UKRAINE AND THE WORLD: THE CHALLENGE OF CHORNOBYL

On the 20th anniversary of the Chornobyl disaster we are to pay tribute to human heroism and the Ukrainian and world's efforts to eliminate the consequences of the nuclear accident. Let us hand down a safe nuclear technology to our descendants.

Ordered by the Ministry of Foreign Affairs of Ukraine

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The Chornobyl explosion demonstrated that radiation, if uncontrolled respects neither state borders nor politics.

On the 20th anniversary of the Chornobyl accident it is time to look back down the road that we have passed along and take stock of what has been achieved. We can reflect on how well we have understood the causes of the accident and consider if we have done everything possible to prevent similar tragedies elsewhere.

Since the accident, tremendous efforts have been made to liquidate and mitigate its consequences. The whole world joined together to fight against the effects of this nuclear catastrophe and its destructive impact on people and the environment. In doing this the world community has learnt many lessons from Chornobyl.

We pay tribute to the 20 years of human endeavour to overcome the consequences of the nuclear disaster. The efforts of the whole world should be mobilized to solve the problems caused by the tragedy of Chornobyl. Without world–wide support it is impossible to move on. We must pass on a legacy of safe nuclear energy to generations to come.

Borys Tarasyuk

Minister for Foreign Affairs of Ukraine

B. Тарасюк

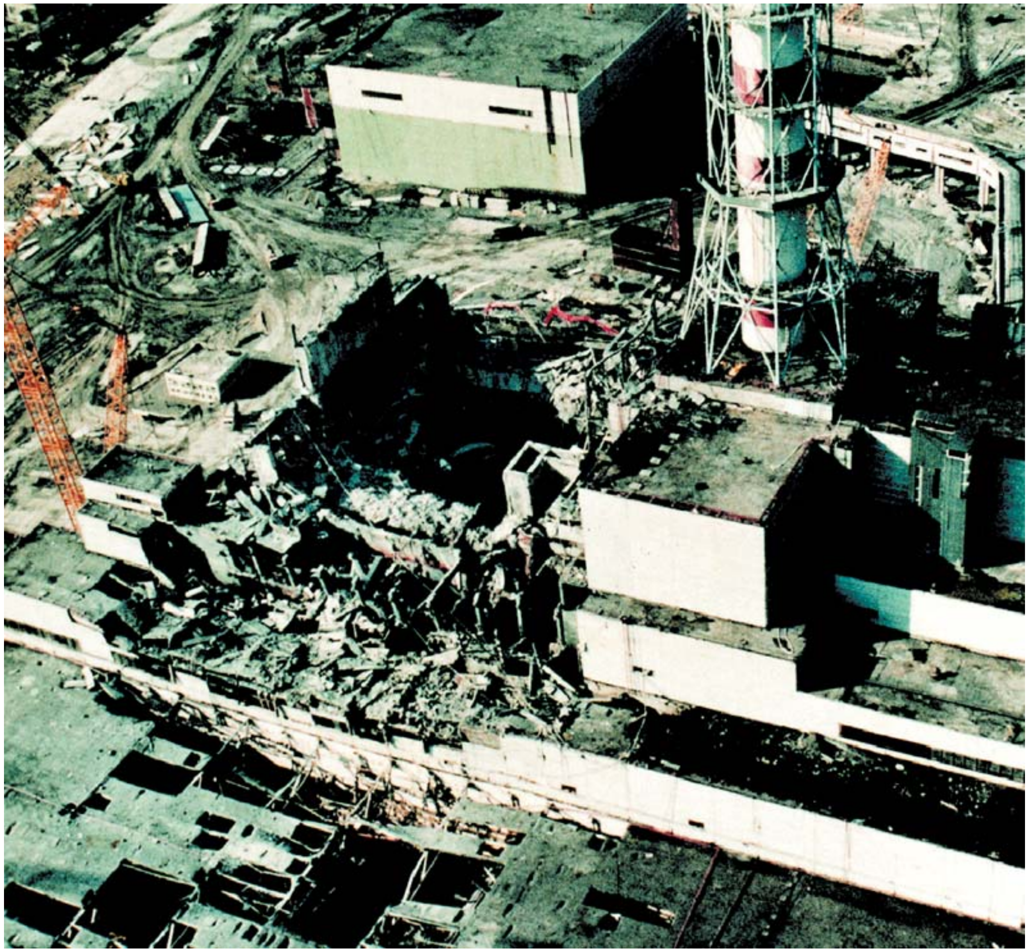
Chornobyl Nuclear Accident

At 01:23 on April 26, 1986 Moscow time, two powerful explosions destroyed Unit 4 of the Chornobyl Nuclear Power Plant (ChNPP).

This terrible event was rated as a Major Accident – level 7 according to the International Nuclear Event Scale.

The accident was unpredictable. Neither the Soviet Union (the USSR), nor any other country in the world using nuclear energy had an action plan to liquidate the consequences of such an event.

Destroyed Unit 4. April, 1986

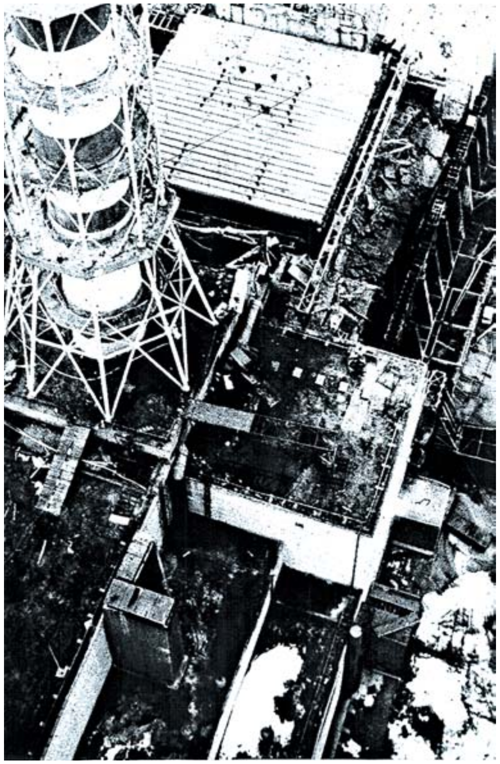


Extremely high radiation levels limited the working time, near to the destroyed Unit 4, to just a few minutes

The Chornobyl accident became a global–magnitude disaster. It proved that serious nuclear accidents could have global ramifications and could affect vital interests in many countries.

The resources necessary to eliminate the consequences of a man–caused catastrophe of this scale go beyond the economic and technological capacity of any single country and require the joint efforts of the world community.

Experience gained in overcoming such catastrophes is of value to the world community by equipping all nuclear countries with the expertise to prevent a repeat of similar accidents anywhere in the world.



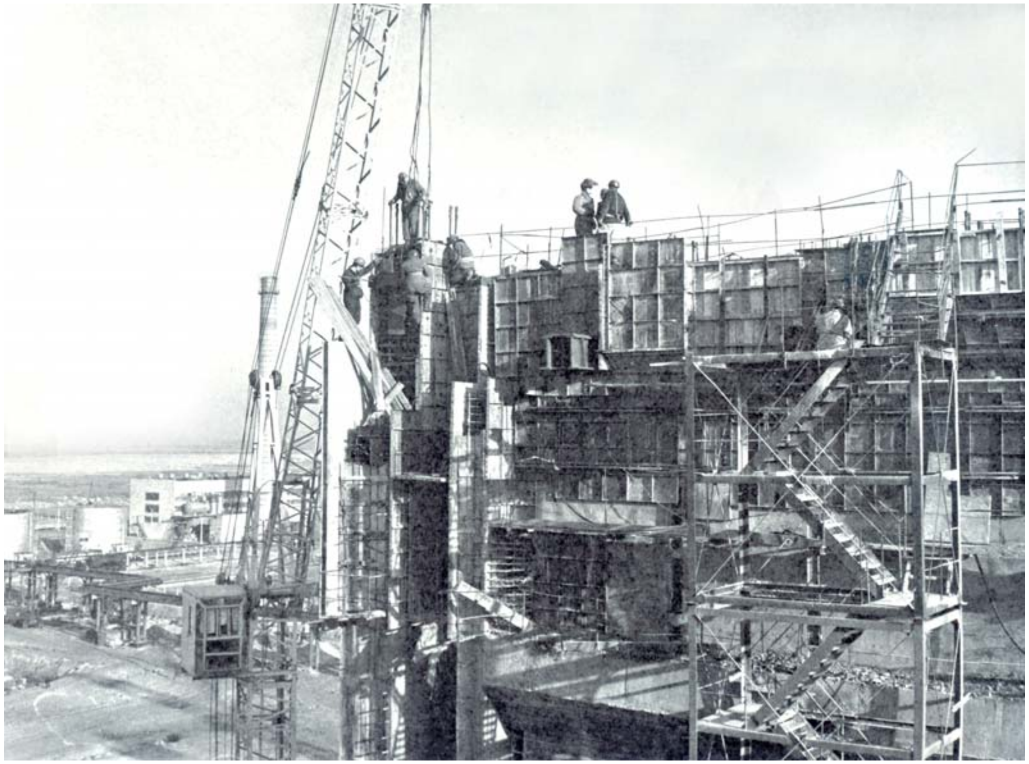
Construction of the Shelter. Laying pipes to form the roof

The Chornobyl NPP, as with many other industrial complexes of the former USSR, it was dedicated to Lenin

The Chornobyl NPP was the first nuclear power plant to be constructed in compliance with the plan to commission a total of 11.9 mln. kW of nuclear power plant capacity in the USSR during 1966–1977.

The site selected for the building of the ChNPP is in the central region of Ukraine and is located 110 kilometers North of Kyiv and 12 kilometers to the West of the town of Chornobyl.

Construction of the ChNPP Unit 1



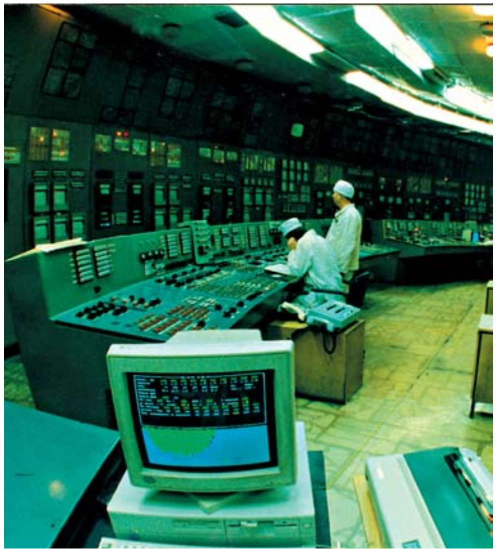
'Ahead to physical start–up!' – reads the slogan as construction of Unit 1 at the ChNPP is launched

The ad hoc organisation, – Pivdenatomenergobud, that was established just for the purpose under the Minenergo (Ministry of Energy), commenced construction in 1970.

The design of power unit that was selected for the Chornobyl Power Plant was the RBMK–1000 reactor having a total capacity of 1000 megawatts (electrical). This is a heterogeneous channel reactor with fission based on thermal neutrons, where graphite is used as a moderator and water for the coolant.

The first unit of the ChNPP was commissioned in September 1977, the second in November 1978, the third in December 1981 and the fourth in December 1983. Construction of a fifth unit was substantially complete and preparation for commissioning was in hand at the time of the Unit 4 accident.

