advice been followed in the fall of 1940, neither Fermi or Szilard would have been hired to work on the A-bomb. And very probably there would have been no controlled nuclear chain reaction on the 2nd of December 1942, in an abandoned squash court at the University of Chicago.

"The light blasted; it pounced; it bored its way right through you. It was a vision which was seen with more than the eye. It was seen to last forever." These were the words of Isidor Rabi, one of the scientists watching the Trinity atomic blast on 16th July 1945. The plutonium device would soon be used to destroy the city of Nagasaki. Years later, Rabi and some of his colleagues pleaded to stop the development of the H-bomb.

Little Boy was the first atomic bomb to be used aggressively. It was detonated 600 meters above Hiroshima around breakfast time on August 6, 1945 and killed more than 150,000 people. Three days later, Fat Man was dropped on Nagasaki.

The first uranium reactors were built in the United States mainly to produce plutonium; the heat from the reactors was merely a side product, and energy generation was, until the fifties, a matter of secondary importance in the military use of nuclear fission. It was restricted to use in the bigger submarines.

After the war, both the United States and Russia developed nuclear weapons at an increasing speed. These new, sophisticated weapons made the Hiroshima and Nagasaki bombs look like children's play. By the late fifties an undercurrent of fear began to emerge as a spur to public action. Fallout from bomb tests became a major issue after several contamination cases were made public, leading to worldwide protests.

After 1946, US policy in the field of nuclear energy was characterized by secrecy and the struggle to maintain a monopoly. However, several West European countries succeeded fairly well in developing their own nuclear weapons. In the beginning of the fifties two new European organizations seemed to be the beginning of an independent West European nuclear co-operation. In 1952 the Conseil Européen pour la Recherche Nucléaire (CERN) was established in Geneva for the research into elementary nuclear particles. And in 1953, even before Eisenhower's 'Atoms for Peace' speech, the Organization for European Economic Co-operation (OEEC), which had been established in connection with the Marshall Aid Plan, was aware that energy supply would become one of the most important problems for economic expansion in Europe. It was then that they started to think about the development of nuclear activities.

In 1957, the members of the OEEC established a European Nuclear Energy Agency (ENEA). The main purpose was to create a joint West European energy policy which aimed at the development of nuclear energy.

A growing fear of remaining technically behind the USA, Great Britain and the Soviet Union led to the establishment of the European Community for Atomic Energy.

The objective of the European Community for Atomic Energy, better known as Euratom, was, among other things, to stimulate research and to exchange data as well as establishing safety norms and creating a market. The USA was very much in favour of Euratom. This was an important way for them to facilitate the control of European nuclear activities. During inspections by the IAEA in a European Community country, a Euratom inspector accompanies the IAEA inspectors. This suggests a common approach, but in reality there is some tension. The EC states consider Euratom to be the pre-eminent controlling authority. But the IAEA considers Euratom a representative of the relevant EC state.

THE RISE AND FALL OF URANIUM

Uranium has two main uses: as an explosive component of nuclear bombs, and as fuel for nuclear reactors. Uranium is both radiologically and chemically toxic. It poses a health hazard as a heavy metal as well as a radioisotope.

Radioactivity:

Uranium is an unstable material which gradually breaks apart or decays at the atomic level. Any such material is said to be radioactive, which means that its atoms are exploding and throwing off pieces of themselves with great force. This process is called radioactive decay. During this radioactive decay, two types of tiny electrically charged particles are given off, travelling very fast. These are called alpha and beta particles; some radioactive materials are alpha emitters, and others are beta emitters. In addition, highly energetic rays called gamma rays are often emitted. Gamma rays are not material particles but a pure energy very similar to x-rays, travelling at the speed of light.

Alpha and beta particles and gamma rays can do great harm to a living cell by breaking its chemical bonds at random and disrupting the cell's genetic instructions. Outside the body, alpha emitters are the least harmful because of their low penetrating power, while gamma emitters are more dangerous than beta emitters. Inside the body, however, alpha emitters are the most dangerous. They are about 20 times more damaging than beta or gamma emitters because of their high energy particles.

Uranium and most of its decay products are alpha emitters. As such, the uranium decay products are among the most toxic materials known to science.

Uranium production:

For the world's mining industry, uncertainty has been the dominant feature for 1993. This uncertainty continues into 1994, especially in relation to the timing and strength of recovery in the industrialized economies, and the level of low-cost uranium exports from the former Soviet Union. The situation has forced many utility fuel buyers to put off purchases. In April 1994, the Russian government proposed to encourage uranium exporters to restrict their exports to the European Union in return for an EU agreement to include nuclear materials in a pending partnership and cooperation accord.

The proven world uranium stock corresponds to fifty times the actual yearly use. This is according to a report of the OECD and the IAEA on supply and demand of uranium in 1994. Due to the low price, the production of uranium has decreased since 1990 by 28%.

Uranium mining:

Tiny amounts of uranium are found almost everywhere. However, concentrated deposits of uranium, called ores, are found in just a few places, usually in hard rock or sandstone. These deposits are normally covered over with earth and vegetation.

Uranium mining is referred to in industry jargon as the 'front end' of the nuclear industry. This is because it is commonly regarded as the first link in the nuclear fuel chain, even though it is preceded by exploration.

Uranium mining techniques can be divided broadly into three categories:
a. open cast mining
b. underground mining
c. in-situ mining

The in-situ mining technology is little used in practice. It involves the chemical leaching of the uranium out of the ore by forcing a leaching solution through the ore bed. It is considered especially useful in cases where the ore is embedded in sandstone, which does not need to be artificially fractured to allow the leaching solution to pass through the rock.

By far the most frequently employed technologies for uranium mining are the open cast and underground mining techniques. They are used with equal frequency and together account for almost all of the world's uranium production.

The problems with mining:

All mining inevitably goes hand in hand with the production of wastes which have disastrous effects on the surrounding environment, especially areas downstream of the mines. And in addition to the usual risks faced by miners, uranium miners worldwide have experienced a much higher incidence of lung cancer, other lung diseases, and skin and stomach cancer. Uranium deposits exist today because of their isolation from oxygen and water for millions of years. The mining destroys this natural containment, allowing water and air to carry contamination throughout the environment.

Uranium milling:

The ore from the mines is crushed into a fine sand in a mill and mixed with large amounts of water and chemicals. The marketable product which is extracted by this method is called ammonium diuranate or uranium oxide, but is generally referred to as "yellowcake". It is only a small percentage of the ore (0.5 kg uranium in 1000 kg uranium ore). The (radioactive) remains are solid wastes called "tailings" which contain approximately 85% of the total radioactivity contained in the original ore. These tailings are usually forced out the end of a waste outlet pipe into a holding pond where they can mix with air and water. If this radioactive sand is left on the surface and allowed to dry out, it can be blown by the wind and deposited on far away vegetation. Or it can wash into rivers and lakes, contaminating them. Large volumes of waste are produced in the milling process over a short period of time: hundreds of tons for every ton of yellowcake.

The tailings contain over a dozen radioactive materials. One of them is radon gas, which escapes from tailing piles and can be carried hundreds of kilometers by the wind, affecting large numbers of people.

Tailings at Ronneburg (FRG) Loeke Pam (LAKA)

There are three main reasons why radon is so dangerous.
* First, it is a gas and can thus be breathed in. It is the only gas that occurs in the uranium decay series. Unnaturally large amounts of radon gas are continually coming out of the ground at uranium mine and mill waste areas.
* The second reason is because it releases the most harmful type of radiation -- alpha radiation.
* The third reason is that radon has a short half-life and is followed by extremely hazardous "radon daughters" -- the decay products directly deriving from the 'parent' radon. The radon problem is especially serious for underground miners because the gas accumulates in the tunnels.

PRODUCING COUNTRIES(the European countries are treated in special country-status-reports which will be published during the walk):

AFRICA

The first uranium mine in Africa was situated in the then Belgian Congo (Zaire).
There are four major uranium producing countries in Africa: Gabon, Niger, Namibia and the Republic of South Africa. Today Niger and Namibia alone account for about 40% of the worldwide output of uranium oxide.

Zaire

The western world's first African uranium mine was established in 1938 at Shinkolobwe in Katanga province (nowadays Shaba). Mining was carried on until 1960, supplying uraniumoxide for the US 'Manhattan Project', but has since been abandoned.

Zambia and Zimbabwe

There are apparently several uranium sources in the valley of the Zambezi River, or close to it. Exploration is being carried out by InterUran GmbH, a joint German-French company, and the Federal German Agency for Geology and Resources on the Zimbabwe side of the river.

Niger

Uranium exploration in Niger was begun in the 1950's by the French Commissariat à l'Energie Atomique (CEA). In 1965, commercially viable reserves of uranium were discovered in the Arlit region in the northwest of the country. The Société des Mines de l'Air (SOMAIR) was formed to develop the deposit and in 1971 production of Nigerian uranium began. Further exploration resulted in the discovery of the Akouta deposit. In 1974 the Compagnie Minière d'Akouta (COMINAK) was formed.
Like in a dream, Niger developed economically very quickly until uranium prices fell at the end of the 80's. This drop also revealed strong structural problems. The number of inhabitants of the whole of northern Niger is low. Although some of them live permanently near reliable water supplies, most of the population is nomadic. The Tuareg people make up by far the largest population group and the exploration of uranium being carried out in the Arlit region has considerable impact on them. In addition, the increased human presence has brought increased pressure on the natural resources of the area. The threats to the fragile ecosystems undermines the viability of the traditional nomadic lifestyle.
The contractors for the Nigerian uranium are only partly known. The most important importing countries have been the countries who are COMINAK shareholders: France, Japan, Spain, the Federal Republic of Germany, and Italy. In the early 80's, Libya was also an important importer.

Gabon

There is only one uranium mine in Gabon. It is located near Mounana and is operated by the Compagnie des Mines d'Uranium de Franceville (COMUF). France is Gabon's major customer. Mining operations began in 1961. As in Niger, 8% of the workforce consists of Europeans (mostly French) who occupy management positions. And just as in Niger, black workers are employed in the most dangerous and hazardous jobs in the underground mine shafts.

Morocco
The world's largest phosphate deposits are found in Morocco and Western Sahara (the former colony "Spanish Sahara"), which was illegally invaded and occupied by Morocco in 1975. The deposits contain between 110 and 140 milli-grams uranium per kilogram. The uranium resources of Western Sahara are one of the major reasons for the Moroccan invasion of the country after the end of the Spanish colonial rule.

Algeria
Uranium deposits are found in the Hoggar Mountains. Several efforts have been made by Algeria with the assistance of France to exploit its resources. But at the present time, no further information about Algerian uranium mines and production facilities is available.

South Africa
There are three principal uranium deposits: Palaborwa, Witwatersrand and Karoo Basin. Since the early 50's, uranium has been produced as a by-product of gold or copper. In the 70's the decision was taken to extract uranium from the tailings of gold mines and to open two new uranium mines. So, in the 80's there were three categories of uranium producers: primary producers, by-product producers and tailing producers. Because of the weak uranium market and declining prices, and because of world political pressure against purchases of South African uranium, only the lowest cost producers survived.
The mine at Palaborwa is a copper mine operated by Rio Tinto Zinc (RTZ) which contributes an estimated 300 tons annually to South African uranium production. More important is the yellowcake production at Witwatersrand's fifteen gold mines. These mines are operated by two companies: Anglo-American Corporation (AAC) and General Mining and Finance Corporation (GENCOR).
The economic importance of uranium mining is tremendous, since South Africa's production amounts to 15% of the world production. Export statistics are not available as South Africa's Atomic Energy Act forbids the release of details of uranium contracts.

Namibia
Namibia's economy depends almost entirely on mining. Extensive uranium exploration started in 1966. Following independence in March 1990, after 75 years of South African colonial rule, mineral earnings were adversely affected by weak prices caused by reduced demand from industrialized countries. The SWAPO government hopes to revitalize the mining industry (which is not only uranium but also includes diamonds, gold, copper and silver, among others). A mining law approved by the National Assembly at the end of 1992 is designed to maximize exploration by overseas and local mining investors.

Namibia's Rossing uranium mine, developed in the mid 1970's, is among the five top global producers. Output from Rossing (whose major shareholder is Rio Tinto Zinc) was cut to 2,500 tons, half of its capacity, in 1991. Rossing is the largest open-pit uranium mine in the world (one km by two km in size). The mine is situated in the desert of western Namibia, close to the coastal towns of Swakopmund and Walvis Bay. Before Namibia gained its independence, SWAPO had severely criticized the unauthorized exploitation of the uranium deposits, which, among other things, violated the 1974 UN Declaration no.1. Besides that, SWAPO always criticized health conditions in the mine and demanded compensation for all mining activities by foreign companies. After independence, however, the new SWAPO-run government is apparently compelled to work together with the mining companies due to economic pressure.

Other African Deposits: Mauretania, Central Africa, Sudan, Somalia, Guinea.

PACIFIC

Australia

As of 1990, at least 42% of the world's known exploitable uranium resources were located in Australia. This country is sixth on the list of producers after Canada, the USA, South Africa, Niger and Namibia. Uranium mining is one of the most capital-intensive industrial activities currently undertaken in Australia. It requires more investment to create a job in uranium mining than in most other industrial activities.

The existence of uranium in Australia was known in the 1890's, but uranium ores were not mined until the 1930's when very small amounts of radium were mined at Radium Hill in South Australia. In 1949, deposits were discovered south of Darwin, at Rum Jungle. The mine there was run by Conzinc Rio Tinto Australia (CRA), a joint venture of Rio Tinto Zinc and the Australian government. In 1977, the mine's tailings dam broke and an area of 100 square km was contaminated by radioactive waste. Fish and all other animals in a 10 km downstream section of the river died. Even though this tract of land can no longer be used by the traditional Aboriginal caretakers, the company denies any responsibility in the disaster.

In the 1950's and 60's there were a number of uranium mines in operation in South Australia, the Northern Territory and Queensland. By 1970 they were all closed down, although the largest producer, Mary Kathleen Uranium Ltd., was reopened in 1974. It remained open until 1982, when its orebody was exhausted. Today, Australia has three uranium mines in operation: Ranger and Nabarlek in the Northern Territory and Olympic Dam in South Australia. Olympic Dam is also a major copper, gold and silver producer and is the only underground mine among the three. The Australian company Western Mining owns 51% of this mine and the European daughter company of the South African Anglo-American company Minorco owns the other 49%.

The Aboriginal peoples who have been living in Australia for at least 40,000 years suffered greatly under the white colonists who, step by step, took over the country. Until World War II, many Aboriginal peoples were evicted from their lands or killed. In the second half of the 19th century the Australian colonial administration assigned the first reservations to Aboriginal peoples. One of the main reasons for this was to minimize conflicts between white farmers and black Australians. The reservations, however, did not provide any protection to Aborigines when mineral resources were discovered on their land.

Until 1993, no treaty was ever signed between the Aboriginal peoples and whites. (It wasn't until 1967 that Aboriginal Australians obtained equal civil rights. Even then though, they were given no rights as landowners on their own reservations.) In October 1993 the Australian government finally recognized by law the traditional land claims of the Aboriginal peoples. Many Aborigines called this announcement historic. Others, however, rejected it, calling it a clearance sale. As Aboriginal people feel responsible for protection of the land and its sacred sites, the harm being done to the land by mining companies is a severe encroachment on Aboriginal culture. Without land rights, Aborigines cannot do their duty towards the land. But the law does not give these rights. What it gives is the right of Aboriginal people to participate in the lease of the mines on their territories. This participation, however, doesn't mean control over what happens to the land, and is only meant to decrease the alarm.

THE AMERICAS

Canada

In 1984, Canada became the world's leading uranium producer, taking the position previously held by the United States. At the Eldorado re-finery in Port Hope, Ontario, uranium from the Northwest Territories and the Belgian Congo was processed for the US army. The US Army used it to produce the world's first atomic bombs, and the Canadian government secretly bought up shares in the company which owned the Eldorado refinery during World War II. For twenty years after the first atomic explosions, Canada's uranium was sold to make many more atomic bombs. In 1959, uranium

was Canada's fourth most valuable export. At that time, virtually all of it was sold for military explosive purposes.
With the speedy increase in mining activities, northern Saskatchewan came to be called the *"Saudi Arabia of uranium mining"*. The Saskatchewan Mining Corporation and Eldorado Nuclear Ltd merged in 1988 to become the world's largest uranium producer, CAMECO.

One of the oldest mining sites in Saskatchewan is Beaverlodge, which opened in 1952 and closed 30 years later in 1982. During those three decades, more than 20,000 people were employed in the mine. The mortality rate among miners was considerably high due to exposure to radon gas and gamma radiation. Fishing had to be completely abandoned in the vicinity of the mine after its closure in 1980. In 1953, 25 open pit and subsurface mines started operation in the vicinity of Uranium City. They were closed in 1981, leaving 12 million tons of tailings behind.
The majority of uranium tailings - some 200 million tons in total - are located at Elliot Lake. However, neither the federal nor provincial governments can confirm exact locations and quantities. Most of the major nuclear powers (the US, France, Japan, Germany) and several other countries involved in nuclear power and/or interested in obtaining nuclear weapons are now involved with uranium mining in Saskatchewan.

United States

Uranium mining has been carried out in the US since 1943. Until 1970 it was for military purposes exclusively. Meanwhile, though, uranium production has drastically declined. Production is concentrated in three 'established uranium provinces': the Colorado Plateau, the Wyoming Basin and the Gulf Coastal Plain along the Atlantic Coast from Boston until the Gulf of Mexico.

The Grand Canyon National Park in Arizona is the location of one of the very few new uranium mining projects in the US. The Havasupai are a small group of about 600 people, living at the bottom of an extension of the Grand Canyon. The proposed mining site, at a place called Red Butte, doesn't constitute a part of their reservation, but is considered sacred by the Havasupai and is an important part of their traditional territory. Among other things, mining operations could also endanger the groundwater supply, and radon gas emissions and poor handling of the tailings are feared. The Havasupai have been resisting uranium mining on their sacred territory since 1985. They are supported by several environmental organizations such as Earth First and Canyon under Siege.

In 1980, half of the uranium produced in the US was mined on Indian reservations, with the state of New Mexico contributing 50%. The mining severely affects the Navajo and Pueblo Indians. Dust from the enormous tailings piles is spread around by rain and wind, contaminating large areas. In the past, the radioactive waste was even used in building houses. In 1979, the media was focused on the accident at Harrisburg. More or less at the same time, a tailings dam at a uranium mill in Church Rock in New Mexico broke. Millions of litres of radioactive water were spilled into the river, which crosses a Navajo reservation, with all the dangerous consequences for the environment and the people, but the media was not interested.

Mexico

Uranium exploration began in 1957/58. The four existing mines are closed at the moment. But two of them are only indefinitely deferred and could go into operation again.

Venezuela and Brazil

According to the Venezuelan government, there is strong evidence for the existence of "radioactive minerals" on the Brazilian-Venezuelan border, a region inhabited by the Yanomami Indians.
The principal uranium deposits in Brazil are located in the district of Quiteria, Ceara, Gandarela, Bahia and in Pitinga.

Argentina
Over 20 districts contain some 31 uranium deposits. Of these, a mine in the Sierra Pintada district is the largest with an estimated reserve of 14,500 tons of uranium.

ASIA

Israel
According to a broadcast of the Israeli News Agency, significant uranium resources have been found in Israel (on the occupied West Bank Territories). Location of the deposits have not been revealed.

Iraq
Iraq's domestic uranium mining still takes place at Rabda in the Western Iraqi Desert. Mill-ing is done at Al Qaim, where uranium is produced as a by-product of phosphate fertilizer production. Mining and enrichment take place in the Jebel Quarasjok-Mountains, close to the Turkish border.

Pakistan
According to western sources, there is one uranium mining site in Pakistan, at Dera Ghazi Khan in Balochestan.

India
One uranium mine is operating in the state of Bihar and another one is planned in the state of Karnataka. The Uranium Corporation of India Ltd (UCIL) is a 100% government-owned mining company, coming directly under the responsibility of the Atomic Energy Commission. Attempts to open up two tribal states (Meghalaya and Nagaland) for uranium mining, are being met with resistance. Mining in Bihar first began under the British colonial government and was later taken over by the Indian government. The mines are situated 2000 ft underground. The total number of workers at all the UCIL mines is 4000, the majority of which works underground. Ninety-five percent of these underground miners are tribal. No trade union or political party has, to date, effectively addressed the issue of radiation and its effects on the workers and the residents of the local villages. Neither the workers nor the villagers have any knowledge about the hazards or effects of the mining.

China
Uranium deposits are rare and scattered throughout the whole territory of China, including the so-called autonomous regions, Tibet and Sinkiang. Rich uranium ore beds were found in Sinkiang province between 1944 and 1949. Large scale exploitation began around 1950 through Sino-Soviet joint effort. After 1962, China took over the complete operation. Since 1959, however, the Chinese take most of their uranium from Tibet.

Tibet
Tibet had been independent from China for most of its history and had regained independence from the Manchu Empire in 1912. The country was forcibly incorporated into the People's Republic of China by a military invasion in 1959 and has been subject to extreme forms of cultural, military and political oppression ever since.
According to rumors, the world's richest uranium sources could well be located near Lhasa. Riots in 1988 at Riwoche in Eastern Tibet indicate that the Chinese are already mining uranium in Tibet. However, due to the geographical and climatologically conditions of the country, large scale mining will be very unlikely.

One mine is located near Tewe, the other is in Ngaba. There is concrete evidence of the effects of the mining that has already taken place. Illnesses and deaths occur when the streams, fed by rainwater, pick up heavy metals from the mine tailings; Tibetans live near the mines and drink from the streams or water their animals there. At least 35 of the 500 inhabitants of one village in the Ngaba Prefecture have died from drinking poisoned stream water. A publication released by the International Campaign for Tibet (based in Washington, DC, US), entitled *'Nuclear Tibet: Nuclear Weapons and Nuclear Waste on the Tibetan Plateau'* reports that more than 50 Tibetans died between 1988 and 1991 from mysterious illnesses; domestic animals mysteriously died; trees and grasses "dry up"; and polluted rivers are colored black and smell bad.

Japan

There are no domestic uranium deposits in Japan except in seawater deposits. Since 1970 Japanese scientists have been trying to extract this uranium from the sea. The main uranium suppliers to Japan are France and the US.

Indonesia

Uranium exploration activities started in the early 60's. Ten years later French and German companies began more concrete efforts in Kalimantan (Borneo), Western, Northern and Eastern Sumatra, Sulawesi (Masamba) and Eastern Indonesia (Ramsiki). The last exploration was done in 1987 in Sibolga (North Sumatra) and Kalan (West Kalimantan).

NUCLEAR PROLIFERATION AND ITS WATCHDOGS

INTRODUCTION

Atoms for war
On a bitterly cold January morning at the US Los Alamos National Laboratory in New Mexico, a hundred scientists gathered together to discuss new nuclear armaments. Many of the United States' top experts on nuclear weapons were there, including Edward Teller, legendary father of the H-bomb.
The press was barred from the meeting. It was a call for more and bigger nuclear bombs. As the meeting continued, a protegé of Teller at the Lawrence Livermore National Laboratory could not contain his excitement; from the back of the audience he shouted: *"Nukes forever!"*
Teller himself urged the development of a new superbomb -- 10,000 times more powerful than any bomb ever built! A bomb so powerful that it could never be detonated on earth: it would mean the end of all living creatures and total destruction.

When was this? Just after World War II? During the Cuba missile crisis? In the heyday of the Cold War? No. It was January 1992. The Cold War had ended, and new disarmament pro-posals were the order of the day. Why, then, such a proposal? Who was the enemy?

The enemy was a comet! Somewhere, sometime in the future, a giant comet might hit the earth. Just as it was believed to have done 65 million years ago to end 60% of all life forms on earth, including the dinosaurs. Those who had defended the Free World from the Evil Empire would now save the earth from cosmic disaster.
The handful of non-weapons specialists attending the meeting, including experts on asteroids and comets, were horrified.

This example, and it's not the only one by far, shows the mentality of the leading and influential nuclear weapons designers: 'Let's find a new justification, otherwise we'll lose our jobs'. In their minds, the powers of nuclear fission have to be seen as they are: destructive.

ATOMS FOR PEACE

The speech and expectations
Nearly forty years earlier:
"...to find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life". This is part of the famous speech to the United Nations' General Assembly by US president Dwight D. Eisenhower on December 8, 1953. It was the beginning of a change in image for nuclear power. Until then, nuclear power was the power of the bomb. But after the 'Atoms for Peace' speech (as it came to be called), there was suddenly another kind of nuclear power: one that would bring the world and all living creatures on it prosperity, happiness and peace.

Expectations in these very first years were very high. Everything seemed possible. Electricity would be so cheap and abundant, its use wouldn't be worth measuring. But other applications were to be developed as well. The transport sector was believed to be an area that would be especially affected, becoming 'nuclearized' over the coming decades. Ships and submarines, rockets, airplanes, and even trains and busses were to use uranium as fuel. And the applications were numerous. It was to be used to 'feed a growing world' in agriculture, health, industry.

Eisenhower also referred to an International Atomic Energy Agency which was to be set up under the aegis of the United Nations. Its "more important responsibility", he said, would be to "devise

methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind".
The timing of this 'Atoms for Peace' initiative was well chosen: there was a general unease growing about the 'atoms for war' (see box). In addition, the US had lost its heavily defended monopoly on nuclear technology and was looking for a way to earn some money with it.

The unease about nuclear weapons in general, and testing in particular, was growing rapidly. - August 12, 1953: The USSR tested its first hydrogen bomb (exactly four years after it had exploded its first plutonium bomb). - October 3, 1952: Britain tested its first A-bomb at Monte Bello, Australia. - June 1953: Ethel and Julius Rosenberg were executed in the US after they were found guilty of nuclear espionage.***** - December 1953 (the same month as Eisenhower's speech): The US introduced strategic nuclear weapons into Western Europe. - In 1957 an opinion poll showed that 63% of the population in the US opposed nuclear testing. The British Labour Party introduced an anti-testing motion into parliament, and the West German Bundestag advocated a general test ban. The peace movement held its first anti-A-bomb demonstrations. ***** In May 1992, Igor Kvasnikov, a member of the team that developed the Soviet nuclear arsenal in those days, was quoted in the Komsomolskaya Pravda as saying that although much of the knowledge for the first Soviet A-bomb came from espionage, the Rosenbergs didn't have anything to do with it. - **NRC** (NL), 15 May 1992: 'Rosenbergs stalen niet atoomgeheim' ('Rosenbergs didn't steal atomic-secret')

Only a very select group of people was directly involved with the Manhattan Project in plutonium research and development, either in the actual research or in policy making or both. The Project's atmosphere of unparalleled secrecy continued after World War II, cloaking nuclear activities everywhere in mystery.

Although the US, Britain, the Soviet Union and France had been wartime allies, nuclear fission divided them at once into hostile camps. The 1946 US Atomic Energy Act (also known as the McMahon Bill) summarily cut off British and French access to US nuclear data, although both countries had helped to launch the Manhattan Project. This slap in the face left a legacy of bitterness. On a governmental level, each country mistrusted the motives behind the nuclear programs of the other three, a mistrust that rapidly evolved into intense nuclear nationalism. The possession of plutonium and plutonium technology, with its military implications, became a mark of international status and pride.

The end of the US monopoly
The McMahon Bill was aimed at secrecy and monopolizing (or to *"foster and control"*, as the Chief Historian of the US Department of Energy puts it) nuclear knowledge and materials. An example of the activities carried out under the Bill is a secret agreement the US signed with The Netherlands on August 4, 1945 for the purchase of all known and unknown thorium ore in the Dutch colony of Indië (now Indonesia). This secret agreement was discovered by chance in 1991, during research being done on the Dutch role in NATO.

One of the consequences of the Bill was the establishment of a Joint Committee on Atomic Energy which, amongst other things, ordered the death penalty for nuclear espionage, even in peace time.

After the Soviet Union and Britain notified the world that the monopoly on nuclear technology and knowledge had been broken by exploding their first A-bombs, the US changed its policy. *"...[T]he dread secret, and the fearful engines of atomic might are not ours alone"*, as Eisenhower put it. So the next step was to earn money with it: the Atomic Energy Act of 1954 permitted and encouraged the participation of private industry in the development and use of nuclear energy, and by 1957 the US already made agreements with 35(!) countries for the supply of nuclear research reactors and was negotiating such a deal with another 8 countries. The era of nuclear proliferation was on its way.