Unit 3 main control room at the Chornobyl Power Plant



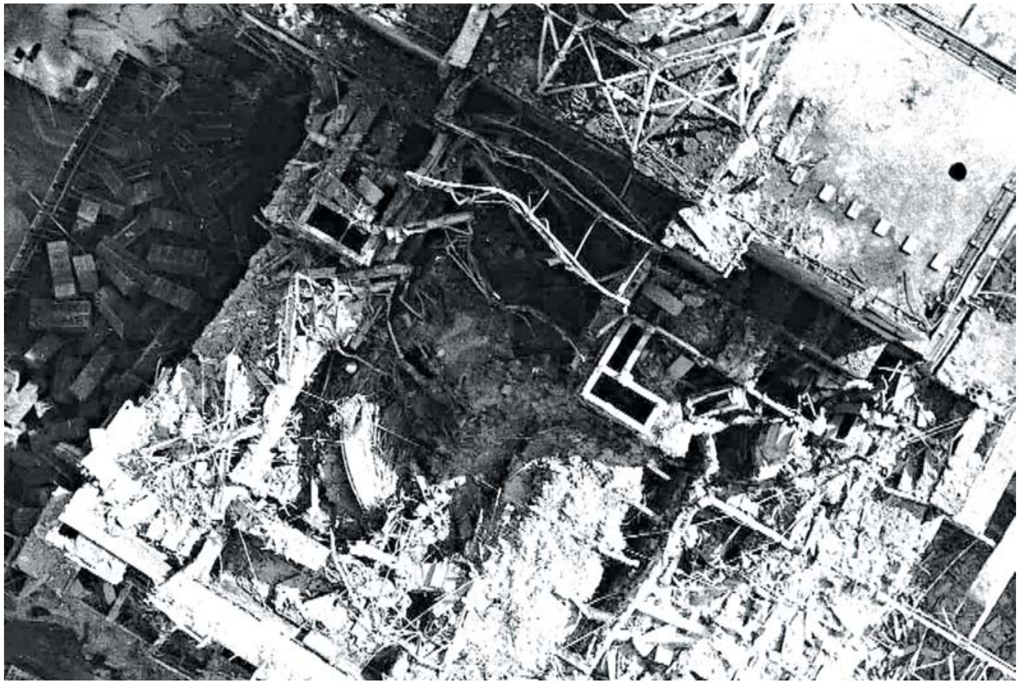
The accident happened during design–basis testing of one of the safety control systems. The reactor and Unit 4 building were extensively damaged by two powerful explosions, which resulted in local runaway of reactor power on prompt neutrons leading further to a pressure increase within the reactor space.

The explosions tilted the reactor cap by 90 degrees and blew off the roof of the building opening the reactor core to the sky.

Metallic materials, graphite blocks, fuel fragments and other materials, were thrown out by the explosions. Smoke and steam containing around 50 tons of radioactive materials and fission products from the reactor formed a "hot cloud", which rose to a height of two kilometers.

The graphite fire and associated discharge of material from the destroyed reactor lasted for 10 days, before the fire died down and the discharge of radionuclides and other materials gradually decreased.

Several days after the explosion, the discharge of radioactive products into the atmosphere continued



The deadly power of the "peaceful" atom – when out of control. An aerial view of Unit 4

Around 70 tons of fuel was thrown from the peripheral areas of the core zone mixing with debris resulting from destroyed engineering structures and construction components of the deaerator stack, turbine hall roof and the Unit 4 reactor building.

Soldiers manually clear up radioactive fragments

About 50 tons of fuel and 800 tons of reactor graphite remained in the reactor vault. Burning fragments of the reactor core that fell on to the roof of the reactor and turbine zones caused many fires.

The explosion disabled the automatic fire–fighting system of the reactor core area of Unit 4 and destroyed other installed fire fighting systems allowing the fire to spread to various combustible materials.

Deposits of lava–like fuel–containing materials remain within the Shelter. Due to its shape this accumulation was named the 'Elephant's Foot'

Ecological Contamination

The "Red Forest" was badly damaged by the accident's radioactive plume

The accident at the Chornobyl Power Plant resulted in contamination of 200 000 square kilometers in Europe by cesium and strontium nuclides. Ukraine, Belarus and Russia account for 70 % of this territory, which is equivalent to the combined areas of Bulgaria and Denmark. The increase in background radioactivity was registered also in other countries.

The most intensive contamination was registered near the destroyed reactor, with radiation levels at some spots close to the reactor reaching 2000 roentgen per hour.

Tens of thousands of hectares of forests around Chornobyl suffered the impact of radiation. About 450 hectares of forest in the immediate vicinity of the Chornobyl Power Plant suffered most. The damage resulted in foliage taking on a reddish shade and it was later nicknamed as the "Red Forest".

The major part of the "Red Forest" has been buried in trenches or ditches within the Exclusion Zone (30–kilometer zone around the Chornobyl Power Plant) and new trees have become established there.

Much of the "Red Forest" is now buried in these trenches

Fish from the Chornobyl cooling pond is not allowed for human consumption

Basins of the rivers Pripyat, Desna, some of the Dnipro River, together with lakes and ponds of the Exclusion Zone were also contaminated.

Most of the radionuclides had short half–life decay periods resulting in further reductions in the levels of contamination as time went on. Included in these short–lived elements was radioactive iodine–131 that caused great concern during the immediate days after the accident.

During the years since the accident, radiation conditions have considerably improved. The exposure dose, by comparison with June, 1986, has reduced 100–fold and in the areas that were decontaminated the reduction in activity is as much as 1000 or more times lower.

Impact on the Health of People

More than 3.5 million people suffered the consequences of the Chornobyl accident in Ukraine. Nearly half of them are children. People who lived in the epicenter of the nuclear accident close to the Chornobyl Plant suffered the most. In the years since the accident many of them have died. But because of a variety of circumstances, including mass relocation after the accident, poor medical records and the great distance traveled by the radioactive plume and any effect on people, it is difficult to derive a direct correlation of the mortality rate with the Chornobyl accident. According to the Ministry of Public Health of Ukraine, information which is summed up by the Scientific Center for Radiation Medicine of the Academy of Medical Sciences of Ukraine (SCRM), shows that out of the total number of people under medical supervision between 1987 and 2004, 504 117 people have died of which 6 769 are children.

Summarized SCRM data on the medical consequences of the accident for different categories of the sufferers show:

Acute Radiation Syndrome

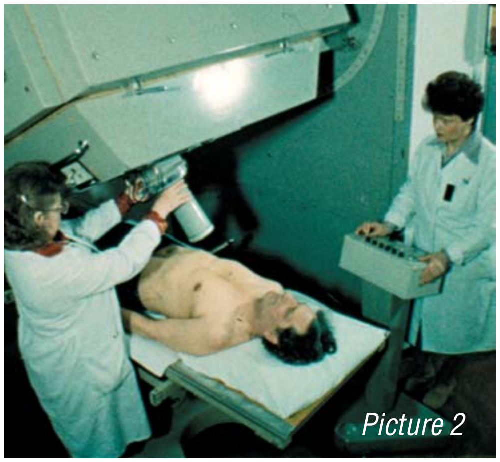
Acute radiation syndrome was registered in 134 patients. In 1986 during the first 90 days after the accident it caused the death of 28 people, since then a further 30 people have died from the effects of radiation.

Liquidators

About 600 000 people are classified as Chornobyl accident liquidators. These people suffer from health deterioration related to almost all classes of disease such as psychic maladies and depression, the number of thyroid cancer cases is expected to grow. Between 1998 and 2004 cases of thyroid carcinoma exceeded the average national level for this disease by a factor of nine among males and by a factor of 13 among females.

Picture 1. Acute radiation syndrome. Many of those who were the first to face the nuclear disaster laid down their lives fighting it

Picture 2. Medical examination of a person affected by the accident



Children

An increase in thyroid cancers is being observed among those exposed during their childhood (0–14 years), although there is no convincing evidence of an increase in leukemia, lymphoma and other forms of solid cancers. As of today there are 2 700 cases of thyroid carcinoma among affected children who were under 18 at the time of the accident.

A definite trend of impaired physical development is being observed among children from contaminated areas.

Thyroid examination on a young person. Cancer of the thyroid was the most common effect of the Chornobyl accident and particularly affected children

Among the exposed children we observe deterioration in somatic and psychic health related to all classes of disease, thyroid pathology and immune, enocrine and nervous systems in particular.

Evacuated Population

An upward trend in the detection rate of solid tumors, non–cancer cases and all classes of illnesses including mental disorders is being observed among those evacuated from the contaminated territories. This is highest among people evacuated from Pripyat, especially women. These disturbances depend also on the whole body and thyroid radiation doses.

Population Affected by the Accident

Those affected by the accident show a dramatic increase in cases of radiation–induced thyroid cancer (especially in those aged between 0–18 years at the time of the accident). The incidence of mammary gland cancers has also increased. One can also observe general health deterioration, decrease in birth rate, pregnancy complications and psychosomatic disorders related to stress.

Social and Economic Losses

Abandoned homes in the Chornobyl Zone

The Chornobyl accident had a significant impact on the economies of the affected countries; Ukraine, Belarus and Russia.

Economic losses from the Chornobyl accident can be subdivided into direct and indirect. The direct losses include:

- Closure of some NPP facilities, losses in electric energy production.
- Decommissioning of production facilities within the Exclusion Zone.
- Deaths, health deterioration.
- Expenses on the mitigation of the accident consequences, including social security and medical services.
- Scientific research work on ecological conditions, health, production of ecologically safe products.
- Radiation monitoring of the environment.

Chornobyl barges that will never sail again

Indirect losses are considered to be the following:

- Lost opportunities: Profit loss from agricultural land, forests, production facilities

- Profit deficit due to loss of generating capacity resulting from the damage and shutdown of the Chornobyl Power Plant and postponement of new nuclear plant construction

Pripyat town. All the people have gone. The way it looked after the accident

People from villages of the Chornobyl area bade farewell to their homes as if leaving loved relatives

- Demographic losses

- Ecological losses

By 2015 the estimated cost of the accident to Ukraine will have reached USD 179 billion including direct losses, financial expenditure, and indirect losses.

20 Years of Endeavor

The first to suffer from the impact of the nuclear catastrophe to Unit 4, were the operators in the central hall.

After the explosion operators working in complete darkness isolated electrical supplies to protect fire–fighters, who were fighting fires in the turbine hall, from exposed circuits. That night the fire–fighters had no radiological protection clothing or equipment.

Their only protection consisted of their helmets, standard uniforms and face masks. All of them knew that they were working in areas of extremely high radiation.

Miners constracting a tunnel under Unit 4 to install the cooling system

Lest we forget. The Memorial in Slavutych town stands testament to the everlasting memory of the Chornobyl heroes

The symptoms of acute radiation syndrome were felt immediately. But they fulfilled their duty to the end, until they were completely exhausted.

Three of those who perished lie in their Ukrainian land: Valery Hodemchuk, Volodymyr Shashenok and Olexander Lelechenko were buried in their Ukrainian motherland. Shortly afterwards 20 more graves appeared in the Mytynsky cemetery in Moscow. Besides the fire–fighters there were plant operators, electricians, mechanics and militarized security personnel.

The accident alert signal was received by the militarized fire station (MFS–2) at 00.28 a.m.

The group on duty comprising 12 people headed by Lieutenant Volodymyr Pravyk, were dispatched to the accident site. Five minutes later a team of firemen from Pripyat under the command of Lieutenant Victor Kibenok arrived.

At 00.46 a.m. the commander of the MFS–2, Major Telyatnykov arrived at the accident scene and assumed responsibility for fire–fighting operations.

The fire raged on the roof and within the turbine hall, in operating areas, on the roofs at different levels of the Unit 3 reactor building, deaerator stack and reactor services areas.

At 6.30 the announcement was made that the fire was extinguished.

Those firemen fulfilled their duty to the utmost. They numbered 28, those heroes who were the first to enter the blaze.

Monument in Chornobyl town to the fire–fighting heroes

Power plant medical personnel were also alerted.

Doctors gave first–aid treatment to people at the Chornobyl Power Plant site and in Pripyat. Some patients were transferred to hospitals in Kyiv and to other cities of the Kyiv region.

Dosimetry laboratories were urgently set up and medical teams assembled. Almost 2 000 doctors, 4 000 nurses and more than 1 000 specialists from higher medical educational institutions were involved in this tragic event.

People who were suffering from the worst effects of radiation were transported to Moscow. It was there that professor Gale arrived encouraged by a well–known American businessmen Maecenas Armad Hammer. Together with Soviet surgeons he fought for the lives of the fire–fighters, but in spite of their efforts, they were unable to save six of them.

Stable iodine was administered to more than five million people, including more than 1.6 million children.

Dose control teams working close to the Chornobyl Power Plant

During the first days after the accident doctors worked under almost wartime field conditions

Helicopters were used in operations to decontaminate areas of the Chornobyl Zone

During the first days after the accident significant amounts of radioactivity were released from the crater of the destroyed reactor.

Operations to blanket the destroyed reactor with sand, lead and boron, dropped from helicopters, started during the afternoon of the 26^{th} of April, but because of the very high temperature of the reactor this attempt failed.

Unfortunately, those materials were lifted into the atmosphere by the heat and together with radioactive products were carried away by the wind in the form of radioactive dust.

To arrest the discharges helicopter pilots performed more than 1 800 flights to drop special materials into the damaged reactor core.

A 'graveyard' of machinery used in liquidating the effects of the Chornobyl accident

The Governmental Commission was set up early on the 26th April 1986 to investigate the cause of the accident. In addition the Commission was to determine the scope of the catastrophe, work out and implement measures aimed at localizing and eliminating the accident consequences, ensure the health protection of the population and to provide any kind of assistance.

The Commission worked under extreme conditions resulting from the unprecedented complexity of the problems and the lack of any experience of this kind of event. At a very early stage it was clear to scientists and specialists that this was an extraordinary accident with significant medical and ecological consequences. The situation demanded immediate and comprehensive measures with economic, scientific and technical support coming not only from the Soviet Union, but also from the whole world.

Governmental Commission members in Slavutych. 1987

On 1 November 1986 the Council of Ministers of the USSR adopted the resolution, which stipulated, that during 1986–1990 a comprehensive program was to be launched, which envisaged research work related to ecology, control and assessment of radioactive contamination and development of radiation medicine, agricultural radiology, decontamination techniques and technology. To implement the program, the Coordinating Council was established under the leadership of academician Olexandr Alexandrov.

On May 3rd the Operational Commission (Permanent Commission of the Presidium of the Academy of Sciences of Ukraine (ASU)), which exercised control over the activities of the ASU organizations and companies, carried out scientific examinations of the proposals related to eliminating the accident consequences. The Commission facilitated liaison between the various ministries and agencies and prepared proposals for the Governmental Commission.

Operational Commission members at the Shelter Object. 1986

The magnitude of the accident can be judged by the number of military units and civil organizations that were involved in liquidation activities.

The work within the 30 kilometers Exclusion Zone alone involved 800 000 people, among them 350 000 military personnel.

Decontamination of machinery during the liquidation of the accident

Decontamination of the land and settlements was one of the most complicated operations carried out by military units.

More than 600 settlements with a total area of 7 000 square kilometers were decontaminated. For some, the procedure needed to be repeated several times.

In all about 7 000 houses and 25 000 kilometers of roads were decontaminated.

Military units were responsible for the evacuation of the population from the contaminated territories

At 12 o'clock on April 27 the Governmental Commission decided to immediately evacuate the population of Pripyat.

This followed radiation measurements of hundreds of milliroentgen per hour. The evacuation of 49 360 people from Pripyat started at 2 p.m. on April 26.

On May 4 a wider stage–by–stage evacuation of people from contaminated territories of Ukraine and Belarus started.

On May 5 the evacuation of Chornobyl town (15 000 people) was completed.

By the end of 1986, 116 000 people were evacuated from 188 residential settlements. In total about 350 000 people were evacuated from the contaminated territories of Ukraine, Belarus and Russia.

Evacuation...

Construction

The construction of the Shelter Object (Sarcophagus) was a key point in the comprehensive process of localising the Chornobyl accident. Within a few days of the accident a group of specialists, consisting of leading scientists of the Soviet Union and the Government Commission decided that it was necessary to build a shelter over the destroyed Unit 4.

Out of 18 variants, the option chosen was the most risky, because it was based on supporting the load–carrying elements of the Shelter on structures of the damaged reactor building. The ability of these structures to bear the load was unknown because detailed inspection was not possible. The risk was justified on the basis of the time expedient due to the far shorter construction time using this variant and the urgent need to protect the environment from further radioactive discharges.

Construction of the Shelter Object northern cascade wall

Erection of the western buttress wall

The Shelter's Mammoth beam shortly before being lifted into position over the destroyed unit

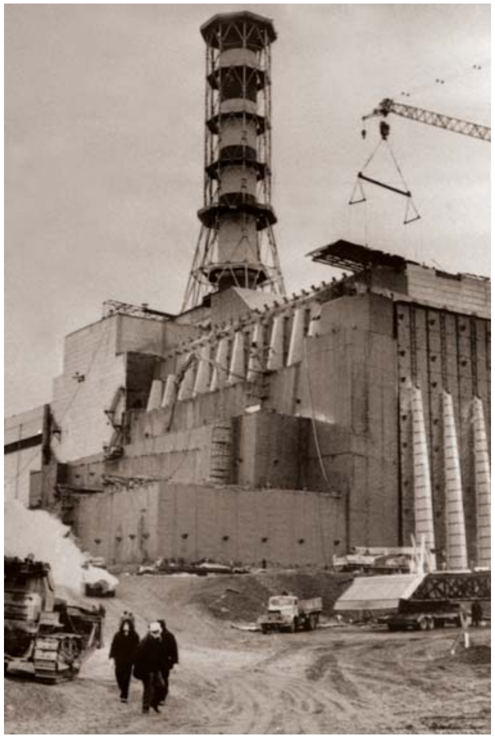
The design that was approved envisaged firstly sealing the damaged Unit 4 from Unit 3.

The northern protective wall had several terraces up to 12 meters high, to which were attached external metal shields weighing 100 tons. Each terrace was constructed as close to the destroyed unit as possible. Radioactive debris and reactor materials were placed inside the walls. The Unit 4 western wall that withstood the explosion was covered with a 50–meter high protective buttress wall of one–meter thickness.

The roofing for the reactor central hall was constructed using 27 pipes of length 36 meters. These were mounted on two metal beams, which were attached at a distance of 36 meters apart and supported on the existing structures.

A huge metal 'Mammoth' beam 70 meters long and 6 meters high weighting 147 tons was mounted to provide the support for the southern zone roof.

One of the 27 pipes that formed the Shelter roof is lifted into position



The construction of the Shelter lasted 206 days and nights, from June to November.

Up to 90 000 people were involved in building the Shelter. During the period 1986–1987, when the radiation level was the highest, about 200 000 people of different nationalities from all over the former USSR, worked in the Chornobyl area.

During the construction of the 'sarcophagus' about 300 000 cubic meters of concrete were poured. In addition 6 000 tons of metal structures were assembled. The expenditure for the Shelter construction has been evaluated as USD 6 billion.

On November 30, 1986 the State Acceptance Commission accepted the completed Chornobyl NPP Shelter Object that covered Unit 4 as being suitable for safe storage and technical maintenance.

Briefing meeting for workers involved in constructing the roof over the turbine hall of the destroyed Unit 4. 1986

Although the materials used in constructing the Shelter had been manufactured in compliance with appropriate norms and rules, the expected life of the Shelter could not be accurately determined due to the fact that it could not be periodically monitored and anti-corrosive coatings could not be reapplied.

The Shelter Object was constructed on the destroyed building, in areas where the radioactivity was high. This necessitated positioning and mounting most of the engineering structures by remote control when it was impossible to check the integrity of supports and fixings.

Given this uncertainty the State Commission set a 30-year life of which twenty have already elapsed.

Seven months had passed since the decision to build the shelter was made and the acceptance of the completed object by the State Commission.

Given the scope of work, complexity of engineering problems and extremely difficult conditions under which work was performed, this can be considered as a unique and outstanding example of construction achievement anywhere in the world.

After just seven months, construction of the sarcophagus (Shelter Object) over the destroyed unit is finished

Hazards and Dangers

Radioactive hazard of the Shelter. Frozen fuel lava

Today the Shelter hides an entire complex of potential internal and external hazards.

According to expert assessments, about 95% of the original reactor fuel remains inside the Shelter. The total amount of nuclear materials remaining is estimated at 200 tons.

During the accident the molten fuel together with other materials formed a highly radioactive lava that flowed into the lower corridors and areas of Unit 4.

The lava eventually solidified into fuel–containing masses. In the course of time this has deteriorated and radionuclides captured within it have transferred from the bound condition to movable dust particles that can be transported by air circulation beyond the boundaries of the Shelter.

The area around the Shelter Object contains significant quantities of radioactive materials, which are not insulated from the hydro–geological environment.

Debris of destroyed engineering structures inside the Shelter

Accident debris makes operations to control conditions within the Shelter extremely difficult

The process of water penetrating into the Shelter can have a negative effect on the level of nuclear, radiological and radio–ecological safety achieved so far.

The Shelter Object's engineering structures do not meet current requirements; they are getting old and deteriorating, carrying the possibility of local collapse.

Metal structures have been considerably damaged by corrosion, while parts made of reinforced concrete have been saturated with water as a result of high humidity within the Shelter leading to their gradual deterioration also.

The analysis of the Shelter's engineering structures indicates the existence of critical zones that are vulnerable to even slight earthquakes, tornadoes or other natural disasters that are possible at the location of the ChNPP site.

Water ingress presents a hazard for structures and radioactive materials of the Shelter Object

The condition of the Shelter Object cannot be fully assessed. This is because many areas are inaccessible due to radioactive materials.

The equipment for monitoring the condition of fuel–containing materials installed during the first years after the accident, is functioning at the limit of its capacity and requires serious improvement or replacement.

The Shelter control systems do not have permanent mechanisms to safeguard engineering structures and there is no fire safety system to protect about 2 000 inflammable materials within the Shelter including graphite, cables, plastic and wood.

The conditions under which dose control specialists work

Construction of the Shelter over the destroyed Unit 4 protected the environment and those who initially worked at the ChNPP site against exposure to further radioactive releases.