Eisenhower was believed to be very concerned about the possibility of a nuclear war. Nevertheless, he continued the US nuclear testing program. On March 1, 1954, nearly three months after his 'Atoms for Peace' speech, the US tested a 15-megaton H-bomb at Bikini Island, in the Pacific. This resulted in the severe contamination of the crew of the Japanese fishing boat *Fukuryu Maru* (the Happy Dragon), which was fishing in nearby waters. In April 1954 Prime Minister Jawaharlal Nehru of India spoke to the UN General Assembly and, for the first time in history, proposed a total ban on nuclear testing.

From August 8 - 20, 1955, as a direct result of the Eisenhower speech, a conference titled *'Atoms for Peace'* took place in Geneva, Switzerland. It was to be the largest conference the world had ever seen up to that time. A total of 1,428 delegates and 1,334 observers produced 16,000 pages of documents. There was a general euphoria among its participants because of its free discussions, free exchange of knowledge, and its atmosphere free of political prejudice. Its chair was Dr. J.J. Bhabha, a scientist from India.

INTERNATIONAL ATOMIC ENERGY AGENCY

History
In 1945 the US proposed to the newly cre-ated United Nations that it should set up an international authority that would control all nuclear material and all forms of nuclear activity throughout the world. The Soviet Union called for the destruction and prohibition of all atomic weapons before setting up such a control system. Later the US modified itÑ plan (called the Acheson-Lilienthal Plan, but better known as the Baruch Plan, named after the US Statesman who presented it in the UN): only the sensitive steps in the nuclear fuel cycle (reprocessing and enrichment) should be owned and operated by an international authority while other activities should be subject to safeguards to ensure that they were not used for military purposes. Despite the modifications, it was obvious that the plan called for individual nations to surrender too much sovereignty to be accepted. The members of the UN Atomic Energy Commission were unable to reach an agreement on it and the commission was dissolved in 1952.

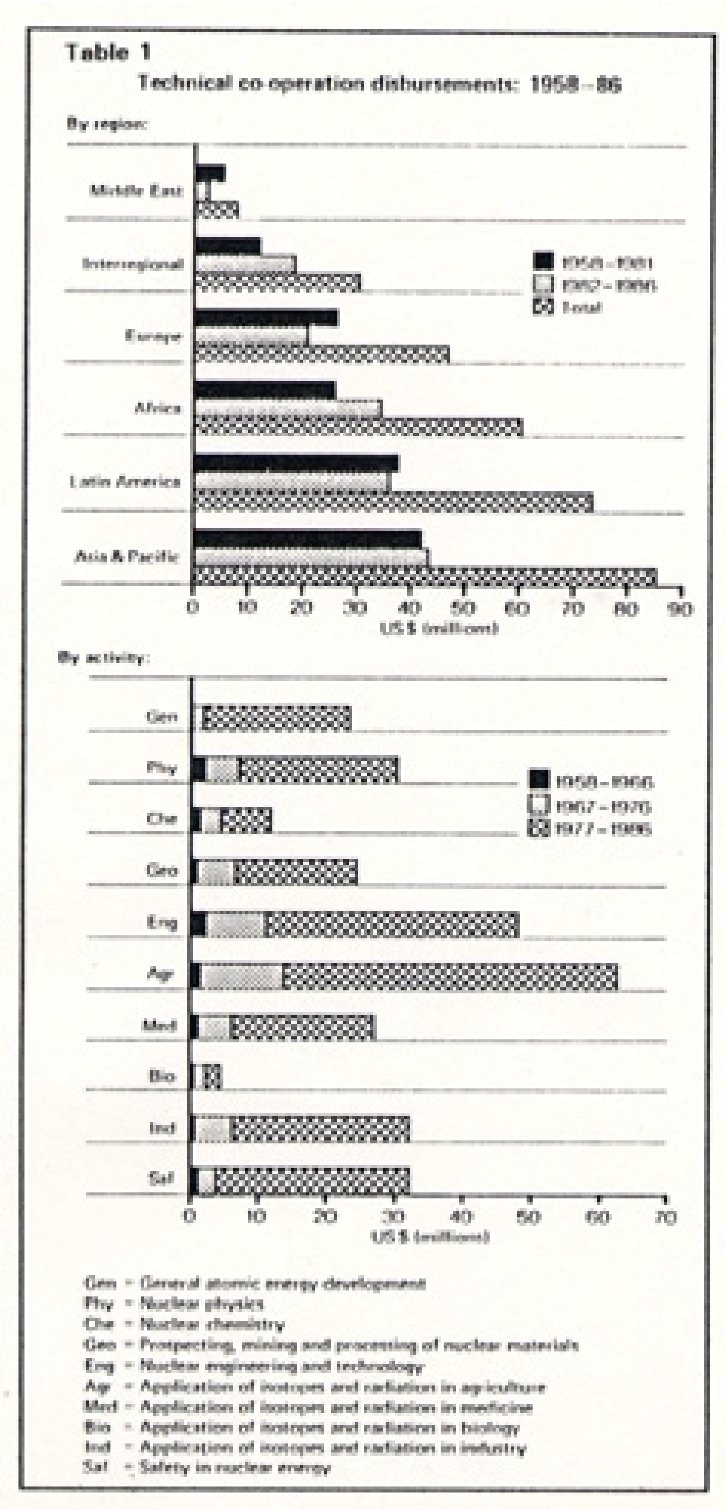
In December, 1954 the UN General Assembly adopted the US' 'Atoms for Peace' resolution, and on July 29, 1957 the International Atomic Energy Agency (based in Vienna, Austria) came into being. The intention was to control nuclear armaments and develop peaceful applications of nuclear technology. At the time, it was widely believed that unlimited technical and industrial progress would be a benefit for all. Nuclear fission was thought to be an unlimited source of cheap energy. The IAEA was to guarantee that all nations would share in its benefit.

Statutes
Neither the ideology nor the statutes of the IAEA have changed since its creation, but the role of nuclear power has. According to its statutes the aim of the organization is: *"to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it...is not used in such a way as to further any military purpose"*.

Article III of the statutes describes the function of the IAEA: *"The Agency is authorized:*
* 1 To encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world....
* 2 To make provisions...for materials, services, equipment and facilities to meet the needs of research on, and development and practical application of, atomic energy for peaceful purposes,

including the production of electric power, with due considerations for the needs of the underdeveloped areas of the world....
* 5 To establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities and information made available by the Agency...are not used in such a way as to further any military purposes....
* 6 To establish or adopt...standards of safety for protection of health and minimization of danger to life and property....

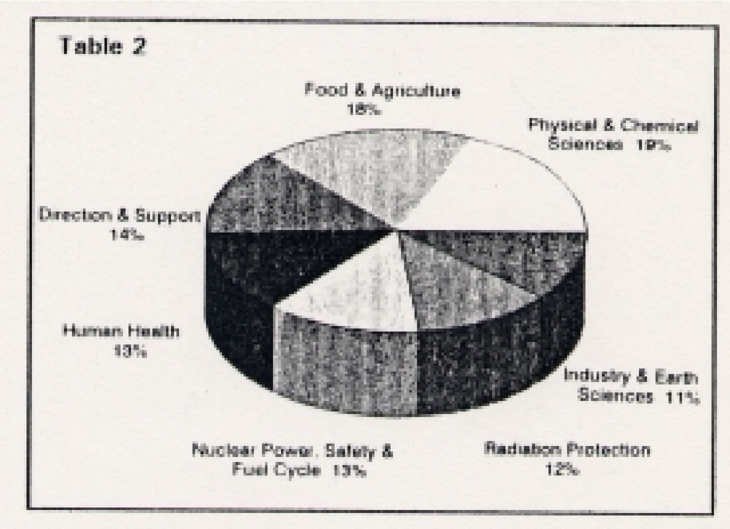
IAEA and Proliferation
Promotion of and assistance with all kinds of applications of nuclear energy is done by 'technical cooperation' and is concentrated especially on the so-called developing countries.



IAEA's Director General Hans Blix puts it bluntly: *"...technical cooperation to help promote the use of nuclear techniques in developing countries forms one of the Agency's main activities"*. The motives behind this vary, but an important factor is the effort of the nuclear industry (and the politicians and organizations who back it) to make nuclear technology 'socially acceptable' and earn it a positive image by creating and spreading as many as possible 'beneficial' and 'peaceful' applications as possible. Applying 'progressive' methods and equipment means an increase in prestige for many scientists and technicians, as well as for politicians and countries. This is true especially for the less developed countries which model themselves on the rich and highly industrialized nations. This is a mistaken and fatal development. In western countries the negative effects have become obvious over the last 20 years, at least, and show that the way of the industrial nations cannot serve as a model for development in other parts of the world.

The main tool the IAEA uses to spread the various applications of nuclear technology is its Technical Cooperation Program (TCP). From 1958 to 1990 a total of US$479 million was spent by the TCP to promote so-called peaceful uses of nuclear energy in the IAEA's developing member states. In 1958 the annual budget for this was US$1.5 million and in 1990 US$72 million. An overview of the various areas on which TCP money was spent in those 30 years

(1958-88) is shown in Table 1. Table 2 shows the specific areas receiving attention during 1993-94.



What is the result of all this promotion and proliferation of nuclear technologies? In addition to the reactors (including research reactors) and other facilities directly linked to the nuclear energy fuel cycle (eg, mining, enrichment, reprocessing and waste storage), there are hundreds of thousands of facilities and machines with nuclear applications spread around the world. No exact figures have been published, but it is estimated that there are:

* approximately 300 neutron generators
* approximately 300 particle accelerators
* approximately 850 low and medium energy electron beam accelerators
* more than 600,000 sealed radiation sources (containing mostly cobalt-60, iridium-192 or cesium-137), including 142 industrial gamma-irradiation devices.
*400,000 X-ray machines (according to the WHO)

All these devices produce hazardous radioactive waste, and their use inevitably involves radiation exposure to humans at the workplace.

The IAEA and nuclear safety

"Would an international safety regime, formalised through an international convention, help build public confidence and help sustain the nuclear option?" This is for the head of IAEA's nuclear safety division the main question. So, according to the IAEA, nuclear safety is a public relations problem; a psychological question, not a technical one. Two years after this statement, in June 1994, the work on such an international agreement on nuclear safety was finished. The agreement is open for signing since the IAEA annual meeting in September 1994. According to this agreement the parties are obliged to supply detailed safety reports on nuclear installations. Governments should give the supervision of the installations to an independent organisation. Safety, sufficient financial support and training of personnel should have top priority. But the agreement is not to the satisfaction of all. Greenpeace, for instance, has criticised it on the following grounds: there is not one word on nuclear waste and transports, plutonium production, uranium mining and processing, nor about nuclear weapons; there are no enforceable safety standards, and the situation with extremely dangerous and old reactors remain unchanged.

In 1992, nuclear safety received only 6% of the Agency's regular budget, a fact which clearly highlights the dominance of nuclear promotion over nuclear regulation.

The IAEA and Chernobyl health-effects

The IAEA is also an important factor in playing down the health consequences of the 1986 Chernobyl accident. In an impressive public relations offensive in 1991, called 'The International Chernobyl Project', the IAEA reported: *"No abnormalities in either thyroid stimulating hormone or thyroid hormone were found in children examined. No statistically significant difference was found between surveyed contaminated and surveyed control settlements for any age group"*. Although immediately heavily criticized, the overall impression in the media was controlled by this statement.

That it was nothing more than propaganda (and immediately used as such by, among others, the Soviet Union) is shown by the fact that the 600,000 cleanup workers (the so-called 'liquidators') and the 500,000 people who lived in the evacuated 30 kilometer zone, were not even included in the IAEA study. And the fact that no increase in thyroid cancers cases was found amongst children was very logical: during the time of the study, almost all the children were away at summercamp! Figures for those who have died range from 31 to 8,000, and predictions for those who will suffer early deaths from 40,000 to 500,000. The most astonishing figure comes from Chernousenko, head of the cleanup program and severely ill as a result of it. He expects that within the area covered by the former Soviet Union, no less than 15 million people will die over the next ten years as a consequence of the accident.

Conclusion
All this (and much more evidence can easily be found) makes it obvious that the IAEA is nothing more than an important public relations organization for the nuclear industry. For this reason it is unreliable as an independent "watchdog" or as a body concerned with matters of nuclear safety, and it is unsuitable as a tool to prevent the proliferation of nuclear weapons technology.

Therefore it should be reformed, or even replaced altogether, to become an independent organization with sufficient credibility to strengthen the development of non-nuclear methods for electricity production. Further, the use of all kinds of nuclear applications in medicine, agriculture and industry should be discouraged. The search for alternative methods should be encouraged. Strict standards for radiation doses should be developed and implemented.

THE NON-PROLIFERATION TREATY

Introduction
The Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which came into force in 1970, has 164 parties, more than any other international arms control treaty. However, from the very beginning the NPT has been a fragile document and remains so to this day. A product of the Cold War era and the political realities that existed at the time, the Treaty's goals were to prevent the further proliferation of nuclear weapons, while also encouraging the development of peaceful applications of atomic energy.

The commercial interests of the nuclear trading states have been shown to take precedence over consideration of the trade's effects on nuclear non-proliferation. In the increasingly competitive environment of the 1990's, the nuclear industry has adopted a two-fold strategy: to try to maintain a scaled-down domestic market, while seeking to increase the export proportion of trade. The existing non-proliferation regime supports such developments, having been designed to promote such trade, not curtail it. This provides one of the clearest justifications for a complete review of international non-proliferation diplomacy as currently practiced.

The Treaty and its inherent weaknesses
The main contradictions and weaknesses inherent in the NPT can be summarized as follows:

* The Treaty has the primary objective of preventing nuclear proliferation, yet it legitimizes nuclear weapons possessed by the official nuclear weapons states.
* The Treaty promotes the development and trade in nuclear technology and materials that are directly useable in nuclear weapons.
* The Treaty promises the benefits of 'peaceful' nuclear explosions (PNEs).
* It is widely perceived as discriminatory by the majority of its parties. This has several components:
    a. It is argues that the obligations on the non-nuclear weapons states (NNWS) are far greater than the weapons states (NWS), and;
    b. NNWSs are prohibited from developing nuclear weapons, yet the NWSs are permitted to expand and qualitatively develop their own nuclear weapons arsenal:
    c. The Treaty discriminates in one of the key areas of nuclear non-proliferation: nuclear safeguards. The official NWSs are not obliged to have any of their nuclear facilities -- civil or

military -- under international safeguards, whereas the NNWSs have full-scope safeguards applied to them.
* NPT safeguards as implemented by the IAEA are unable to detect and deter diversion of nuclear materials into nuclear weapons programs, and hold no prospect for any substantial improvement.
* The only obligation for the NWS is to negotiate effective measures to stop the nuclear arms race at an 'early date', and move to general disarmament.
* The Treaty was deliberately framed to permit continued collaboration between the official nuclear weapons states on the development of nuclear weapons.
* The Treaty does not adequately define a 'nuclear weapon'. This means that all the components of a nuclear weapon -- including the fissile core -- can be acquired, and will not be a formal violation of the Treaty until they are assembled.
* An NNWS party to the NPT can take advantage of its rights to technical and material support for its nuclear program, then, after achieving its objectives, legitimately remove itself from the NPT and develop nuclear weapons.
* The IAEA, which administers NPT safeguards, cannot fulfill even its limited safeguards objectives and is hampered by having its budget and human resources split between implementing safeguards and promoting nuclear technology.