But the haste in constructing the Shelter under difficult working conditions created many problems.

An assessment of the Shelter's condition shows that its quality does not meet the requirements of nuclear safety and its engineering structures cannot guarantee safety in case of emergency.

The hazard has been isolated, but not yet eliminated

International Cooperation

The search for acceptable solutions to the Shelter problems in terms of economy and ecology started immediately after its construction. In 1992 the Government of Ukraine announced an international tender for the designs and technical solutions to transform the Shelter Object into an environmentally safe system.

Ukrainian specialists, in addition to the international community, actively participated in the bids. Their knowledge and experience were very useful and presented a clearer view of the multifaceted problems of the Shelter Object.

In 1993 after summing up the competition results, the concept of gradually transforming the Shelter into an environmentally safe system was approved.

The system incorporated research, stabilizing the engineering structures, establishing a system of radioactive waste management, construction of a new confinement and finally, removal and disposal of high-level radioactive materials from the Shelter.

Kenzo Oshima – the Deputy Secretary-General for humanitarian issues of the UNO at the Shelter observation platform. 2002

Albert Gore the then US Vice–President, at the Chornobyl NPP. 1997

In 1994, to examine the technical and economic feasibility of implementing the concept, the Commission of European Community (CES) announced the tender for a feasibility study. The winner was the Alliance consortium headed by the French company, Campenon Bernard SGE. A year later the consortium submitted the report, which has remained relevant until today.

It emphasized that the Shelter in its current condition was dangerous, and that immediate actions for stabilization and construction of a new confinement were required.

The report also emphasized, that the international community should demonstrate its desire to help Ukraine solve problems related to the Chornobyl accident, show political will and provide financial guarantees for the entire period of project implementation.

Collecting water samples for analysis within the Shelter

On 11 September 1995 the Ukrainian delegation participated in the meeting of the CES in Brussels to determine and coordinate further joint efforts based on the results of the Alliance consortium's research.

Donors to the Chornobyl Shelter Fund on a fact–finding mission to the Chornobyl NPP

More active international cooperation on Chornobyl–related issues was prompted by the signing of a Memorandum of Understanding between the governments of the G–7, the European Commission, and the Government of Ukraine in which Ukraine agreed to close the Chornobyl NPP, a decision that it decided to fulfil in December 2000.

In compliance with the Memorandum, the Recommended Action Plan within the framework of the TACIS project "Chornobyl Unit 4. Short–term and Long–term Actions" was developed for further work based on the conclusions of the Alliance consortium.

Analysing conditions within the Shelter Object in cooperation with Japanese experts

In 1997, on this project, the detailed plan for further work was developed in accordance with the Recommended Action Plan. It was developed in close co-operation with the EC, the USA, Ukraine and a group of international experts and was named the Shelter Implementation Plan (SIP). Developing the SIP was the culmination of the combined efforts made by Ukraine and the international community. It took several years to work out an acceptable approach to solve the problems related to the Unit 4 Shelter of the ChNPP.

In November 1997 New York hosted the first Conference of donor countries within which it was agreed to provide finance to the ad hoc Chornobyl Shelter Fund (CSF) set up to finance the implementation of the plan. The European Bank for Reconstruction and Development (EBRD) was assigned responsibility for Fund management, whereas the general monitoring is the responsibility of the Assembly of Donor Countries. Project Management for key programs and technical projects is in the hands of the Chornobyl NPP, which is supported by the Consultant that comprises a consortium of Bechtel (USA), Battelle, (USA) and EDF (France). The Chornobyl NPP is also responsible for organizing, implementing and controlling work and for safety.

The United Kingdom is a donor to the Chornobyl Shelter Fund.
Mr. Ian Downing the Director of the International Nuclear Policy and Programs of the Department of Trade and Industry of the UK is answering the questions of journalists


Shelter Object

During the first stage of the project, that lasted from 1998 till 2001 the necessary research was carried out, strategies and programs developed, conceptual design developed and major decisions made. Within the scope of this a program of work to stabilize the Shelter Object and improve the infrastructure was carried out.

Completing two immediate and urgent tasks on stabilizing engineering structures was a significant achievement.

Examining the condition of engineering structures of the Shelter Object

Stabilizing beams B1 and B2

In 1998 the support structure of the ventilation stack of Units 3 and 4 , that was damaged by the blast, putting the stack in danger of collapse, was stabilized. In 1999 the supports of the B1 & B2 beams which support the roof of the 'sarcophagus' were strengthened.

About 30 companies from all over the world and several leading Ukrainian scientific and research institutions participated implementing stage 1 implementation.

Stage 2 that began in early 2001, was characterised by the implementation of the program developed in Stage 1: stabilization of engineering structures, and installing and commissioning monitoring systems. It also included developing and testing the technology to extract fuel–containing materials, implementing technical solutions related to the management and treatment of liquid and solid radwaste, construction of a New Safe Confinement and dismantling unstable engineering structures under its cover.

Before commencing the project's core activity much preparatory work to develop the required infrastructure had to be completed.

This included establishing the necessary infrastructure such as building the change facility with the capacity to handle a large workforce, engineering facilities, a construction base and establishing and commissioning rehabilitation and training centres.

The new change facility can accommodate up to 1 500 subcontractors

Stabilizing the Shelter engineering structures is a prerequisite for its transfer into an environmentally safe system. This is one of the most important and most difficult tasks of the SIP.

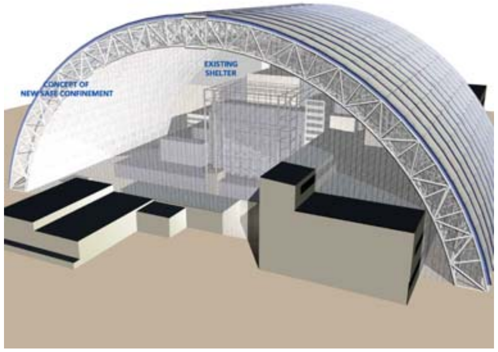
At the beginning of July 2004 the contract for performing stabilizing operations was concluded with the Ukrainian – Russian consortium, Stabilization, which included one Russian and three Ukrainian companies.

The contractor faces a difficult task, made even more complicated by high radiation levels. In some areas of the site they reach 6 Roentgens per hour. To minimise personnel radiation doses there is a need to diligently plan each activity, performing as much work as possible in relatively clean areas by local shielding and through personnel training.

Completion of the Shelter stabilization work is planned for November 2006.

Up to 1 500 subcontractors will be employed on Shelter stabilization work

Preparatory work prior to stabilizing the buttress wall



Conceptual design of the New Safe Confinement (NSC) to cover the Shelter

Many years of research into the conditions and problems of the Shelter showed that the dangers associated with the existing shelter could be significantly reduced by erecting a new safe confinement (NSC) that would be slid over the Object.

This building will comprise a complex of technological equipment for removing fuel–containing materials from Unit 4, and radioactive waste handling and other systems, thus achieving the objective of transforming the unit into an environmentally safe system and providing safe conditions for personnel, population and the environment.

In accordance with the conceptual design the NSC will be an arch structure with a span of 260 meters, height of 109 meters and length of 150 meters. It will be provided with all support and auxiliary systems including decontamination facilities, sanitary locks, workshops, and other technological areas.

Nuclear, radiological and general industrial safety within the NSC will be maintained through systems of control over radiation safety, seismic conditions and structural integrity. Ventilation, fire safety and physical safety control systems will be established there also together with telephone and TV networks.

Outside the Shelter the area is now a construction site for stabilization activities

The start–up cost of SIP, estimated at USD 768 million was calculated back in 1997 prior to the start of the project implementation plan. The above figures take account of the results of the Second Fundraising Conference for the Chornobyl Shelter Fund which was held in 2000 in Berlin. Donor countries (Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Kuwait, Luxembourg, the Netherlands, Norway, Poland, Spain, Sweden, Switzerland, Ukraine, the UK, the USA, Iceland, Israel, Korea, Portugal, Slovakia, and Slovenia and the European Commission) announced a total contribution of more than USD 700 million.

In 2003, following the implementation of the first stage of SIP it was felt necessary to review the project cost. It was caused by the necessity to assess the cost on the basis of the physical scope of required work as well as consideration of contingent risks during the NSC construction.

With this in view the Assembly of the CSF Donors charged the EBRD to prepare a report to address these issues. Revised project cost in this report is USD 1.091 billion.

In May 2005 during the meeting of the Assembly of the CSF Donors the EBRD report was approved and the donors pledged to contribute around an additional USD 185 million. The Russian Federation also joined the CSF donors. Its contribution was USD 10 million.

Headed by the Minister for Foreign Affairs, a delegation of Ukrainian diplomats visits ChNPP. 2005

Many tons of steel will be used to stabilize the Shelter

The plan to perform the work on the Shelter Object is only a part of what is necessary to transform the Object into an environmentally safe system. After the completion of stabilization and construction of the NSC the time will come to start the equally important but complicated work to dismantle the old Shelter.

Hard and intensive work can be foreseen, the execution of which will require thorough preparation. The time–scale will be long and the cost considerable.

The dangers hidden within the Sarcophagus can only be overcome by bringing together the world's scientific knowledge and advanced technologies augmented by the human factor.

Sealing the Shelter roof

Reviving the Energy Units

Decontaminating an area near the Shelter. 1986

Among the most important issues associated with eliminating the accident consequences was the resumption of operations on Chornobyl NPP's first three units. Solving these issues went hand in hand with the work to bring Unit 4 to safe storage.

After completing the decontamination of Units 1 and 2 in autumn of 1986 they were put back into operation.

The scope of work for Unit 3, which shared services with Unit 4, was much bigger.

The cable runs, water and gas supply lines that connected Units 3 and 4 had been cut off, the units themselves were separated by the protective lead–lined wall.

Highly contaminated equipment on Unit 3 was being dismantled to reduce radiation.

Decontamination of Unit 3 further improved the radiological situation at the operating units.

The dose in the turbine hall was considerably reduced by the end of July, 1987 and equalled 7–50 mR per hour.

After completing the Shelter Object and carrying out a comprehensive program of work to decontaminate the areas around the plant, the radiological situation at Unit 1 and Unit 2 was stabilized at a level in line with required norms.

Unit 3 was put back into operation in December 1987.

Soldiers assisted in decontaminating ChNPP units. 1986

High levels of radioactive contamination near the Power Plant required establishing acceptable working conditions for personnel. A pattern of shift work at the Chornobyl NPP introduced from July 1st achieved this objective.

During working days, off-duty operational and maintenance personnel were housed in a special settlement located outside the 30 kilometer Exclusion zone, and on days off they lived at their permanent residential places.

Zeleny Mys – Shift-workers settlement

A working day lasted 12 hours for operational personnel, and 10 hours for maintenance personnel and all other plant employees.

With the completion of the construction of the town of Slavutych in 1988 normal conditions of life and work returned.

Shift-workers at rest

Improving Safety

Examining reactor pressure tube seals

The Chornobyl accident in April 1986 forced a review of the approach to safety at nuclear facilities particularly of RBMK and other Soviet–designed reactors. The key role in the improvement of NPP safety can be attributed to the so–called Lisbon Initiative put forward in May 1992 and the resolution of a summit meeting in Munich in June 1992. It was at that meeting that the heads of states and governments of the G–7 countries proposed that the countries, which possessed the soviet–designed reactors, should embark on a comprehensive program of actions to improve the safety of their nuclear power plants.