We will take a closer look at some of the problems of the NPT.

'Civil' and 'military' nuclear technology
Safeguarding is needed mainly because of the fundamental problem with the NPT; ie, its separation of the uses of nuclear technology into 'civil' and 'military'. It has already been said a million times: There is no difference between 'peaceful' and 'non-peaceful' uses of nuclear technology. There is no difference between 'reactor grade' and 'weapons grade' plutonium; both are suitable for the production of nuclear weapons. In 1962 the US conducted a nuclear test explosion at the Nevada desert test site with a bomb containing reactor grade plutonium. Documents on the test were released in June 1994.

Every country with a nuclear power program is capable of developing a military program. Victor Gilinsky, a former commissioner with the US Nuclear Regulatory Commission, has stated, *"So far as reactor grade plutonium is concerned, the fact is that it is possible to use this material for nuclear warheads at all levels of technical sophistication. In other words, countries less advanced than the major industrial powers but, nevertheless, possessing nuclear power programs can make very respectable weapons"*. But the myth of military and civil uses of nuclear fission had already been destroyed as early as 1946(!) by a report from a US committee chaired by Under Secretary of State Dean Acheson. The report stated, *"The development of atomic energy for peaceful purposes and the development of atomic energy for weapons are in much of their course interchangeable and interdependent...."*.

So, promoting the proliferation of nuclear power is promoting the proliferation of nuclear technology suitable for the development of nuclear weapons.

Safeguards
Safeguarding is the control system used by the IAEA to prevent 'peaceful' nuclear technology or material from being converted into a 'military' nuclear program. There are several ways the Agency has of doing this. They involve a combination of on-site inspections, materials accounting, and containment and surveillance. But none of these methods can ensure a 100% division between the two applications of the same technology. There are reasons for this.

The lack of money, for instance, and the enormous, and growing, numbers of material and facilities which have to be monitored (see box). In a speech, Director General Blix warned about the constant pressure from member states to cut the costs of safeguards. The annual costs come to approximately US$60 million. The Safeguards Department has a staff of some 500 people, of whom approximately

200 are inspectors. Those people have to inspect and control more than 900 declared nuclear facilities in more than 50 countries.

> The volume of nuclear material under safeguards by the IAEA in January 1994 is over 400% greater than that which was subject to inspections in 1981. At the same time, budget allocations, inspector-days, and staff levels have increased by less than 50%.*1 In other words, in 1985 each safeguard dollar covered 556 SQs (significant quantities) of nuclear material, whereas the same dollar was expected to cover 970 SQs in 1990.*2
> *1 Bruno Pellaud, IAEA Deputy Director-General for Safeguards on 27 Jan. 1994, quoted in *Nucleonics Week*, 3 Febr. 1984; "Pu Seperation by India, Japan to Hike IAEA Safeguards by 20%"
> *2 *Nucleonics Week*, 20 Febr. 1992: "Gulf War Will Shift IAEA Safeguards Priorities - By How Much?"

Material Unaccounted For (MUF)
An important term used in relation to safeguards and diversion of material to a parallel military program is MUF (Material Unaccounted For). MUF is the difference between the actual amount of material in stock (for instance, plutonium) and the amount that should, according to bookkeeping, be present but isn't, due to measurement problems and contamination of equipment. Explaining away missing material by attributing it to MUF is an especially common practice at reprocessing and enrichment facilities. And although a certain percentage of Material Unaccounted For is accepted under safeguards standards, there is absolutely no certainty that this material is not actually missing or is not being used for other purposes. Due to the enormous amounts of plutonium and highly-enriched uranium being handled at any given time, the number of MUFs listed each year comes to enough for tens of nuclear bombs. But besides that, only 28% of the world's plutonium inventory and less than 1% of the world stock of High Enriched Uranium (HEU) is under IAEA safeguards anyway.

Significant Quantities (SQ)
The official IAEA definition of an SQ is *"the approximate quantity of nuclear material in respect of which, taken into account any conversion process involved, the manufacturing of a nuclear explosive device cannot be excluded"*. The SQ for plutonium is set at 8 kg (containing less than 80% Pu-238). These threshold amounts include the material that will unavoidably be lost in manufacturing a nuclear device.
But these amounts should not be confused with the minimum amount actually needed for a nuclear device, which is much smaller, especially in nuclear weapons states using sophisticated techniques. As a result of the IAEA inspections in Iraq after the Gulf War, a discussion surfaced about the reliability of the official threshold amount. In September 1994 the Washington based Natural Resource Defence Committee published an report claiming that roughly 1 kg Pu is enough for a nuclear device. The IAEA, however, is not willing to discuss new definitions of SQ's; significantly lower threshold amounts will make safeguarding much more difficult than it is even today.

In April 1994 another reason for doubting the appropriateness of the definition of SQ was presented in a broadcast by an English Channel Four TV documentary team: the trade in RM20/20, or red mercury. Using this mysterious material in nuclear devices would decrease the necessary amount fissionable material very considerably. And because red mercury is not on the list of strategic materials (it doesn't even exist, according to western government authorities), trade is not forbidden. Experts on proliferation and nuclear weapons warned that if the reports on red mercury are true, it would mean the end of current safeguards. The size of a bomb built with this material would be very small: something like the size of a baseball.

Peaceful Nuclear Explosion (PNE)
When India conducted a nuclear explosion in 1974, it claimed that it was a Peaceful Nuclear Explosion and therefore according to the rules of the NPT, which promises the benefits of such PNEs. South Africa never admitted that they conducted a nuclear test in 1979, but if they had, and said that it was for peaceful purposes, no one could have a valid argument against it. In the 70's the IAEA was very much in favour of these so-called Peaceful Nuclear Explosions and even organised meetings on the subject. But lately no such initiatives were taken by the IAEA.

Using the destructive power of the bomb for 'peaceful' purposes is an old idea (and still valid in some minds -- see Introduction to this chapter). In the 50's Edward Teller developed the Plowshares Program: a program to use nuclear explosions for industrial purposes. In the years 1961-1973 the US conducted 27 explosions for the Plowshares program, mostly in the Nevada desert. Until 1982 the USSR also conducted many PNEs for exploration of gas fields, for changing the flow of rivers, to make artificial lakes, and for fighting oil fires. But there were more countries interested: Egypt and France, for instance. And in the early 70s Thailand developed plans to construct a 100 kilometer long canal from the Indian Ocean to the Gulf of Thailand. The plan called for 139 PNEs, US$3.6 billion, and the evacuation for several years of 200,000 Thai.

Allowing PNEs is one of the most striking examples of the dubious goals of the NPT and the IAEA. How is it possible to make sure that a certain country is producing a nuclear device for peaceful purposes? As long as PNEs are allowed under the NPT, the Treaty is worth nothing at all.

COMPREHENSIVE TEST BAN TREATY

Tests and Treaties
During the development of new weapons systems, testing is very important. The very first nuclear test, the Trinity test at Alamogordo, US on July 16, 1945 showed that. Although all the scientists participating were convinced that the bomb would detonate, it was a relief for them to see that it actually did explode. The number of megatons exploded in the atmosphere between 1945 and 1962 doubled every three years, and in his Atoms for Peace speech, Eisenhower made public that the US had already conducted 42 test explosions.

Since October 1963 there has been a ban on nuclear tests in the atmosphere, space and in water. This is the Limited (or Partial) Test Ban Treaty (officially called the Treaty Banning Nuclear Weapons Tests in the Atmosphere in Outer Space and Under Water). It was signed simultaneously by the UK, the US and the Soviet Union in 1963, and later by more than 120 other nations, although two of the major nuclear weapons states continued atmospheric tests until much later: France until 1974 and China until 1980.

There is also a bilateral agreement between the US and the USSR, signed in 1976, called the Threshold Test Ban Treaty. This Treaty prohibits underground tests of nuclear weapons with a yield of more than 150 kilotons.

CTBT and verification
Since as early as July 1958, experts have claimed that it is possible to verify underground testing and that a total test ban could be, at least technically, implemented.
Even relatively small public groups are nowadays able to monitor nuclear tests around the world. For example, the London-based VERTIC (Verification Technology Information Centre) was able to predict and detect China's October 1993 test and reveal detailed technical data on it within three hours.

How does verification work and why, more than 35 years later, is there still no Comprehensive Test Ban Treaty (CTBT)?

In brief, here is just one of the verification methods: Every underground explosion sets up elastic vibrations that propagate as seismic waves through the earth and along its surface. The waves travel great distances, and commonly used seismic monitoring instruments are sensitive enough to record even those generated by very small explosions. The main task is to distinguish the seismic signals of explosions from those of earthquakes. This can be done through a network of several widely separated seismometers. An underground explosion generates very typical waves through the solid body of the earth; ie, all the seismic waves it generates have a nearly radial symmetry around the focal point of the explosion. In contrast, the highly directional character of an earthquake gives rise to seismic waves with strongly asymmetric patterns. In addition, there are also only two types of seismic waves that propagate over the earth's surface. A simple explosion can generate only one of them, whereas an earthquake generates waves of both types. Depending on the number of seismic stations, only very small nuclear tests, with yields of less than one kiloton each (the 1945 A-bombs had yields of 15 to 20 kilotons) might perhaps go undetected.

The main obstacles to implementing the CTBT are politics and the enormous pressure coming from the military-industrial complex. Tests are, at least for the present, held to be absolutely necessary for the development of new weapons systems. And not accepting the possibilities for verification is a way to continue the tests without directly revealing a desire not to end them.

How did it come about that recently most of the nuclear weapons states (with the exception of China) stopped the testing?

The answer of course has to do with political changes (the ending of the East-West Cold War). But there might be other reasons: the necessity for actual physical testing is decreasing because of new computer simulation technology and technical developments in the design of nuclear weapons. The most significant development is the advent of supercomputers that are capable of numerically simulating many of the processes within a detonating nuclear warhead. In addition, weapons designers can study some of the mechanisms of fusion on a tiny scale in the laboratory by firing intense laser beams at small pellets of hydrogen. Reveiling in this aspect is the fact that after the Chinese N-test in October 1994 the US offered China computer technology to simulate tests.

Further, it's very likely that the extension-conference of the Non Proliferation Treaty in April/May 1995, is also an important factor in this moratorium on testing. Strategically it wouldn't be wise to test so close to the date of the conference in which it will be discussed. Certainly it would not be in the interest of the nuclear weapons states because such a thing could (and certainly would) increase the resistance to extending the NPT.

Figures show that stopping the testing had little to do with cutting costs. Although each recent US test has cost between US$30 and US$60 million, the total budget for 1994 (which didn't include one single test) was US$428 million: US$150 million to 'maintain the infrastructure'; US$125 million to 'maintain the capability to quickly resume testing' and; US$153 million for the 'development of alternatives to testing'. Before the moratorium, the budget for 1994 was expected to be US$460 million.

Conclusion:
It is clear that a CTBT is not the end of the road. Implementation will not automatically mean that no new nuclear weapons can be developed; the relevance of a CTBT decreased in the last decade. But it is also obvious that a CTBT is still an important tool to slow down the production of new systems, and therefore can be an important step towards a nuclear weapons free world.

THE DISMANTLING OF NUCLEAR WEAPONS: HOW TO GET RID OF THEM

"In this world there are only two tragedies.
The first is not getting what one wants, and the other is getting it."
Oscar Wilde

Following the explosion of the first nuclear bombs during World War II the amount of nuclear weapons increased dramatically. The U-nited States and the Soviet Union became the main players in the contest to obtain the most potential for nuclear destruction, each trying to be more destructive than the other. In addition, France, Great Britain, China and a few other countries also started to develop their own bombs.

After 50 years the world has changed. As a result, the rapid buildup in nuclear arms is being reversed; the number of nuclear warheads deployed by the US and the former Soviet Union are to be decreased from 50,000 (19,000 and 30,000 respectively) to 7,000 (3,500 each), according to the optimistic scenario of the Stockholm International Peace Research Institute (SIPRI).

The fear of total destruction, international political pressure on both countries, and the obligation under the Nuclear Non-proliferation Treaty to negotiate for the reduction of warheads resulted in peace talks dating from the 1970s and, eventually, agreements such as the Strategic Arms Reduction Treaty (START) and the Intermediate-range Nuclear Forces (INF) Treaty. The 'perestroika' politics of Michael Gorbachev sped up the process. But while the fear of total destruction in a nuclear war has decreased, problems remain. What is to be done with the weapons grade plutonium, uranium and tritium? Are there any good solutions? What are the dangers involved in dismantling?

Warheads, disarmament and stockpiles
START and the INF Treaty mean a large reduction in Soviet and US nuclear warheads. The precise amount to be dismantled is unclear, but some 40,000 will hopefully be destroyed before 2003. This will create about 140 tons of weapons grade plutonium and 640 tons of weapons grade enriched uranium. Add the existing stocks of military materials (for instance, already dismantled weapons) and the quantities come to around 200 tons of plutonium and 1160 tons of uranium. Several kilograms of tritium will also be removed. France, Britain and China are expected to reduce their nuclear potential as well, but the amount of material they will produce will be much less.

PU AND HEU STOCKS

World stocks of plutonium are growing as a result of the weapons dismantling, but also as result of reprocessing civilian nuclear fuel. These growing amounts are worrying because of proliferation risks and the extreme toxicity of the material. Approximately five kilograms are enough to make an atomic bomb. Even smaller quantities can be used to make a so-called radiation bomb which disperses plutonium in the air with conventional explosives. While highly enriched uranium is less toxic than plutonium, it is also suitable for building bombs; about 25 kilograms is needed. Tritium is not suitable to make a fission bomb, but can be used to trigger the chain reaction. It can be used in a hydrogen fusion bomb as well.