The positive response of the G–7 heads of states reinforced bilateral cooperation between Ukraine and other countries. This cooperation covered all aspects of nuclear–related issues such as nuclear safety, radioecology, medical and social reconstruction.

The G–7 also established a multilateral process to enhance the operational and technical safety of nuclear power plants that were not already covered by bilateral agreements. The G–7 urged the world community to help finance the initiative.

In 1993 the EBRD Board of Directors agreed to set up the Nuclear Safety Account (NSA). Donor states pledged to contribute funds to finance safety improvement projects that included upgrading the safety of nuclear power plants.

Donors to the NSA comprised the EC and 14 countries: Belgium, the United Kingdom, Denmark, Italy, Canada, Netherlands, Germany, Norway, the USA, Finland, France, Switzerland, Sweden and Japan.

IAEA delegation at the Chornobyl NPP. 2000

The IAEA played an important role in identifying specific areas in need of technical assistance and by improving the efficiency of the information flow between different countries.

The exchange of information led to a meaningful dialogue on nuclear power plants safety between experts from Western and Eastern countries. Recommendations of the IAEA have been widely used in developing national, bilateral and other international safety improvement programs for nuclear power plants.

All RBMK reactors, including those at Chornobyl have been subjected to a comprehensive program of safety improvements. Thus, during the period from 1987 to 1999 alone, the measures aimed at providing safe operation of ChNPP Units 1–3 accounted for more than USD 260 million that was invested by Ukraine and the international community.

Safety improvements were discussed at the international conferences on Shelter Object problems

Chornobyl Power Plant closure – Decommissioning

The events of 1986 had a dramatic impact on the development of nuclear power and on the attitude of the world–wide population towards it.

The Chornobyl NPP itself became a symbol of danger and the focus of close attention. In June 1994 the G–7 put forward the initiative to close down the Chornobyl NPP on condition that the world community would compensate for the cost of fulfilling this decision.

Chornobyl NPP site

It was by no means a simple decision for Ukraine, given its technical, economic and social problems. But on December 20, 1995, demonstrating its good will, the Ukrainian government signed a Memorandum of Understanding – on the shutdown of the ChNPP by 2000 – with the governments of the G–7 countries and the EC.

Few will remember that the major goal of the Memorandum of Understanding was to work out a joint approach to develop and implement a comprehensive program of support for Ukraine in overcoming the consequences of its decision.

Main circulating pumps room

The program stipulated in the Memorandum included the following priorities:

- Restructuring the energy sector, which presupposed "the attraction of Ukrainian and international resources necessary both for the safety measures and for the new capital investments into the production, transfer and distribution of electrical energy."

- Program to invest in the energy sector for the "completion of the construction and upgrade of the Khmelnitsky Nuclear Power Plant Unit 2, and Unit 4 of the Rivne Nuclear Power Plant and for the reconstruction of thermal and hydro power plants."

- Nuclear safety program for the preparation and implementation of the projects focused on short–term improvement of the ChNPP Unit 3 safety, decommissioning of the power plant and working out cost effective and ecologically acceptable approaches to solve the problems related to the Shelter and Unit 4 of the ChNPP.

- Plan for the mitigation of the social consequences of the ChNPP closure.

Reactor hall

A minute before the total shutdown of the ChNPP Unit 3

To finance the measures mentioned in the program, Ukraine and the G-7 committed themselves to cooperate in attracting international and domestic support to fund those measures. Some experts estimate the total cost of works envisaged in the Memorandum of Understanding as between USD 4 and 5 billion.

To review progress and manage the program and consider any technical or financial problems, representatives of Ukraine, the G-7 and international financial institutions were to conduct joint meetings at least once a year.

Taking into account the interests of its own people together with those of the international community and of future generations and in compliance with international obligations, the Chornobyl Nuclear Power Plant was shut down on 15 December 2000 by decree of the President of Ukraine.

Prior to this historic event, parliamentary hearings on Chornobyl Nuclear Plant shut-down were held with the participation of Russia, Belarus, USA, France, Italy, Spain, Korea, Austria, Germany, and representatives of international funding institutions. The decision to shut down the Plant in the interests of nuclear safety was unanimously approved.

Analysis of progress in implementing the Memorandum of Understanding shows that to date, the majority of measures outlined in the comprehensive program have not been accomplished.

This is especially true of the restructuring of and investments into Ukraine's energy sector, aimed at cooperation for construction of compensative capacity, rehabilitation of thermal plants, and supply and distribution systems.

In the event, in 2004, Ukraine alone completed the construction of the second unit at the Khmelnitsky Nuclear Plant and the Unit 4 at the Rivne Nuclear Plant. However, several projects remain unaccomplished due to the complicated economic situation in Ukraine.

In the area of the Chornobyl Nuclear Plant post–accident decommissioning, international cooperation has fallen short of expectations, similarly much of the action plan to mitigate the social aftermath has been unfulfilled.

The newly – commissioned Unit 2 of the Khmelnitsky NPP. 2004

Fifth anniversary of the ChNPP closure. The President of Ukraine Viktor Yushchenko at the control panel of the Chornobyl Power Plant

The early shutdown of the Chornobyl Plant ahead of its design service life caused complex social and economic problems.

To meet these challenges the President of Ukraine set up the 'Inter-departmental Governmental Commission on Comprehensive Solution of the Chornobyl Nuclear Plant's Problems' in April 2000.

In late November 2000 the resolution "On Measures of Social Protection of the Chornobyl Nuclear Plant Employees and Slavutych related to the Plant Closure" was passed. This defined the steps necessary to mitigate the social consequences of the closure decision. Ukraine's government promised that every Plant employee would be socially protected.

At the time of shut-down more than 9 000 people worked for the plant. Since then the number of employees has reduced more than two-fold.

"Decommissioned"

Decommissioning the Plant's units began under the most unfavourable conditions: there was no decommissioning project and the required infrastructure was not in place.

The first attempts to estimate the cost of the Chornobyl Plant decommissioning project were undertaken in 1994. The calculations were performed under the TACIS project and the estimated cost to decommission the plants and construct new facilities – without which decommissioning would be impossible – was ECU 541 million over 15 years (the cost of maintenance of the shutdown units being excluded). Estimated cost for personnel social protection amounted to USD 505 million for 6 years.

Compliance with safety standards and rules and regulations of the nuclear energy industry must be guaranteed at every stage of decommissioning. This requires a comprehensive infrastructure costing more than USD 50 milion that is financed by Ukraine itself from the state budget.

Dismantling plant and equipment. 2005

Inspecting newly–installed equipment of the Liquid Radioactive Waste Treatment Plant

Safe decommissioning of nuclear units requires a supporting infrastructure comprising many different elements. Their construction has been financed by Ukraine and the international community. In 2001 the construction of the Replacement Heat Plant supported by the US Department of Energy was completed. This was needed at an early stage to supply heat to all areas of the Chornobyl Plant site after its shutdown.

Construction of the Liquid Radioactive Waste Processing Plant based on a "turnkey" contract is almost complete. This is financed by Ukraine and from the EBRD–administered Nuclear Safety Account (NSA).

Replacement Heat Plant at the ChNPP

Construction of a new spent fuel dry storage facility at the ChNPP

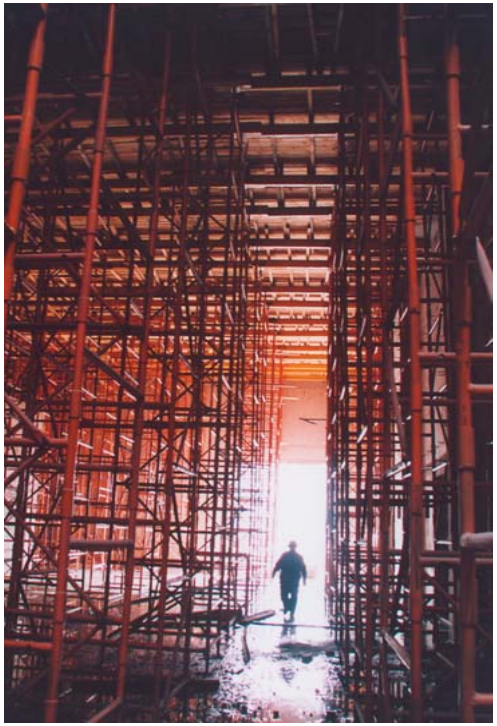
The European Commission is financially supporting Ukraine in constructing a solid radioactive waste treatment plant to handle waste accumulated during the operational life of the ChNPP.

Currently the Chornobyl Nuclear Power Plant is undergoing the first phase of decommissioning involving defuelling units 1–3. This is scheduled for completion in 2008.

To accommodate the spent fuel removed it is crucial to have an interim nuclear fuel storage facility. Construction of a dry fuel store on a "turnkey basis" started in 2001 and was financed by Ukraine and the NSA. Unfortunately, design errors resulted in the suspension of construction work in 2003. The Donor Countries of the NSA will determine the fate of this facility.

The support of the international community in dealing with the Chornobyl Plant shutdown is of a special importance to Ukraine. But it is Ukraine that bears the main burden of expenditures related to solving Chornobyl's problems.

Total international technical assistance for the decommissioning amounts to more than USD 300 million (without the Shelter project transformation into Ecological Safety System). The estimated cost for the next 10 years is EURO 1 billion.



Shortly after the Chornobyl accident 91 200 people were evacuated from the most contaminated regions of Ukraine. The territory, from which the people were evacuated in 1986, was later designated as the 'Exclusion Zone'. The status of the Exclusion Zone is stipulated by the Law of Ukraine "On the legal order of the territories radioactively contaminated as a result of the Chornobyl disaster"

The Exclusion Zone covers 2 600 square kilometers.

Due to radioactive contamination the land is unsuitable for human habitation. It is also unsuitable for agricultural use or for any type of food production since its radioactive content would exceed national and international permitted levels.

Abandoned village of the Chornobyl Zone

Immediately after the accident the priority tasks within the Exclusion Zone were to carry out wide-scale decontamination and to create safe conditions to allow further operation of the Chornobyl Nuclear Power Plant.

Scientific research started within days of the accident and continues today. Those participating in these studies include institutes and laboratories from Ukraine, USA, UK, Japan, Germany, France and other countries.

In particular, scientists are investigating the radioactive condition of the Exclusion Zone environment (forests, soils, surface and underground waters, surface air etc.) and the radiation impact on flora and fauna and animal life.

Scientists of the Chornobyl Center's International Radioecological Laboratory carrying out research in the Exclusion Zone

The Pripyat river

The influence of forests was a major factor in stabilizing the radio-ecological condition within the Exclusion Zone.

The foliage of the forest canopy captured radio-nuclides and prevented much of the contamination from spreading to further regions.

Because wild mushrooms and berries readily accumulate radio-cesium, they represent a long-lasting source of additional internal radiation dose to the population in affected areas.

Today significant work to restore affected areas and to revive nature is being performed within the Exclusion Zone.

Mushrooms growing in Chornobyl forests

Protective dams in the basin of the Pripyat River

A number of water protection measures have been undertaken in the Exclusion Zone. One of the most effective has been the construction of dams in the River Pripyat flood plain. This measure has reduced the wash–off of radio–nuclides from contaminated areas of the flood plain into the river during spring floods.