Dismantling problems
The proliferation danger presented by these stocks of weapons grade plutonium and uranium demands constant surveillance. The political and economic instability in the former Soviet states is seen as representing special risks. Even before the end of the Cold War, standards for safeguarding nuclear materials were even lower there than in the US. The US system monitors the amounts of the materials; in every facility and storage place, books are kept with detailed accounts. This way losses can be detected, at least theoretically, as material is often lost as waste during the production

process. The former Soviet system relied on special army forces to protect weapons sites and transports. They did not have a bookkeeping system.

SIPRI is urging the establishment of an international register to be kept by the United Nations. This should clarify the amounts of weapons material, making it easier to safeguard. SIPRI wants the creation of such a register to be placed on the agenda for the 1995 NPT conference. Although this would give more clarity, it is no guaranty against theft or misuse.

According to SIPRI, essential electronics and tritium should be removed and the warheads should be sealed up, put in storage and guarded. To prevent the secret production of new weapons, every production facility should be open to inspections by international observers. The US does not agree with this proposal because of the fear that this would reveal their production methods.

When the warheads and the recovered plutonium and uranium are put into storage, the danger of proliferation becomes a particular problem. Dismantling facilities are unable to process large amounts of warheads into less proliferation sensitive materials, such as waste or reactor fuel, on short notice. Thus, at this stage, bomb material in its pure form can be stolen and sold. Hopefully, though, all the pure metal will have been processed around the year 2000.

HEU: cheap nuclear fuel

The reduction of uranium weapons will result in the release of 640 tons of weapons grade uranium. Already 520 tons, from military stocks and old nuclear weapons, is in storage. After dismantling, a solution must be found for the total 1160 tons. One possibility is to mix it with other radioactive waste and store it so that it is almost inaccessible for the production of weapons. This solution, though, is not being considered by either the US or the CIS because uranium in this form is still suitable for use in civilian nuclear power plants. As a fuel it is economically attractive. In addition, the limited amounts of natural uranium and easy methods for converting weapons grade uranium to reactor fuel are reasons that fuel fabrication is presently preferred over its disposal as waste. The highly enriched uranium (HEU) is not directly usable in reactors, because it has been enriched to 93%. (Uranium used in commercial nuclear reactors is generally only enriched to about 3%.) The fissionable fraction in the uranium must be reduced. This can be done by mixing it with natural uranium or depleted uranium, the residue left over from uranium enrichment and spent fuel reprocessing.

The process of blending the weapons uranium is not free of dangers. The uranium must be transported from weapons storage facilities to chemical facilities where it is converted into uranium hexafluoride gas, after which it must be transported to a mixing facility. After the mixing it must again be transported to facilities which convert the gas to solid uranium fuel. Uranium hexafluoride gas is toxic, and when it comes into contact with water it releases other dangerous gases as well. Transport between the different facilities only increases the dangers of accidents and the risk of theft.

Plutonium: deadly gold

Under the dismantling agreements some 200 tons of plutonium will be released. In the US this will be approximately 80 tons and in the former Soviet Union approximately 100 tons (from, in both cases, warheads as well as the military plutonium already in stock). The main concern is to prevent theft, and each potential method of disposal has its safety risks.

The most ridiculous solution proposed so far is to launch it into the sun with rockets: probably wishful thinking on the part of those scientists who have been proposing rocket launches as a solution for radioactive waste for years. It is expensive and too risky because of its potential for accidents: according to a 1982 NASA study the costs would be US$200,000 per kilogram plutonium.

Another proposal is to mix the plutonium with other radioactive waste and bury it in the ocean seabed, far from land so that it is almost impossible to bring it up again without being detected. Mixing it with other waste makes it almost impossible to recover the plutonium in its pure form. Currently, because of the increasing pollution of the oceans with chemical and radioactive materials, seabed disposal is forbidden by the London Dumping Convention.

Among some officials and scientists in the CIS an idea being considered is to dispose of the plutonium in a large underground nuclear explosion by burying tons of it in deep holes together with a nuclear bomb. After the explosion the plutonium and fission products would mix with molten stone. This could cause contamination of large areas through unexpected accidents such as gas leaks. Plutonium remains radioactive for millions of years and leakage into the ground-water is to be expected.

Another possibility put forward is to burn the plutonium in accelerators or in irradiation reactors. Both are forms of actinide-burning, irradiating long-lived heavy isotopes with neutrons to produce short-lived fission products. However, this technique is only in the development stage and there has been no practical experience with it at all. It involves small plutonium samples that are 'bombed' with neutrons to produce fission products. This method would require a large number of expensive accelerators or irradiation reactors. In any event, residues would remain and the fission products are radioactive. In addition, the machines themselves would become radioactive because of intense neutron irradiation.

The most likely solution to be chosen in the US is to mix the plutonium with other high radioactive waste and melt it into glass, a process called vitrification. The high radiation levels and the glass would make the plutonium almost impossible to recover. The vitrified product must be stored in containers for millions of years because of the very slowly decreasing radioactivity. However, no storage place has yet been found. Deep underground storage is the method which has so far received the most investigation, but it is almost sure that after a certain period the containers will leak radioactivity into their surroundings. Above ground storage requires expensive buildings which must be replaced from time to time, as well as constant protection from fire, accidents or military attacks.

Mixed Oxide Fuel

The last method of disposing of plutonium is, like with the highly enriched uranium, to mix it with natural or depleted uranium to make reactor fuel for civilian nuclear power reactors. However, most reactors need modifications and, of course, licenses to use this type of fuel.

Fabricating this so-called MOX (Mixed Oxide) fuel is proliferation sensitive. It is also dangerous. Because of the extreme chemical toxicity and the high radiation levels involved, a MOX fabrication plant requires a lot of safety measures to protect workers and to prevent its release into the environment. An accident is possible if a critical mass of plutonium is reached. This can happen when enough plutonium to start a nuclear chain reaction accumulates in a small enough space, for instance if residue gathers in a pipe. This would result in the release of high levels of radiation and great heat or fire.

MOX Hanua moves to Tomsk 7

After closing its MOX facility at Hanau (Germany) in December 1990, the Siemens company signed a contract to move parts of its fuel manufacturing facility to Tomsk in Siberia. To this new facility Siemens is transporting 40 tons of production residues containing uranium to be purified and taking back the resulting 70 tons of enriched uranium hexafluoride gas.

With the move, Siemens is able to avoid compliance with European environmental nd safety standards, and actually admits that it cannot meet safety regulations. The

MOX-fuel that will be produced in the Tomsk-7 facility, and the nuclear waste thta results, are being managed according to Russian regulations. Even though the Tomsk facility is not currently producing weapons, it is still listed as a military facility. Thus it is excluded from inspections by the IAEA and relies on 'self-control', which increases proliferation risks. Also increasing these risksis the possibility that a multinational like Siemens could easily obtain nuclear weapons technology while working in a weapons facility.
There are other worries with this facility. In April 1993 a serious accident occured at Tomsk. A tank full of waste exploded and plutonium was released, severely contaminating an area of more than 200 square kilometers.
(*WISE News Communique*, 28 January 1994 and Pressrelease Siemens Boykott, 30 December 1993)

MOX fabrication as a way to get rid of the plutonium is the solution which will take the most time. By using it in reactors, new amounts of plutonium are created from the uranium, thus increasing the dangers of proliferation further. In addition, fabricating large amounts of MOX takes years, and once the fuel is made, it has to be stored because it is not widely used. The plutonium or the fuel can be stolen from either the fabrication facilities or storage. Precise accounting for the amounts of plutonium in a fabrication facility is impossible because of inaccuracies in weighing it in powdered form and because of residues left in the pipes, machines, etc. The theft of small amounts can only be detected through security measures taken against facility personnel.

Further, using MOX does not mean that all the plutonium is burned. After a certain period fission products pollute the fuel, which obstructs the fissioning, thus a certain amount (20-40%) is still present. Also present is newly formed plutonium due to irradiation of the uranium compounds. To recover the plutonium the fuel is re-processed. This increases the amount of waste. Reprocessing plants like Sellafield (UK) are extremely polluting because of large releases of radioactivity into the air and water. Reprocessing also increases the amounts of separated plutonium. This plutonium is processed for new fuel with the same safety and proliferation dangers.

MOX fabrication is also expensive. Even if the plutonium were given free to manufacturers, the price of MOX fuel would be six times higher than conventional enriched uranium fuel because of high production costs due to expensive safety and security measures.

Map DOE's legacy

Tritium

Disposing of tritium is a smaller problem than weapons uranium or plutonium, but not free of dangers. The growing amount worldwide is only 50 to 100 kilograms and its radiation is not as long-lived as in plutonium and uranium. After 12.3 years, half of it has already decayed. Tritium can be stored in pure form or mixed with other waste. Because it is explosive in its pure form, tritium facilities must provide safety measures to ensure that there are no leaks or possible fires.

Another possible use for the tritium is in nuclear fusion energy research. It is economically attractive because tritium on the free market is very expensive: the Canadian Ontario Hydro company asks about 28 million dollars (Canadian) a kilogram. Tritium is not on the US list of strategic materials because it is only useful when a country already possesses a nuclear bomb, therefore it can be sold to any customer. However, tritium can be used to increase the power of existing bombs, reducing the amount of plutonium or uranium required for bomb production, and for the development of the more destructive hydrogen bomb.

United States
In the United States some 15,000 warheads are to be dismantled, resulting in 49 tons of plutonium

and 210 tons of weapons grade uranium. Thirty tons of plutonium and 265 tons of uranium from old nuclear weapons are already in storage. Over the last 5 years, the Department of Energy (DOE) has dismantled some 6000 warheads, so it will take about 10 years to complete the job.

The plutonium warheads are dismantled in the Pantex plant (Amarillo, Texas), a 50-year-old nuclear weapons assembly plant. Plant workers dismantle about 1500 warheads a year and some 35 tons of plutonium are already stored in bunkers. The growing amounts have resulted in protests from local groups; they doubt the safety of the storage bunkers and fear accidents. Tritium levels around Pantex are already many times higher than normal due to the earlier work done on assembling fusion bombs.

There is no solution yet for disposing of the plutonium in the US. Its use in civilian reactors is unlikely because of resistance from electricity utilities and a government principle against the use of plutonium fuel. The government rejected plans for recycling a decade ago on economic and proliferation grounds and is very reluctant to change that decision now because of licensing, safeguards and political problems. However, in June 1994, the Senate voted to continue funding the Advanced Liquid Metal Reactor (ALMR), a breeder reactor that would burn weapons plutonium. Also, the DOE, in cooperation with the Canadian electricity board, Ontario Hydro, and the reactor builder Atomic Energy of Canada (AECL), is preparing a study on the use of plutonium in Canadian reactors.

Because of fears that weapons plutonium could be stolen, the government may prefer to store it in an inaccessible form. A research facility has been built on the Pantex site to search for a solution. It is likely that the plutonium will be mixed with highly radioactive waste in glass. However, no vitrification plant exists yet, although there are plans build seven at Savannah River (South Carolina) and Hanford (Washington State). The first of these is expected to begin processing waste from old weapons facilities in 1996. But it would still be another 15 years after that before the process of mixing in the plutonium could even begin.

Some plutonium will be left in storage because the US reserves the option to refabricate it into new weapons. The government refuses to agree on bilateral verification of dismantlement and material storage. Thus control remains with the military establishment. In April 1994 the US decided to place "considerable quantities" under IAEA safeguards. These "considerable quantities" amount to about seven tons, only 10 percent of the dismantled plutonium.

The uranium weapons, mostly from fusion bombs, are dismantled in Oak Ridge, Tennessee. Here it is diluted with natural uranium to produce civilian uranium fuel. However, in late 1994 Oak Ridge's "Y-12" facility for dismantling nuclear warheads was shut down after safety inspections by the Nuclear Regulatory Commission. The Y-12 is the only facility in the US capable of dismantling nuclear weapons containing HEU. How long it will remain closed, and how it will effect the overall dismantling process in the US is unclear.

Former Soviet Union

In the former Soviet Union some 25,000 warheads are to be dismantled. This is more than in the US, because most of the old weapons in the Soviet Union are stored, whereas in the US they are immediately dismantled after being removed from the missiles. The dismantling will result in 89 tons of plutonium and 430 tons of weapons grade uranium. Twenty-three tons of plutonium and 215 tons of uranium are already stored outside weapons.

The state of Russia is responsible for collecting and dismantling warheads from the former Soviet Union. Kazachstan, Ukraine and Byelo-russia have agreed to ship about 7,500 of the warheads on their territory to Russia in exchange for economic help or fuel for their civilian reactors.

The US Congress has promised Russia US$1.2 billion to help destroy nuclear, chemical and other weapons. Examples of what is needed to aid in the dismantling are storage containers, protective clothing, transport safety equipment and assistance in building a plutonium storage facility. Because of various problems, only a small part of this money (10%) has actually been guaranteed through contracts, at least as of May 1994. Those problems include, for instance, the narrow definition the US gives for the types of programs needed. There is also opposition from the US Department of Defense (DOD), which fears it budget will be cut. After ending the Cold War the DOD is still not eager to spend money on the CIS. But not all the problems lie with the US.

The political mechanisms and institutions left over from the former Soviet Union are not yet ready to accept assistance. Nor is Russia eager to take items like containers and sealing equipment coming from the US because their production does not stimulate its own economy. In addition, Russia wants to use part of the aid for other programs, like building schools, roads, etc.

Smuggling

The breakup of the former Soviet Union has also given rise to other problems. Stories are circulating about stolen warheads being smuggled out of the country. The weak economic situation makes the sale of weapons materials by employees of nuclear facilities attractive.

Many smugglers have already been arrested. In August 1994, German police arrested three men for smuggling 300 grams of plutonium out of Russia after an undercover agent arranged a deal with the smugglers. Following the arrest, the German section of the International Physicians for the Prevention of Nuclear War (IPPNW) accused the police of provoking and stimulating illegal nuclear trade, and several newspapers accused government parties of having staged the incident for publicity during the election campaign. Since then, the German and Russian goverment have come to an agreement to exchange information about illegal nuclear trade.

In 1991 Greenpeace was almost able to obtain a complete nuclear weapon. A Russian army lieutenant at a storage facility near Berlin, disappointed by the politics of Gorbachev, offered Greenpeace a 700 kilo bomb in exchange for 500,000 German Marks and political asylum in the west. Greenpeace agreed to the deal, planning to display it to the press and, afterwards, give it back to Russia. The theft was supposed to take place on September 7, during the changing of the guards at the storage facility. But the deal did not go through because the lieutenant was transferred to another unit after the failed coup against Gorbachev.