Over time, radio–nuclides have migrated vertically into the geological environment contaminating ground waters.

Local hydro–geological conditions and natural barriers act to retain radio–nuclides and slow down their migration out of the Exclusion Zone. However, within the zone in areas close to the ChNPP, contaminated underground waters will pose a radioactive risk for a long time.

The most contaminated waters are those of the Glyboke lake and the Chornobyl NPP cooling pond.

Detailed dosiometric analysis of the Exclusion Zone shows evidence that the combination of radioactive decay, natural purification of the environment and the countermeasures taken, has reduced external and internal irradiation by factors of between two and three.

Today most radioactive contamination in the Exclusion Zone is due to radio-nuclides of cesium 137 and strontium 90, which have half-lives of about 30 years. Consequently, a 10 kilometer zone around the ChNPP will not be suitable for commercial use in the foreseeable future and it might not be possible to use the rest of the territory of the Exclusion Zone for several decades.

An abandoned village in Belarus

The inhabitants of this house have moved back

Today, Pripyat, the former town of nuclear power workers that is located in the Exclusion Zone just 4 kilometers from the Chornobyl NPP, lies deserted. The world calls it a 'ghost town'.

Before the accident the average age of Pripyat's inhabitants was 26 years.

Pripyat town now lies empty

There was already a well–developed infrastructure and new residential homes and other buildings were being constructed in the town. After the accident 49 630 people were evacuated due to high radiation levels. They never returned.

'Self–settlers' of the Exclusion Zone

In the spring of 1987 more than 900 people moved back to the Exclusion Zone. By the autumn this number had increased to 1 200. They were mostly elderly people who could not adjust to the alien environment away from their native homes. They have been labelled 'self–settlers'.

Today 357 people live in 11 villages within the Exclusion Zone. Self–settlers live off the land and hardly ever leave the zone. Essential goods and food products are supplied to them by mobile shops.

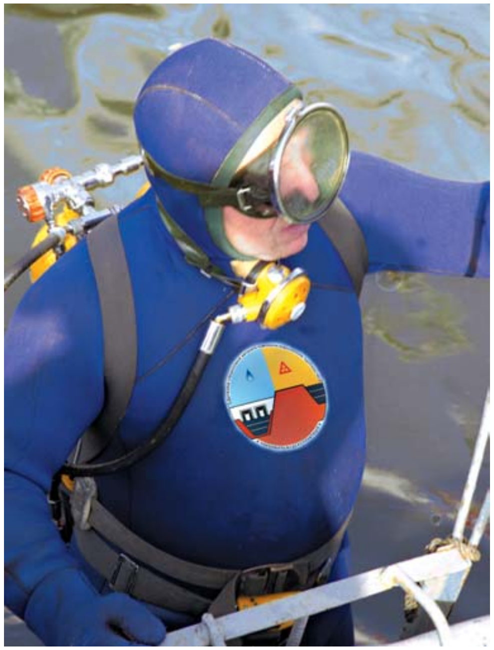
A State Department 'Administration of the Exclusion Zone and the Zone of Obligatory Resettlement' is responsible for managing the Exclusion Zone.

It coordinates the following activities:

- sanitary and fire–prevention measures in forests and fields
- medical and sanitary services for those working in the Exclusion Zone
- disposal of radioactive waste
- water protection measures
- scientific support to the work being done and scientific research
- advising the population about the ecological condition in the Exclusion Zone.

Exclusion Zone Administration

Inspecting water pools within the Exclusion Zone



Management of radioactive waste (radwaste) accumulated over the operating lifetime of a nuclear power plant is an important issue that is of great concern to the public. The future of nuclear energy is dependent on effectively solving this issue.

Radioactive waste management at the Chornobyl Nuclear Power Plant is particularly complicated because in addition to operational waste there are significant quantities of radioactive waste resulting from dealing with the aftermath of the accident.

Most of the work, related to decommissioning Chornobyl Units 1–3 and on the Shelter project is associated with radioactive waste management. This arises firstly from discharging and transporting spent fuel, removing and treating solid and liquid radwaste accumulated at the plant and decontamination of systems and structures associated with nuclear facilities. Significant volumes of waste in the form of excavated contaminated soils and construction material are accumulating due to Shelter stabilization activities and preparation of the sites for a new safe confinement. This is of course arises because the area close to the destroyed Unit 4 is heavily contaminated with radio–nuclides.

Special containers used for packaging radioactive waste

The objective of radioactive waste treatment is to protect the environment and people from exposure to radioactive elements. It is particularly important to avoid laying the immense burden of storage and processing of nuclear waste on the shoulders of future generations. Operation and systematic improvement of radwaste treatment systems existing in Ukraine is a means to meet this challenge.

Treatment of radioactive waste produced within Ukraine is carried out under the direction of the Ministry of Emergencies. The exception is waste originating from Chornobyl the treatment of which is organized and coordinated by the Exclusion Zone administration – a State Department of the Ministry of Emergencies.

Currently radioactive waste is stored at about 800 temporary sites throughout the Exclusion Zone. The total volume of waste is close to one million cubic meters containing around 380 000 curies of radioactivity. Two sites containing radioactively contaminated equipment and machinery used in the clean–up operations between 1986 and 1987 are also located within the Exclusion Zone. Solid low–level radioactive waste from the Chornobyl NPP site is sent to the Buriakivka repository, where 26 trenches out of 30 have already been filled.

Radioactive waste treatment requires strict conformity to safety standards

Construction of the solid radioactive waste treatment industrial complex

To solve the problem of radioactive waste treatment at the Chornobyl NPP site the liquid radioactive waste treatment plant (LRWTP) and the industrial complex for solid radioactive waste treatment (SRWTRIC) are being built with the assistance of the international community.

The LRWTP is planned with a design throughput of 2 500 cubic meters per year, the end product being solid residue encapsulated in cement mixes. Processing of the first batch of waste will begin in 2006.

The SRWTRIC will facilitate the removal of solid radioactive waste from existing storage and transfer it to a specially equipped surface storage facility for low-level and medium-level short-lived waste that is being constructed within the Exclusion Zone. It will incorporate a facility to sort and process the waste.

Monitoring radioactive waste

Interim storage site for contaminated soils

Resulting from the expanding work on decommissioning and transforming the Shelter into an environmentally safe system, the amount of radwaste with varying levels of radioactivity has increased significantly. Accommodating this waste requires more handling and storage facilities. Ukraine is financing the construction of interim storage sites for contaminated soil and solid high–level radwaste.

In compliance with the law of Ukraine the disposal of long–lived high–level waste, including fuel–containing materials from the Shelter, should be to storage facilities located in stable geological formations. There is no such facility in Ukraine. The National Academy of Sciences estimates that the design and research activities alone would take around 10–15 years and cost USD 600 million.

Remote monitoring of radioactivity in waste

Irrespective of national programs and international projects there is still no unified strategy to deal with all of the existing and increasing (due to decommissioning and Shelter activities) quantities of radwaste. The problem becomes more acute as time goes on.

In accordance with the Memorandum of Understanding and its resulting actions, three stages were envisaged to transfer the Shelter Object into an environmentally safe system. Within the framework of the SIP (Shelter Implementation Plan) only the first two need to be implemented.

This will result in Ukraine having a new confinement with a 100 years design life. This will initially facilitate the dismantling of unstable engineering structures of the Shelter Object.

Container of Shelter-derived radioactive waste prior to disposal

As to the removal of fuel–containing materials and other high–level radwaste from the Shelter Object, there are only conceptual ideas on how this could be achieved and on the cost and time implications.

But when the New Safe Confinement is in place, the ultimate safety of the Shelter Object can only be finally assured after removal of the fuel–containing materials and radioactive waste. Without this target the problem will not be solved; it will merely be shifted to the shoulders of the generations to come.

Implementing such a task is a necessary step towards the safety of the Chornobyl "sarcophagus". It is time for the international community to get involved right now.

Soviet experts delivered a detailed report on the Accident, its consequences, and the ameliorative measures at the IAEA experts' council in Vienna in August 1986. There a priority list of cooperative actions was developed featuring:

- Investigate the causes of the accident and its scope

- Estimate adequacy of the measures taken for population protection against radiation

- Increase the safety level of RBMK reactors and all nuclear power plants equipped with reactors manufactured by the USSR.

Cooperation in this direction continues up to now with the participation of Ukraine, together with international organizations including: IAEA, IRNS (France), GRS (Germany), and USA national laboratories (PNNL, BNNL, ANL).

The Shelter Object is of great interest to the international community

Global Problem
Calls for Global Cooperation

The Chornobyl accident led to the incentive to develop the 'Convention on Early Notification of a Nuclear Accident' and the 'Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency' adopted by the IAEA General Conference in Vienna on 26 September 1986. But it took some more years to persuade Soviet officials to abandon the policy of suppressing information concerning the real causes and magnitude of the accident and to disseminate information to the international nuclear community.

It was not until December 1989, that the USSR officially addressed international experts working under the auspices of the IAEA.

The former USSR Government requested support to carry out an international examination on the safety of the population living in the radioactively contaminated regions and to evaluate the effectiveness of the measures taken by Ukraine, Russia and Belarus.

Since then the number of participants cooperating on Chornobyl–related issues has steadily increased. Methods of cooperation have been improved and the necessity for joint efforts has been recognised both in Ukraine and in the world community.

Heads of USSR–based foreign embassies visiting a radiation measuring station in Kiev region shortly after the Chornobyl Accident

*The Director –General of the IAEA
Dr. Mohammed El–Baradei
at the Shelter Object. 2000*

In early 1990 the IAEA Secretariat initiated the International Chornobyl Project which stipulated international research into the radiological consequences of the Chornobyl accident on people and the environment.

The Chornobyl Project was managed by the International Advisory Committee that was established through the initiative of the relevant organizations of the UNO and the Commission of the European Communities .

In April 1990 the Permanent Mission of Ukraine to the United Nations together with the plenipotentiary representatives of the former Soviet Union addressed the UN with the request to include an additional item "Strengthening of International Cooperation and Coordination of Efforts to Study, Mitigate and Minimize the Consequences of the Chernobyl Disaster" to the agenda of the 1990 first regular session of the Economic and Social Council of the UN.

The positive response to the USSR request signalled the start of the wide–scale Chornobyl cooperation.

Although delayed, this cooperation brought in international practical and technical expertise to research the Chornobyl accident consequences. This included researching the technical, medical and social assistance given together with the rehabilitation of the population and territories that were affected by the accident consequences. This also gave other countries the opportunity to learn from the Chornobyl experience and incorporate this experience into their own emergency plans.

Humanitarian aid en–route to those impacted by the Chornobyl accident

Many young people visit the Social Psychology Center in Slavutych town

Since 2001 the UNDP Chornobyl Program has been carrying out intensive activities in the field of overcoming the social consequences of the Chornobyl accident by psychological and social rehabilitation of the population residing in contaminated territories.