Ukraine, warheads and Chernobyl.

The Ukraine is suffering from huge economic debts. In March 1994 Russia reduced its gas supply because of debts of about US$900 million. The republic of Turkmeniya did the same due to a debt of US$700 million. Prior to this, Ukraine president Krawtschuk warned Russia that the delivery of Soviet warheads to Russia, in accordance with a US, Russian and Ukrainian agreement, depends on gas supply from Russia. The delivery has so far progressed very slowly; the warheads have been taken out of the missiles, but a transport carrying 10 warheads leaves the Ukraine only every two weeks. This means that it will take approximately 7 years to transport all 1,766 warheads, although improvements in the railway system could speed it up.

According to the Ukraine, the lack of natural resources makes it dependent on nuclear energy. In exchange for the agreement to ship all its warheads to Russian dismantling facilities, the Ukraine receives low-enriched uranium fuel resulting from the blending of 50 tons of weapons uranium. The amount received corresponds to the amount of uranium in the weapons. In fact, the US-Russian agreement to convert the weapons uranium into civilian fuel makes it possible for the Ukraine to keep its unsafe reactors open, including the two operating Chernobyl reactors.

This dependency on nuclear energy is questioned by Greenpeace and other environmental organizations, both inside and outside the Ukraine. According to Greenpeace, energy saving is a realistic option. The modernization of existing conventional power plants would increase energy production by 6000 MW. Total replacement of all its aging plants with new ones would add another 15,800 MW. Eight percent, or 3000 MW, of the national electricity production is lost through transport. Energy saving measures could also be taken in households to save 40% of the fuel used for heating. All these actions would save enough energy to enable the Ukraine to close all its nuclear power plants.

But what will happen with the Ukraine's nuclear plants will most probably depend on plans made by the countries belonging to the G-7. In May 1994, the G-7 offered the Ukraine an 'economically friendly' loan of US$800 million ($600 million of which will come from the European Union) to complete the three nuclear power plants being built in Khmelnitzky, Zaporozhye and Rovno. Their construction had earlier been halted due to lack of money. The G-7 wants to include the condition that the Chernobyl plant be closed as part of its deal. The Ukraine government won't promise a quick closure of Chernobyl, because the money offered is too little. It looks like Chernobyl has become the subject of blackmail.

Russia

Russia has four dismantling facilities: Arzamas and Penza, south of Gorky, and Sverdlovsk and Zlatoust, in the Urals. Their capacity is 1,500 to 4,500 warheads a year, so dismantling will take six to nine years to complete. The plutonium is being stored to await a solution to the problem of its disposal. The US will assist in building a final storage facility with US$15 million. The facility will probably be located at the reprocessing plant at Chelyabinsk, which also has a small MOX facility. In April 1994 a Minatom (Russian Ministery of Atomic Energy) official appealed for more US aid, another US$1.2 million, to complete the design before 1997. He warned that the present interim storage for plutonium is unsafe and not well controlled or properly guarded. He also said that money is needed for civil programs like building hospitals and making other improvements. Otherwise, he says, the local people will probably not accept the storage facility. Other possibilities for storage sites are to build a large facility at Tomsk-7 or to build a number of smaller storage facilities at a number of different places. The proposal for a facility at Tomsk faces public resistance because of the 1993 accident, while the idea for storing it at a number of different sites has led to protests from the US. One storage facility built with US aid would, according to the CIS-US contract, give the US access to the location. But additional facilities built without the US aid would not be accessible.

Agreements

Russia's ultimate plan is to burn the plutonium in fast reactors. Tests have been conducted in two test reactors, the BR-10 and BFS, and in the power fast reactors BN-350 and BN-600.
Their technical design makes fast reactors suitable for burning plutonium, but their explosive natrium-metal cooling system also makes them unsafe. Two thousand MOX-fuel elements containing 1.2 tons of plutonium fuel have been tested. Existing fast reactors can consume 1 ton a year. A newly designed BN-800 in Sverdlovsk, Beloyarsk can burn 1.6 tons a year, not very much considering the large amount (112 tons) of weapons plutonium that needs to be burned. In addition, a fuel fabrication facility in Chelyabinsk also needs to be completed to make the fuel. Plutonium can also be used in light water reactors, but modifications in the reactor and special security and safety measures must be taken first.

Dismantling and development of new generation reactors

As a result of fewer contracts to sell reatcors due to public resistance, teh nuclear industry is trying to develop new reactors which would be more safe or even 'inherently' safe. To types, a small fast reactor called PRISM and a helium-graphite reactor, are able to use weapons grade plutonium. The companies developing these reactors see a chance to sell a reactor for this purpose.
The US company General Atomic and the Russian Ministry of Atomic Energy

(Minatom) singed am agreement in April 1993 to form a joint venture to build a helium-graphite reactor. The US$1.5 billion reactor would be built in Russia and burn its weapons plutonium. It will take 10 years design and build the reactor General Atomics requires up to US$100 million over five years from the US government. However, it is unclear whether the government will pay because of its policy of discouraging teh use of plutonium in fuel. General Atomics claims the reactor to be inherently safe and that a fuel meltdown and release of radioactivity is not possible. It may be impossible for the plutonium/uranium/-graphite fuel to melt, but th eclaims ignore the risks of burning graphite-fuel, which releases radioactivity, as happened at Chernobyl in 1986 (*Internatioonal Herald Tribune*, 7 April 1993)

On the 18th of February 1993 the US and Russia signed an agreement concerning the sale to the US of approximately 500 metric tons of highly enriched uranium from dismantled soviet warheads. In the Verk-Neyvinsk enrichment plant near Yekaterinburg, the weapons uranium is being blended with natural uranium to produce reactor fuel for civilian nuclear power plants. The capacity of this plant is 10 tons a year, which must be tripled to fullfill the agreements to process all the uranium in 20 years.

The 500 tons of uranium is to be converted into 15,300 tons of reactor fuel. At the time the agreement was being negotiated, it became clear that this would be enough fuel to supply all the nuclear power plants in the world for two and a half years at a low price. This projection led to protests from the enrichment industry. Suffering from the low prices on the uranium market, enrichment companies feared any extra competition.

But it was not only the enrichment industry that was complaining. In 1992 the US Com-merce Department claimed that Russia was competing unfairly by selling uranium to power reactors in the US for below-cost prices. An October 1992 agreement set price-based quotas for Russian uranium exports. With regard to the 500 tons from dismantled warheads, the US resolved the economic issue involved through negotiation. Under the final agreement, the total revenues the US pays to Russia will amount to about $12 billion, after the deduction of the blending costs. This price is somewhat higher than today's spot market prices, but is significantly lower than the price the DOE charges its commercial customers.

The resultant low-enriched uranium will be transported to the harbor at St. Petersburg where it will be shipped to the US from early 1995 on. The uranium will be distributed to commercial customers by the DOE.

Conclusions

The dismantling of 40,000 nuclear weapons and the release of 200 tons of weapons plutonium and 1160 tons of weapons uranium raises the question of whether a safe and secure solution can be found for disposing of these materials. The extreme toxicity of plutonium and proliferation dangers of both materials make a good solution necessary.

The choice to re-use either or both materials in civilian nuclear power plants will be a big stimulus for nuclear energy. This option has already been chosen for uranium in both the US and Russia. The nuclear industry thus obtains quite cheap fuel, even if, as is most likely, the US decides to treat its plutonium as waste. But the different steps for conversion to nuclear fuel involve several facilities with their own distinct dangers involving accident and the risk of theft, as well as increased transport which will mean increasing the dangers even more. And in the case of the plutonium, these dangers will be intensified because of reprocessing, which itself creates more waste, including plutonium (again in its pure form).

The option to treat plutonium and uranium as waste leaves another problem to be faced over millions of years. The radioactivity in both ma-terials is long-lived and they need a safe method of disposal which is under constant surveillance. Escape of the materials and their radioactive daughters into the environment must be prevented. But, as yet, there is no known safe disposal method.

To safeguard the generations to come from the legacy left by weapons production, it would be better to prohibit their possession and order an immediate stop to their production.

SOME PRO-NUCLEAR ARGUMENTS DISMANTLED

General introduction
During the 1950's nuclear energy was generally viewed in a very positive light. Stimulated by international initiatives such as 'Atoms for Peace' there was an atmosphere of widespread enthusiasm. Because use of this revolutionary technology for civil purposes was only in the beginning stages, there was no public awareness of possible consequences.

However, this period was also the beginning of the Cold War and a rapidly growing arms race. When the fallout from the nuclear test explosions which were a part of this arms race were shown to cause cancer, anxiety began to grow. A decline in loyalty to authority, accompanied by an awakening civilian population and the rise in social movements at the end of the 60's, led to a reversal; the early euphoria had, by the 1970's, turned to resistance. Ques-tions that came to public attention were, for instance, questions about the safety of nuclear power plants, what to do with radioactive waste, how to stop proliferation, and what to do about the threats posed by the growth of the atomic state.

These questions are still relevant. And another question which also needs to be discussed has surfaced, namely: Can nuclear energy be important in lowering CO2 emissions in order to minimize the so-called greenhouse effect? The claim that it can is the nuclear industry's latest 'argument' in support of nuclear energy, the one it hopes will help it regain a prominent place in the world market.

INHERENTLY SAFE REACTORS

The current generation of nuclear reactors is unsafe. Too many accidents and the large risks involved have brought the nuclear industry to its latest idea, which is to develop reactors in which the chances of a dangerous nuclear meltdown are impossible, or, as the industry calls them, reactors which are 'inherently safe'.
The term 'inherently safe' is being used in the hope of winning public opinion over to the industry's point of view. The term is, however, misleading. A safe reactor doesn't exist, nor will it ever.

Meltdown
The problems of waste, transport, reprocessing, accidents and proliferation will not be solved by new reactors. So far as safety is concerned, it should not be forgotten that flaws in design and construction in the current power stations still exist, despite several reports. Nevertheless, authorities, with risk studies in their hands, still assure us that safety is no problem.

The biggest danger with a nuclear reactor lies in the fuel core. In this core is a huge amount of uranium, plutonium and highly fissionable radioactive waste. Most reactors use water to cool the core. When the level of the cooling water drops and the core is (partly) uncovered, the core's temperature rises sharply. When that happens, a chemical reaction may occur between the fuel cladding (the metal or ceramic casing covering for the fuel) and the water, causing the formation of explosive hydrogen. If the core is left uncovered for a long period of time, there is a chance of the worst possible accident occurring: a nuclear meltdown accompanied by the release of radioactivity.

To prevent a loss of coolant, there are several emergency cooling systems. These systems pump water into the core when the normal cooling system doesn't function anymore, due to, for instance, a leak. It is conceivable that these emergency systems can also fail.

At a conference in December 1986, James Asseltine, a member of the US commission on nuclear policy (the Nuclear Regulatory Commission, or NRC), said: *"There is a 10 to 50 percent chance of a core meltdown at one of the 100 plants now in operation in the US over the next 20 years."* The containment design for the first generation of boiling water reactors (BWRs), he continued, *"is thought by our staff to have a high likelihood of failure during a core meltdown accident."*

The same can be said about the West Euro-pean nuclear power plants. Those in East Europe carry even greater risks. According to independent safety analysts from the Öko-Institut in Darmstadt (FRG), many of the important safety characteristics required under present western safety standards are lacking in most of those reactors.

In the history of nuclear development several accidents have led to meltdowns. On March 29, 1979 a cooling pump at Harrisburg, US (Three Mile Island) failed. The emergency systems went into operation, but badly functioning valves were unable to prevent the core from becoming drained. As a result, the core began to melt and radioactivity was released into the environment. The disaster would have been even worse if the hydrogen gas which formed in the reactor had exploded.

Anxiety about nuclear accidents has led to a very low public acceptance of nuclear energy. As a consequence, there are moratoria on building more nuclear power plants in many West Euro-pean countries. Particularly since the tragic ac-cident at Chernobyl (April 1986), most nuclear states have stopped their nuclear energy programs. In the US this trend had already taken hold following the accident at Harrisburg. It is worth mentioning that this was not the only reason. The high costs of US nuclear power plants and the expensive electricity they generate were also factors.

New developments
Not one new nuclear plant has been ordered in the US since the disaster at Harrisburg. The risks are too great. Since that time sales have also dropped in the rest of the world. The big reactor builders are in a deep crisis. This crisis is what has led to the idea of developing a new generation of reactors which would be safer.

Reactor builders expect to enlarge their markets again. The development of the current generation of reactors was characterized by frequent modifications to meet new safety requirements as safety standards changed. Safety systems were developed that back up systems that were already present. In this way, reactors have become too complex, too sensitive, making them susceptible to disturbances and human failure during operation. So the industry comes up with this new plan, to design the inherently safe re-actor.

At the end of the 1980's the nuclear industry started with the design of the second generation reactors. The supposition is that this second generation will be safer than the current first generation, but not yet inherently safe.

The second generation reactors possess large reactor vessels, which, according to the designers, can contain sufficient water for cooling in case of problems. This provides more time before the core melts and before measures, such as evacuation, need to be taken. Passive cooling systems (warm water rises, cold water descends) have been incorporated into the design to take care of continuous heat transfer. The emergency coolant is forced by gravity in the direction of the core. This action is independent of pumps.

General Electric (GE), Hitachi, Toshiba, Westinghouse, Asea Brown Boveri (ABB) and Rolls Royce are working on this second generation, while the Canadian AECL is working on an improved version of its Candu reactor. The second generation is supposed to be on the market by the end of the '90s.

Classification of reactors in stages of development
In the past forty years many types of nuclear power plants have been developed. Most of the worldwide reactor capacity is based on Light Water Reactors (LWRs), in which water is the moderator as well as the cooling fluid. At the end of October 1993, more than 85% of the installed capacity were LWRs (302 out of 354 GWe). Other types of reactors are, for example, the CANDU (Canadian-Deuterium-Uranium) reactors and the water cooled graphite reactors (RBMKs), a

Russian design. In the course of the development of reactor technology a number of classes of reactors, called 'generations', can be distinguished.

The most usual classification of the different stages is as follows:
Generation 0: The first series of LWRs, built in the period 1956-1970.
Generation 1: The current operational power stations, mostly LWRs with relatively huge capacities.
Generation 1+: Advanced LWRs (ALWRs) (1993). Optimalization of the current reactor designs with restricted 'evolutionary' improvements, developed for the short term. They are based on 'proven' technology. The capacities are in the range of 900-1500 MWe.
examples: ABWR (GE); APWR (Westinghouse); BWR-90 (ABB); N4 (Framatome); Konvoi (Siemens/KWU); CANDU-6 (AECL)
Generation 2: Evolutionary reactor designs; Passive ALWRs (1995). These reactors are also based on the experience of conventional technology. The reactor design, however, is thoroughly revised, and mostly simplified. Safety depends partly on passive systems, and capacities are lower (300-600 MWe).
examples: AP-600 (Westinghouse); Simplified BWR (GE); CANDU-3 (AECL).
Generation 3: Revolutionary reactor designs (2010). These reactors are based on essentially new principles with the aim of providing greatly improved safety. Capacity is low (80-600 MWe). Safety depends mainly on passive systems.
examples: PIUS (ABB); HTR-M, Siemens/ABB; MHTGR (HTR Siemens/GA); PRISM (GE).

Uncertainty and propaganda
Besides designing a second generation, there are additional plans being developed for inherently safe reactors, which, as with the second generation designs, currently only exist on paper.
* Asea Atom (Sweden) has plans for the PIUS, a water cooled reactor in an enormous vessel with water. If problems arise, water enters the reactor core to cool it down.
* GE is working on the small sodium-cooled breeder reactor, PRISM, based on a large sodium reservoir and passive cooling.
* Finally, General Atomics (daughter company of GE) as well as ABB and Siemens are working on the high temperature reactor, a small reactor with helium gas cooling and uranium fuel in graphite spheres.

These reactors will be available only long after the turn of the century. These developments are not making any progress. These kinds of revolutionary designs entail a lot of uncertainty and financial risks; few companies have wanted to put money into them. The ex-chairman of the NRC was charged by the US Congress to do research into the new reactors. In August 1992 he pleaded with Congress not to put money in either the PIUS design or the high temperature reactor. Thus, establishing a joint venture to develop the PIUS was unsuccessful. In addition, US president Clinton stopped the subsidy for the PRISM because he thinks that too much money is put into nuclear energy and too little into alternatives. And ABB's and Siemens' high temperature reactor never took off because of a lack of market prospects.

The IAEA has distanced itself from the term inherently safe. According to the international nuclear energy agency, no reactor exists that can exclude the possibility of an accident. A failure in the inherently safe reactor can ultimately end in a disaster, however small this chance may be. So the IAEA has insisted that the misleading term inherently safe be replaced by 'third generation' reactors. But for the purposes of propaganda, the industry continues to use the term.
In fact, the risk of a hydrogen explosion does exist in second and third generation water reactors. The possibility that the water could boil off, exposing the core, cannot be excluded. According to former member of the IAEA Skjöldebrand, there is a risk of an increase in capacity with the sudden supply of cold emergency coolant. A nuclear meltdown could be the result.

The Candu reactor has a principle design flaw which causes the fissioning in the core to rise when the water level drops.

In the small PRISM reactors, explosive sodium is used. The fact that sodium is unsuitable appears obvious when looking at the problems in the French Superphenix breeder reactor, which, for safety reasons, was closed down for a period of four years. When it was finally reopened in August 1994, it was restarted at only 3% of its capacity. And shortly after it was shut down again, because of steam escaping from one of its four generators.

A prototype of the high temperature reactor in the German town Hamm has been closed down forever because of a helium leak and economic problems.

The fuel in a high temperature reactor is not supposed to melt at the highest attainable temperature, but there is the question of whether the reactor vessel can bear the heat. Also, because graphite is mixed with uranium fuel, there is a big risk of a graphite fire occurring. When a fire occurs in the core, the radioactive elements are very quickly released. The fire in the graphite reactor at Chernobyl showed what consequen-ces this can have.

Although chances of them happening are not very big, dangers from outside the station also exist: the possibilities of airplane crashes, explosions in neighboring industrial complexes, sabotage and threats of war. There is also the problem that, during normal functioning, radioactive elements are emitted continuously into the environment.

Another aspect is the high price of the electricity produced by the new generations. The US Council for Energy Awareness, a public relations organization for the nuclear industry, calculated that electricity from the second generation of reactors is 21 percent more expensive than that of the current generation.

Proliferation
The spread of PRISM and Candu technology also contributes to the proliferation of nuclear weapons. Both types are capable of being used in the production of nuclear weapons grade plutonium. It isn't astonishing that the Candu and breeder reactor are very beloved in countries that (want to) develop nuclear weapons, such as Pakistan and India.

NUCLEAR WASTE

Nuclear energy produces nuclear waste. It is often claimed that this waste can be controlled because of its small volume. But of course the problems lie not only in the amount produced, rather it is a question of the radioactivity.
Although the nuclear industry has already been dealing with the production of nuclear waste for fifty years, not a single country in the world has succeeded in disposing of it in a safe and permanent way. In 1990 the total volume of spent (used) fuel in nuclear power plants exceeded 80,000 metric tons. That is twice as much as in 1985 and twenty times as much as in 1970.

This radioactive material, which retains its deadly impact for thousands of years, is accumulating in the temporary waste stores in the 26 countries that have produced it. By the year 2000 the volume worldwide could well surpass 190,000 metric tons, predicts Nicholas Lenssen of the Worldwatch Institute in Washington, DC.

Nuclear waste is released at every step of the nuclear fuel cycle. The problems at the stages of uranium mining and enrichment are examined in the chapter on uranium. The waste from nuclear power stations and reprocessing plants will be considered in the fact-sheets on the different countries, as will geological burial. Of course the resistance against all this will be handled there too.

Transport of nuclear waste
Radionuclides are transported every day in huge amounts across the whole world, by road, by air and by sea. The transports include everything from depleted uranium to plutonium, as in last year's shipment from France to Japan. Solid uranium is converted into gaseous uranium hexafluoride (UF6) to make it suitable for enrichment. That is the reason why so much UF6 is transported to and from enrichment facilities.

The French ship Mont Louis that sunk on August 25, 1984 is probably the most well known accident involving the transport of radioactive material. The Mont Louis, a cargo boat, collided with the German ferry boat, Olau Brittania, which travelled regularly between Vlissingen (NL) and Sheerness (GB). Thirty containers holding 450 metric tons of highly toxic, radioactive and reactive uranium hexafluoride sank to the bottom of the North Sea, ten miles off the coast of Oostende (Belgium). Afterwards, the authorities revealed that three of the containers held enriched uranium. On 4 October 1984 the last barrel was retrieved.

On contact with air, uranium hexafluoride, whether in a solid, liquid, or gaseous form, quickly forms a highly toxic cloud made up in part of hydrofluoric acid (HF). The hazards of UF6 are chemical as well as radiological.

Radioactive waste and actinides research
Every element (atom) consists of an atomic nucleus and a cloud of electrons with almost no mass. The negatively charged electrons move in orbits around the nucleus, like planets around the sun. The nucleus consists of two kinds of mass particles, namely the non-charged neutrons and the positively charged protons, with the same number as the number of electrons.

In the case of radionuclides (radioactive elements), the composition of the numbers of these particles will change during the natural process of radioactive decay or technically generated nuclear fission. Radiation is released and one or more element(s) is (are) formed.

During nuclear fission a neutron hits an atomic nucleus which, because of being hit, can be split in two. In a nuclear plant, the energy which is released in the form of heat as this process takes place within the reactor core is converted into steam. The split nucleus lets loose neutrons that fly off, hitting other nuclei, splitting them, and so on and so on. This is the (controlled) chain reaction. The splitting process is called fission, and the two parts coming from the fission process (called the fission products), are nuclear waste. Mostly different in size and mass, they each form an isotope.

One of the problems of the fission process is that not every atomic nucleus is split. Instead of breaking the nucleus apart, the neutron stays pasted on to it. In this manner uranium-326 can be formed from uranium-235, which means that a new isotope with a half-life of 23 million years comes into existence. In the same way, uranium-239 can be formed from uranium-238. Uranium-239 then decays after a few days into plutonium-239 with a half-life of 24,400 years. These isotopes are the so-called actinides, isotopes that are heavier than uranium, which include the elements with atomic numbers 90 to 104. (These are also often referred to as transuranic elements, although the actinides include two elements more than the transuranic elements, which go from atomic number 92 to 104.)

It is the actinides in particular which make the waste highly radioactive. But there is also an additional problem with the formation of other fission products which also have long half-lives; Technetium-99, for instance, which is not a true actinide but which nevertheless has a long half-life (200,000 years).
From the beginning, when nuclear technology first began to be used, the problem of waste was systematically pushed aside. The problem has remained unsolvable.

Since the 1970's the burning of actinides and other methods involving the transmutation of long-lived fission products have come into the center of international interest. Research is being done in the hope of finding ways to shorten the radioactive decay periods of the actinides and other long-lived fissionable products. Burning the actinides means that these radioactive elements are exposed to fast neutrons, for example in high flux reactors. In contrast to the moderated (controlled) neutrons in normal light water reactors, the half-life of the fission products created by being exposed to fast neutrons will be much shorter. In practice, however, it takes time for all the long-lived radionuclides to be converted into short-lived radionuclides. New actinides are constantly being created in the nuclear power stations, thus the rate at which the actinides are burned must be faster than the speed with which the new actinides are formed. Additionally, it must be said that reprocessing takes a lot of energy. As more energy is used, the net yield of the reactor decreases. The speed of burnup is a problem, especially in light water reactors. In these reactors, the burning up and formation of actinides are kept almost in equilibrium: there are as many new long-lived isotopes formed as there are fissioned.

The Belgian nuclear researcher Baetslé made the following calculation for the sodium-cooled burner station (ie, breeder reactor). After eight cycles, 96% of the actinides are fissioned. Each of these cycles involves irradiation of fuel elements in a nuclear power plant, as well as their reprocessing and manufacture. This whole process (all eight cycles) is supposed to take place over a period of 20 to 25 years. This should mean that each cycle takes three years to complete.

Considering current experience, however, it is more realistic to suppose that each cycle takes at least five to seven years before even getting to the stage where reprocessing can begin. The reprocessing itself and the manufacturing of the fuel elements take a minimum of one to three years. When an additional three years is added (the time it takes before a fuel element is placed in the reactor core), the number of years it takes to complete eight cycles is actually 72 to 104 years! This is the amount of time it would take for 96 percent of the number of actinides formed in the space of just one year to be fissioned.

A lot of theoretical research has been done into burning actinides and other ways of transmutation, especially in France. In 1975, how-ever, the Economic and Social Committee of the European Union could not see "any technical and economic benefit in this".

Today, twenty years later, research in this field has started up again in various laboratories in the US, Japan and Europe, although many still doubt its feasibility. The NEA, the office for nuclear energy of the economical organization OECD (Organization for Economical Co-operation and Development), has taken over the co-ordination of research that was originally being done by Japan, called OMEGA (=Options for Making Extra Gains for Actinides and Fission Products). The European study is being done by researchers from France, Germany, Italy and the Netherlands.

Besides the burning of actinides, the nuclear industry is promoting fast breeder and thermal power reactors as the ideal recyclers for plutonium or other actinides/transuranic elements. Apparently they still hope for a future for the fast breeder reactor. The average velocity of the neutrons in the fast breeder reactor is much higher than in a normal reactor. By using plutonium-239 in a fast breeder as fuel, more neutrons become available for the 'breeding' of more fuel by transmutation of the difficult fissionable uranium-238 into plutonium-239. Because of this increase in net yield, the breeder reactor can provide itself with its own fuel ('recycling').

The French fast breeder reactor Superphenix, was in fact functioning as a fissioner of plutonium, such as explained above. Its restart is proving so costly (US$112-130 million a year) that its foreign investors are having serious doubts about continuing their participation.

Another 'actinides recycling' process is the use of Mixed Oxide (MOX), plutonium mixed with uranium, in thermal power reactors. For its production, uranium and plutonium are withdrawn from

the spent fuel. That happens in several large reprocessing plants.
The burning up (fissioning) of actinides is possible in thermal as well as in fast breeder reactors. In both cases there is an as high as possible flux (density) of neutrons desired.

NUKES AND THE GREENHOUSE EFFECT

Nuclear energy is frequently connected with the so-called greenhouse effect; ie, the use of nuclear power in place of fossil fuels is said to make a positive contribution in decreasing the greenhouse effect. However, this claim doesn't nearly come up to expectations.
The expected warming up of the earth as a result of the greenhouse effect is one of the most important environmental problems we have to deal with. It is essential that this threat be stopped. Nuclear energy is proposed as one of the ways in which this warming trend can be stopped. Nuclear power plants, so it is claimed by the nuclear lobby, don't contribute to the development of the greenhouse effect.

Before analyzing the truth of this statement, it is important to take a quick look at the causes and consequences of the greenhouse effect.

The earth, a greenhouse
The principle is simple: around the earth lies a layer (the atmosphere) which is composed in such a manner that it allows the transmission of precisely enough heat (sun) towards and from the earth. The proportions of all the substances making up the atmosphere are very carefully balanced. When there are naturally no greenhouse gases present, the moderate temperature on earth should be more than 30 degrees centigrade lower than it is at present.

Over the last hundred years, however, the equilibrium among all these different substances has been drastically disturbed. Enormous amounts of unnatural greenhouse gases are emitted. Due to the accumulation of a number of these gases in the atmosphere, a layer has come into existence which lies around the earth like a 'blanket'. The result is that the heat of the sun indeed reaches the surface of the earth, but is not reflected sufficiently.

The substances which are responsible for the greenhouse effect have come almost completely into being through human activity: traffic, de-forestation, energy production, agriculture and industry. The amount of gases which humanity has emitted in the last hundred years has multiplied above the amount which the natural ecosystem is able to cope with.

The most important of the emitted gases is carbon dioxide (CO_2). This gas is responsible for about one half of the greenhouse effect. Concentrations of CO_2 in the atmosphere increased by approximately 9% between 1958 and 1984, largely as a result of growing fossil fuel consumption. Other culprits are chlorofluorocarbons (CFC's, the same compound responsible for the hole in the ozone layer), nitrous oxide, methane (agriculture) and ozone (in the lower atmosphere).