Its Chornobyl Program portfolio includes:

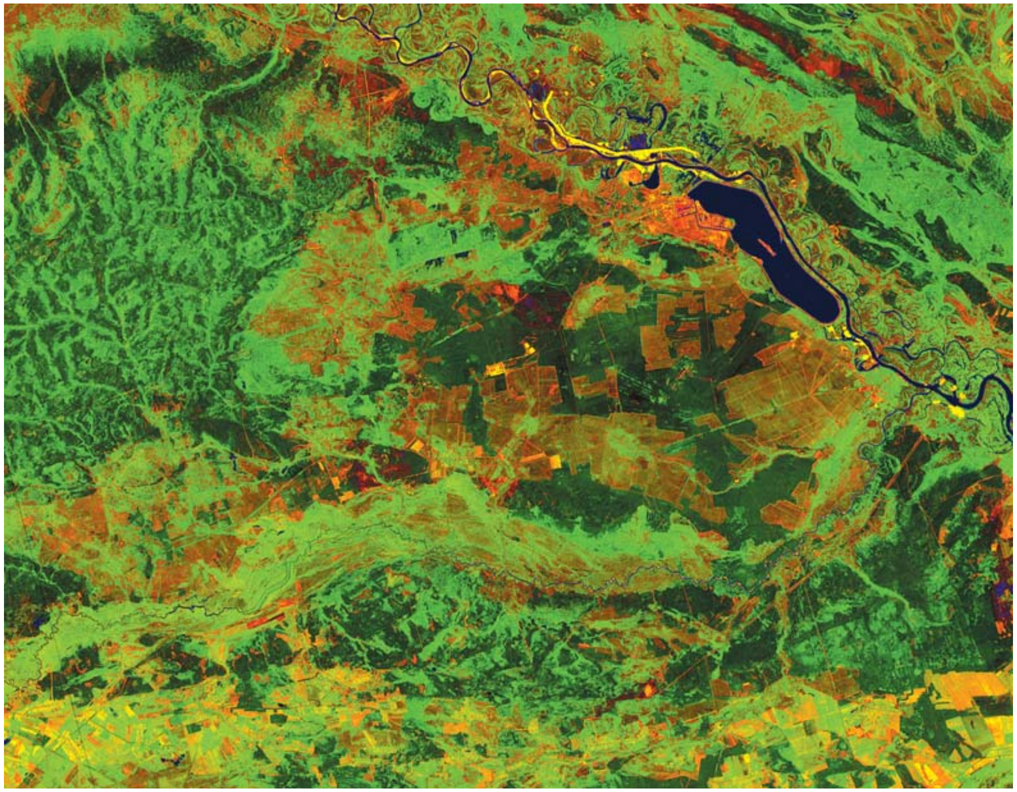
- Establishing the social and psychological rehabilitation centers
- Projects promoting local initiatives to overcome existing problems
- Information projects
- Supplies of medical and diagnostic equipment.

Specialists of the Social Psychology Center carry out sociological research among the population from contaminated areas

Global Problem
Calls for Global Cooperation

Organization of joint international research by the European Commission and the affected states of Ukraine, Belarus and Russia contributed greatly to solving the whole complex of Chornobyl problems.

A map showing the distribution of radioactive contamination in the Chornobyl Exclusion Zone



Prominent scientists from nearly 200 institutions participated in the research projects. Sixteen projects related to designing an atlas of radioactive contamination in Europe; regularities of secondary transfer of radionuclides and their migration in the natural environment and into food chains; analysis into the pathways and effects of human radiation exposure and diagnosis of the medical effects of radiation and their early detection and treatment. These were accomplished over a four–year period between 1992 and 1996.

Results from these projects are now widely recognised in the areas of radiation protection of populations and radiation medicine. All the results were discussed at the International Conference in Minsk (1996) and published in prominent national and international scientific editions.

The influence of radiation on human health is of special interest. Since 1992 intensive international cooperation in the area of research into the medical consequences of the Chornobyl accident has continued. This research is being conducted under the auspices of the WHO, IAEA, Commission of the European Communities programs and within the programs of cooperation with research institutions of the USA, Japan, Germany, the UK, Italy, France and other countries.

The main directions of cooperation are as follows:

- Establishment of data banks of neoplastic tissues of thyroid gland in each of the three countries (Ukraine, Belarus and Russia) to be used by different research groups.

- Creation of the database on the medical consequences of the accident including oncological and haematological diseases, physical and mental health of accident liquidators.

- Definition of the different radiation dose pathways in the populations living in contaminated territories.

- Comprehensive research of cancer and other diseases of the thyroid caused by radiation.

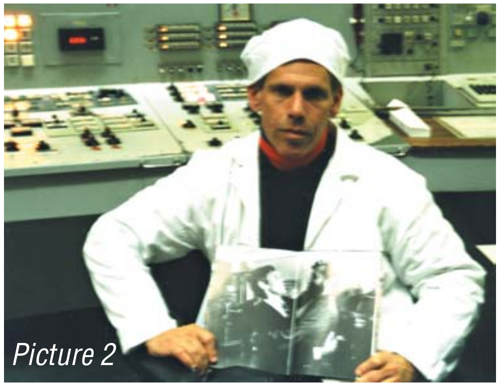
- Comprehensive research into the different oncological diseases and their possible correlation with the influence of radiation.

- Comprehensive research of different diseases of the haematogenic system and their possible correlation with the influence of radiation on the human body.

Advanced diagnostic and medical equipment was supplied to all three countries. This facilitated examining and monitoring people exposed to radioactive contamination and those living in the contaminated territories.

Picture 1. Control of radioactive contamination of food products

Picture 2. Doctor Robert Gale visited the Chornobyl NPP on the 10th anniversary of the Accident. 1996



International organizations and countries that assisted Ukraine in solving the Chornobyl problem did their best to relieve the life of hundred thousand people, who suffered from the Chornobyl accident.

This fulfilled the humanitarian mission brought to life by goodwill and human values. People provided humanitarian assistance in many ways such as through supplies of medicines, food and clothing.

Thousands of children who survived the Chornobyl accident were given a chance to get necessary treatment in France, Germany, Spain and the UK. Since 1990 more than 20 000 Ukrainian children have visited Cuba under the 'Republic of Cuba to Children from Ukraine' assistance program.

Medicine, food and clothes for those who suffered the Chornobyl disaster were sent from all over the world

People affected by the Chornobyl Accident on the way to Checkoslovakia for rest and recuperation

The French–German Initiative (FGI): 'Chornobyl Results and Their Implication for Man and Environment' was a significant milestone in international cooperation. It was aimed at the collection, unification and reconciliation of a wide range of scientific data on the accident consequences and on the efficiency of the counter measures.

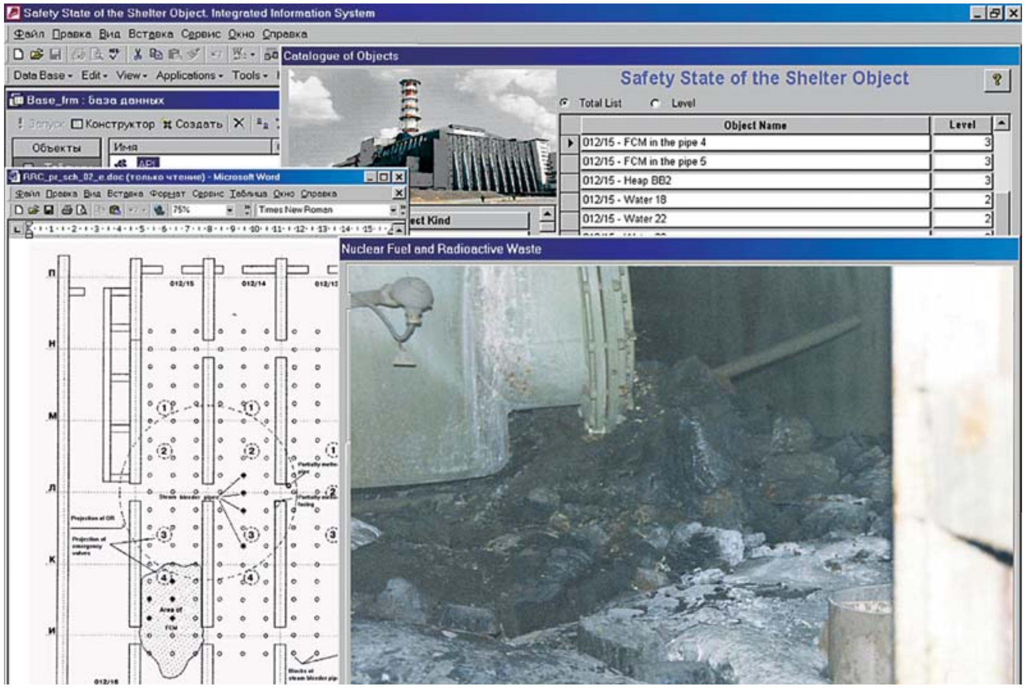
Institut de radioprotection et de surete nucleaire (IRSN, France) and Gesellschaft fur Anlagen– und Reaktorsicherheit mbH (GRS mbH) Germany) were in charge of the FGI Program implementation. The Chornobyl Center for Nuclear Safety, Radioactive Waste and Radioecology coordinated the activities of the research centres, laboratories and institutions from Russia, Ukraine and Belarus participating in the FGI.

The FGI comprised three sub–projects:

- Sarcophagus Safety
- Radioecological Consequences of the Accident
- Medical Consequences of the Accident

The FGI Program resulted in the creation of the integrated databases for all main aspects of the assessment and minimization of the accident consequences. Data related to the assessment and minimization of the Chornobyl accident consequences is now available for both domestic and national scientific communities.

Example of information held on the database of the "Sarcophagus Safety" project. It was created within the framework of the French–German Initiative



Global Problem Calls for Global Cooperation

The Chornobyl Center in Slavutych

The International community was eager to have access to the unique Chornobyl site and learn from the experience of overcoming the consequences of the world's worst civil nuclear accident.

The huge variety of issues to be addressed by a large number of participants called for the establishment of effective mechanisms of cooperation that would provide for:

- Effective utilization of the international technical assistance in the field of nuclear and radioecological safety
- Accumulation of the scientific and technical experience and technologies developed under the international cooperation for further practical use
- Concentration of the scientific knowledge on the causes and consequences of the Chornobyl accident.

On 26 April 1996 the 'Memorandum of Understanding between the Governments of the USA and Ukraine' was signed and provided the necessary mechanism to establish the International Chornobyl Center (ICC).

In due course the UK, Germany, France and Japan joined the ICC.

The Chornobyl Center represents Ukraine in the ICC.

Participation in ICC activities is based on bi– and trilateral interstate agreements. The mechanisms of participation are very flexible: each country–participant defines its own format and scope of participation. The ICC has its Consultative body, the Council of Members.

The effectiveness of this vehicle is evidenced by the ten–year period of ICC's activity. During this period nearly 100 nuclear safety and radioecological projects have been implemented, and their results are widely used by Ukrainian and international scientists.

Chornobyl Center experts working on an international project on decommissioning

Early days of Slavutych construction

Construction

The issue of constructing a new town for energy specialists working for the Chornobyl Nuclear Power Plant was first raised in May 1986 when it became clear that Pripyat had been lost forever and the plant would continue operating.

The Governmental Commission managed the process of determining the future town siting. It was necessary to take into account not only the radiation factor but also a range of manufacturing, ecological and psychological requirements. There was one ultimate requirement: the town should be located outside the 30–kilometer zone. After a long feasibility study the proposal to locate the town next to the Nedanchychi village (Nerafa railway station) in the Chernihiv Region (Oblast) was put forward.