The results are predictable
How exactly the rise in temperature is developing and what exactly its results will be are still being discussed in scientific circles. In any case, it is evident that a rise in temperature is taking place due to environmental pollution and that the results will be disastrous:
* The sea level could rise a minimum of 24 cm and maximum of 70 cm by the year 2030. This would have extreme consequences for the millions of peoples who are living in areas below sea level such as river delta's, atolls in the Pacific and countries like Bangladesh.
* Strong changes in weather conditions, different for each place on our globe. Shifts in climates with huge dryness in area's which are presently fertile. The further melting of the polar caps, more destructive storms and floods.
* Further and faster die out of plant and animal species due to fast changes in vegetation and weather conditions.

So, it is important to prevent further warming up of the earth. The risks which we take in waiting for more evidence are too big. Besides this, there is something that can be done about it, because human activity, which caused the disturbance of the atmosphere, is at stake. But it is not simple. It requires big efforts and political courage.

CO2 emission factor of nuclear energy
While a nuclear power station doesn't itself emit greenhouse gases, carbon dioxide is nevertheless produced during the many stages in the nuclear chain which precedes the actual electricity production.A lot of energy involving CO2 emission is used especially during the stages of uranium mining and enrichment. The emission factors involved in the different energy fuels are as follows:

Coal	924 grams CO2
Gas	448 grams CO2
Uranium(*)	62/230 grams CO2

(per kWh generated electricity)
* The factor 62 is based on the 'richness' of the uranium ore being currently mined. With a large increase in nuclear energy produced using uranium ore of a much lower quality, the emission factor will rise to 230 grams

Nuclear energy and CO2
Carbon dioxide is responsible for one half of the greenhouse effect, so it isn't surprising that policy-makers are looking especially at the possibilities to limit the production of CO2. Carbon dioxide is liberated by the burning of cut wood (deforestation), but especially by the generation of energy. Two thirds of the total CO2 emissions are caused by the burning of fossil fuels like oil, coal and gas. Only a small part of these fuels are used in the generation of electricity. Most are used in cars and planes, the warming of houses and, for example, cooking.
Suppose that new nuclear power stations were built to provide for increased demands for electricity. This would give the possibility for eventually replacing the coal and gas-fired stations by nuclear power.
Nuclear power makes a contribution of 18% to global electricity use, which is 4.5% of global energy use. If nuclear power did not exist, the expulsion of CO2 emissions would be only about 7% higher. This can be shown by using the above figures, which make it possible to calculate what the maximum contribution of nuclear energy can be towards the reduction of greenhouse emissions, especially CO2. The maximum share of nuclear energy in curbing today's emissions is: 1/2 (the contribution of CO2 to the total greenhouse effect) x 2/3 (the amount of CO2 which comes from fossil fuels) x 1/5 (the amount of these fuels used for electricity generation) so: 1/2 x 2/3 x 1/5 = 2/30 = 7%.

This maximum contribution to lowering CO2 emissions can only be reached if all the electricity in the world were to be generated by nuclear power. To judge the possible contribution on a worldwide level we need to look at the data and projections for the total energy use. For this we will use the IAEA's calculations (*'Energy, Electricity and Nuclear Power Estimates for the Period up to 2005'*, July 1988). The IAEA takes the view that energy consumption will grow in the coming years. It has calculated what kind of results a wholesale building program for nuclear power stations would have for CO2-emissions worldwide.
As said before, only a small fraction of the total needed amount of energy is electricity. Nuclear energy's contribution to electricity production is, at the present time, approximately 18%. If, by the year 2005, that contribution were to be increased to 70% (its level in France today), the use of fossil fuels would still have increased to amounts above today's use as well, as would the emissions of CO2. This is due to the expected growth in total energy use.

Every little percent is a percent
When nuclear energy is used to provide only part of the electricity demand, the growth of the

greenhouse gas CO_2 will be even higher. If nuclear power were to replace the other fuels presently being used to provide electricity, then, theoretically, it should be able to contribute to a lessening of CO_2. However, this option is, from a technical point of view, totally impossible.
To bring worldwide production up to 70% by 2005, 110 new nuclear power stations with an average power production of 1000 MW would have to be built every year. A comparison: at this moment worldwide there are about 420 nuclear power stations in operation. During the last ten years, there have been only three stations per year built by the whole industry.

The current building capacity of the nuclear industry as a whole was estimated (in 1993) at 18 power stations. This is not per year; if all builders were to start working today on a joint program for building these 18 power stations, they would be take more than six years to finish. Then, the construction of the next 18 stations could be begun. Of course the capacity could be enlarged; at a cost of tens of billions of dollars and taking even more time. The building of a nuclear power station involves work of a very specialized nature, and it is work in which very few people are trained at this moment in time. The training of new personnel would take years. And there is yet another problem; given the amounts of uranium that would be needed to fuel a 70% production rate, the uranium stock (even that of a much lower quality) would be entirely exhausted by the year 2016.

In summary: nuclear energy produces less CO_2; the benefit is, however, marginal. Even a large increase in its production would be of no help and would, moreover, be impossible to realize. In addition, the fuel for nuclear power stations (uranium) is finite and would be exhausted faster than any fossil fuel.
The use of nuclear energy results not only in harmful CO_2 emissions. Other emissions which are the exclusive byproduct of nuclear energy also influence the climate. One example is Krypton-85, a gaseous radionuclide that enters the atmosphere through the chimney of a reactor and is released especially by reprocessing plants. Krypton-85 emissions cannot be caught and they accumulate in the atmosphere because the element is long-lived. As it is not found naturally in the atmosphere, the chemical processes that determine the climate are disturbed by its presence.

Zero emissions
A number of scientific studies have shown that nuclear energy is a very expensive way of producing less CO_2. Surveys have been done on how money can be spent most effectively.
The most effective way to save costs is to save energy. The US Rocky Mountain Institute calculated that an investment in energy saving per dollar yields seven times more CO_2 reduction than an investment in nuclear energy.
Electricity from solar and wind energy is 25% cheaper than nuclear energy. Moreover, these two energy bearers have a CO_2-emission factor which is almost equal to zero.

THE NUCLEAR CHAIN

When we talk about atomic energy we generally think about the nuclear power plant where the electricity is produced. This is only a small part of the whole nuclear chain. It all begins with uranium exploration, mining and milling.

Exploration, mining and milling:
Uranium is a dark grey metallic element that was discovered in 1789. It is also the heaviest metal found in nature. Uranium ore is found in Canada, Namibia, South Africa, Australia and in lesser amounts in other countries. It is a raw material and only a fraction can be used (1 kg of uranium in 1,000kg ore, of which half can actually be extracted from the ore: 6 500grms in 1,000kg ore). Much exploration takes place on indigenous lands, where open boreholes are often left unplugged to cause damage after the exploration is finished.

Once it has been mined, the ore is crushed, ground and then leached to dissolve the uranium. The uranium is separated out and precipi-tated as a concentrate containing 90% or more uranium oxides. This granular concentrate is also known as yellowcake. In itself it is only mildly radioactive. In fact most of the radioactivity in the original ore is found in the tailings (these are the particles left over after extraction) and the waste streams.

Enrichment:
Uranium in its natural form cannot be used in weapons or in most reactors.
There are mainly two kinds of uranium in the ore.
* fissile (U-235)
* non-fissile (U-238)

Only the uranium-235, making up 0.7% of the natural uranium, is fissile. In order to produce a sustained chain reaction, the proportion of uranium-235 must be increased. This process is called 'enrichment'. It requires the conversion of the solid materials to a gas called uranium hexa-fluoride (UF-6). Nuclear waste is also produced in large amounts during this process. Highly enriched uranium (up to 20%) can be used for the production of atomic bombs.
Once it is enriched, the uranium hexafluoride proceeds on its way to the fuel fabrication plant.

Fuel fabrication:
The uranium hexafluoride is returned to a solid form. Then, before going to the nuclear plant, the enriched uranium is squeezed into tablets which are put into long metal pipes, the fuel rods. A bundling of these rods forms the fuel for the atomic plant.

The nuclear power plant:
In the nuclear power plant the uranium-235 is fissioned. A lot of energy is freed through heat and radiation. By means of a turbine and a dynamo generator electricity is produced. As with all fuels, in time the fissile component of the fuel assemblies becomes exhausted. Hence, it is necessary to periodically replace the uranium fuel.
And now begins what has become known as the back end of the fuel chain - waste management, storage, disposal, dismantling and, in some cases, reprocessing.

The storage of the fuel rods:
After their use as fuel, the rods are so intensely hot that they have to remain at least a year in a cooling basin before they can be transported. They are also extremely radioactive.
At this point the rods are considered as waste and stored or transported to a reprocessing plant.

The reprocessing plant:
Non-fissiled uranium-235 is still in the spent (used) rods, along with plutonium which has been created as a result of the rods' use in the nuclear power plant. In the reprocessing plant the rods are chopped into pieces and dissolved in chemicals. This allows as much of the uranium and plutonium

as possible to be separated from the other (radioactive) materials. At the same time, a huge amount of radioactive waste is produced. The uranium goes back to the enrichment plant where it is made suitable again for use in a nuclear power plant. The plutonium can be used for nuclear bombs. There are only a few reprocessing plants and they are all regularly confronted with technical problems and accidents.

The breeder reactor:
Uranium-238 is the biggest non-fissable part of uranium. But it can be converted into plutonium. This process, called breeding, is done in a breeder reactor. Plutonium is fissable. When it is fissioned in the breeder reactor the freed neutrons can be used to convert the uranium-238 into plutonium. As in the nuclear plant, the heat produced by the fision is used to generate electricity. The purpose of the breeder reactor is to produce more plutonium than initially was put into it. Because of the limited uranium stocks, the nuclear industry feels forced to build breeder reactors. But the past and the present have demonstrated that the breeding technology is difficult to control as well as extremely dangerous because the nucleus can melt and explode. In other words, the breeding technology doesn't work.

Dismantling:
The process of cleaning up a retired nuclear plant is an essential step in the use of nuclear power. The most common nuclear power plants were constructed to last twenty to thirty years. This means that a large munber of reactors have now reached their retirement, if they have not already been shut down due to other problems. One of the main reasons to shut down a reactor is the embrittlement of the reactor vessel.
The high levels of radiation present in shutdown reactors makes the dismantling procedure complex and very costly.

Waste storage:
No country has yet found a final solution for the safe storage of nuclear waste.

GLOSSARY OF NUCLEAR TERMS

AEC: The Atomic Energy Commission is the predecessor to the US Nuclear Regulatory Commission.

CERN: Conseil Européen pour la Recherche Nucléaire. This European Laboratory for Particle Physics was established in 1952 and is based in Geneva.

CTBT: Comprehensive Test Ban Treaty.

DEPLETED URANIUM: Uranium with less U-235 than in the ore. It is a product of the enrichment process.

DOD: US Department of Defense.

DOE: US Department of Energy.

EBRD: The European Bank for Reconstruction and Development was established in 1988 in order to support the economic development of the East-European countries.

ENEA: European Nuclear Energy Agency. The agency was established in December 1957. In 1972 the name was changed into Nuclear Energy Agency, when Japan became a member. The aim is to promote the development and the peaceful use of nuclear energy by cooperation of the member states.

EURATOM: The European Community for Atomic Energy, Euratom, was established in March 1957 as one of the exponents of the European idea of cooperation. It actually entered into force on the first of January 1958. Its purpose was to develop a European nuclear industry. The Commission is the juridical owner of the fissile material in the member states. And so, Euratom is responsible for the safeguard inspections and can send inspectors to control the nuclear material of the member states. Four laboratories were built in the 60's to carry out nuclear research for a planned, but never achieved, joint nuclear industry for the European Community. These laboratories, part of the Community's Joint Research Centre, are at Ispra in Italy, which also has a tritium laboratory; Belgium, with two particle accelerators and one electron linear accelerator at the Central Bureau for Nuclear Measurements in Geel; Petten in the Netherlands, with a high-flux reactor, and; Karlsruhe in Germany where the Institute of Transuranium is established.

G-7: The seven richest industrialized countries: USA, Canada, Japan, France, Great Britain, Italy, Germany.

HEU: Highly Enriched Uranium. Uranium enriched to 20% or more U-235 is considered highly enriched.

IAEA: International Atomic Energy Agency.

IPPNW: The International Physicians for the Prevention of Nuclear War is a federation of physicians' groups in 80 countries committed to the abolition of nuclear weapons.

ISOTOPES: Elements with the same number of protons, but with a different number of neutrons. Physically they have almost the same behavior, except their total mass is different. More than a hundred different isotopes can be formed. Most of them have a short life. They decay quickly to other, mostly stable, isotopes.

LONDON DUMPING CONVENTION: Nowadays called the London Convention 1972. The deliberate dumping of wastes at sea is regulated worldwide by the Convention on the Prevention of

Marine Pollution by Dumping of Wastes and Other Matter since 1972. In November 1993 the Convention banned the sea dumping of low-level radioactive waste.

MINATOM: Russian Ministery of Atomic Energy.

MOX FUEL: Mixed Oxide fuel. This is a mix of plutonium with natural or depleted uranium to make reactor fuel.

MUF: Material Unaccounted For. It is the difference between the actual amount of material in stock and the amount that should be present, but isn't, due to measurement problems and contamination of equipment.

NNWS: Non-Nuclear Weapon States.

NPT: The Treaty on the Non-proliferation of Nuclear Weapons came into force in 1970. Goals were to prevent the further proliferation of nuclear weapons, while encouraging development of peaceful applications of atomic energy.

NRC: US Nuclear Regulatory Commission.

NWS: Nuclear Weapons States.

OEEC: Organisation for European Economic Cooperation became later the OECD, the Organisation for Economic Cooperation and Development.

PNE: Peaceful Nuclear Explosion is an explosion carried out for non-military purposes.

SIPRI: The Stockholm International Peace Research Institute is engaged in problems of peace and conflict. It was established in 1966 to commemorate Sweden's 150 years of unbroken peace.

SQ: Significant Quantities. The official IAEA definition is "the approximate quantity of nuclear material in respect of which, taken into account any conversion process involved, the manufacturing of a nuclear explosive device cannot be excluded".

START: STrategic Arms Reduction Treaty.

TCP: The Technical Cooperation Program is the main tool of the IAEA to spread various applications of nuclear technology.

TRITIUM: A nuclear material that facilitates fissioning and increases the yield of a nuclear explosion. When using tritium in an atomic bomb, less fissionable material is needed.

UF-6: Uranium Hexafluoride is natural uranium and fluorine. When heated UF-6 becomes a gas which can be used to make enriched uranium.

WANO: World Association of Nuclear Operators.