On October 2, 1986 the Cabinet of Ministers of the USSR approved the resolution of this issue. Site work started on October 15, 1986, when the builders began to erect premises for construction organizations and accommodation for the builders themselves. This date is therefore considered as the beginning of the construction of Slavutych.

A bird's–eye view of Slavutych

The selected site was 50 kilometers from the Chornobyl Plant and already had the necessary railway infrastructure, but the radiation level did not meet safety requirements. To reduce the level of background radiation to an acceptable level a number of measures were taken including deforesting, removal of the upper soil layer and planting new trees.

Construction organizations from Ukraine, Russia, Lithuania, Latvia, Estonia, Georgia, Armenia, and Azerbaijan took part in the town construction. The first stage of construction was completed just over two years later and in 1988 the first Slavutych inhabitants moved in.

The first dwellers of this new town for power workers and their families

Celebrating the start of holidays in Slavutych

Current Situation – Problems and Solutions

Currently, the population of Slavutych is approximately 25 000 people of 49 nationalities. Average age is 30 years. Nearly 9 000 residents are children below 16 years old.

An educational system that meets the educational requirements of all the town inhabitants has been established.

Slavutych is a new town and it sets its own traditions.

This is evidenced by cultural and sports events in Ukraine, Europe and on the wider international scene by performing art groups, musicians, dancers and champions from the town representing numerous sport teams.

Slavutych has hosted the "Slavutych Golden Autumn" International Festival of Children's Arts and Media for 12 consecutive years. Children are the focus of special attention because they constitute a third of the town's population.

"Healthy Towns", a project of the World Health Organization, is being implemented in the town.

Slavutych is a mono–functional town. It was designed and constructed for the Chornobyl Power Plant employees and the plant was the sole employer for the town. Annually the Chornobyl Plant allocated USD 10 – 15 million of its energy sales revenue towards the town development.

After the plant shut–down in 2000 Slavutych authorities faced the problems of maintaining the social infrastructure, retaining jobs and finding new diverse opportunities.

In 1997 local authorities, together with the town public, developed the Slavutych Action Plan. It was developed under the auspices of the TACIS project and stipulated the following:

- Legislating to mitigate the social and economic consequences of the Chornobyl Plant shut–down
- Creation of compensatory jobs
- Assistance in developing small and medium businesses
- Facilitation of the social activity of Slavutych inhabitants.

Slavutych today

In 2001 the Cabinet of Ministers of Ukraine approved the following documents aimed at the mitigation of the social and economic consequences of Chornobyl Plant shut–down:

- On Provision of the Additional Governmental Guarantees to Employees Dismissed Upon the Ahead– of –Schedule Shut–Down of the Chornobyl Nuclear Plant

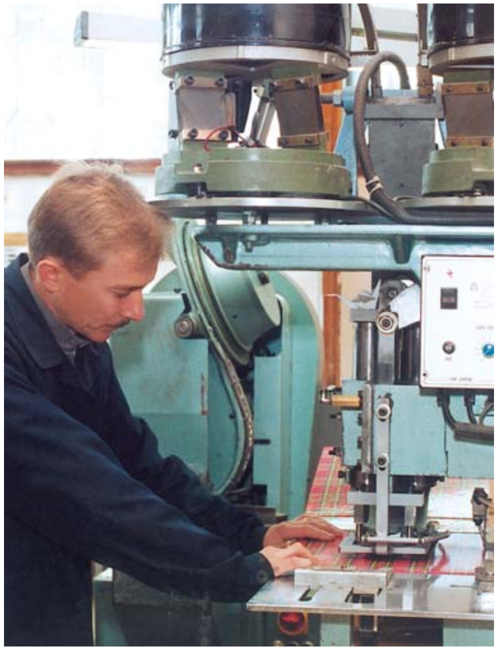
- Program of Creation of Additional Jobs for the Chornobyl Plant Employees Made Redundant After the Ahead–of–Schedule Shut–Down of the ChNPP and for Other Slavutych Inhabitants

- Program for the Social Protection of the Chornobyl Nuclear Plant Employees in Connection with the Plant Shut–Down.

Since 1995 nearly 20 international projects aimed at promoting business and attracting investments have been implemented in Slavutych. Due to this cooperation compensatory jobs were created in the town. Among those that actively participated in the projects were TACIS, BIZPRO, USAID, UCAN, UNDP, and the Department of Trade and Industry (UK) and the U.S. Department of Energy.

Children – the future of Slavutych

Perspectiva – one of the first acting enterprises to take advantage of the Special Economic Zone "Slavutych" – produces stationary



*The Kronpack factory.
New companies – key to the future prosperity of Slavutych*

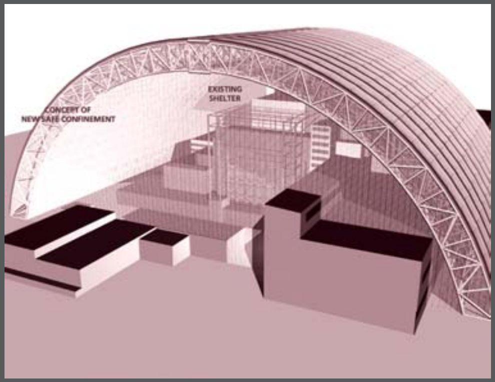
To create a market and to provide services for other companies associated with the nuclear industry the "Atomremontservice" enterprise was established based on the Repair and Maintenance Department of the Chornobyl Nuclear Power Plant. Currently it employs more than 700 people; more than 300 are ex–Chornobyl Nuclear Plant employees.

Establishing utility enterprises to provide support facilities for Slavutych helped significantly towards solving the employment problem of service staff at the plant.

The Law of Ukraine "On Establishment of the "Slavutych" Special Economic Zone" laid down special terms and benefits for start–up companies, which attracted investments and increased the number of jobs in the town.

Slavutych facilitates the development of small and medium businesses and implements innovative projects. Currently, Slavutych is rated #1 in attracting per capita investments, which equal USD 1 270 for the period since introducing the "Slavutych" Special Economic Zone. Small and medium businesses account for 33% of the town's budget and the financial dependence on income from the ChNPP has dropped from 99% to 40%.

Nuclear Safety for the Future



After the accident to Unit 4 of the Chornobyl Nuclear Power Plant in 1986 the world attitude towards nuclear energy deteriorated. Consequently some countries decided to cancel their nuclear energy development programs.

Nuclear energy became a political issue in many countries with moratoria on nuclear energy development programs initially imposed and then lifted. This disrupted safety improvement activities and slowed down modernization of the nuclear industry.

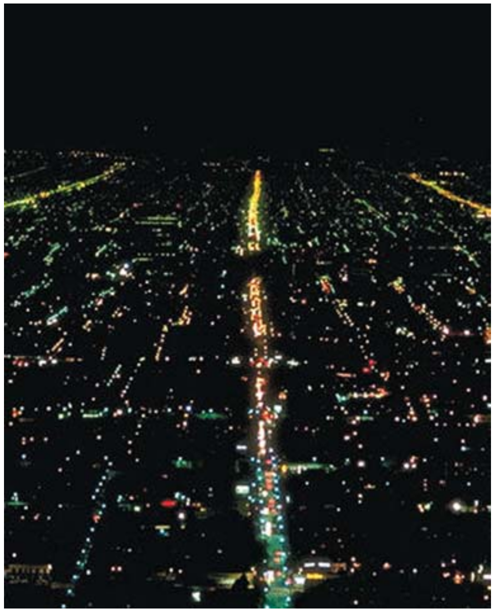
According to the UN, nuclear output rose by just 7% during the 1990's compared to 24% in the previous decade. In 2001 only one power unit was put into operation world–wide and for the first time in decades no new power units were ordered.

Eventually reason prevailed and new plant designs emerged that incorporated lessons learned from the scientific analysis and research of previous accidents.

Perspectives for World Nuclear Energy Production

Taking a realistic view it is now clear that the Chornobyl syndrome has been overcome. World interest in nuclear energy is being reawakened as realization grows of the contribution that nuclear power can make in helping to solve energy problems.

Energy consumption will continue to grow at the rate of two percent each year. As the Earth's population increases and the economic development of many countries expands energy consumption will accelerate.



Experts assess that nuclear energy will play a significant role in meeting mankind's energy demand in the future. This is particularly so in view of the threat of climate change caused by the greenhouse effect resulting from the burning fossil fuels.

The cost of electricity production by nuclear power plants is between 10% and 20% less than that of coal and gas–fired generation.

Reserves of uranium and thorium are sufficient to provide for the large–scale, long–term development of nuclear power. Moving to fast neutron technology will increase this resource by 60 – 70 times.

Currently, nuclear energy provides 17% of the world's electricity production. Forecasts by the IAEA are for a rapid increase in the development of nuclear power over the forthcoming years. Some experts believe that by 2030 nuclear energy's share will reach 25%.

Nuclear power plants produce nearly one third of all electricity in Western Europe.

In some countries such as Lithuania, France, Belgium, and Slovakia nuclear energy dominates and its share is more than 50% of total electricity production.

In Ukraine nuclear plants produce nearly 52% of total electricity production.

Canada, Japan and several other developed countries are also experiencing a nuclear renaissance.

Experts evaluate that Asian countries will increase their nuclear power capacities significantly. Over the last 20 years, Asia has accounted for 22 out of the 33 reactors that were put into operation. China, India, Japan, and South Korea have been the most active in building new power plants.

Suspended nuclear power plant construction projects in Bulgaria and Slovakia have been restarted again. Finland has started construction of a new nuclear power plant (Olkiluoto). France has announced the decision to construct two more power units at the (Flamanville site). Plans to construct new nuclear plants are being considered by Turkey, Poland, Argentina, and Brazil.

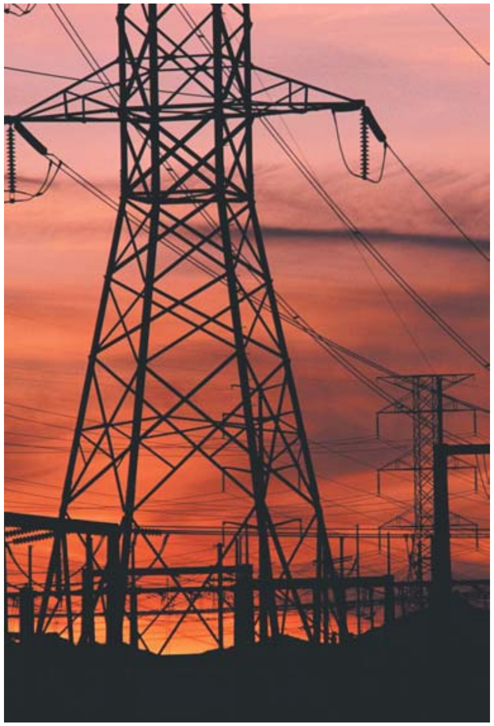
The law on energy development in the 21st century that makes particular reference to nuclear power has been adopted in the USA. By 2010 the construction of 4 – 6 new power units is expected to start.

The Prime Minister of the UK has officially announced an energy review in which nuclear energy development is paid particular attention.

Perspectives for World Nuclear Energy Production

Experience in operating nuclear reactors throughout the world has been accumulated over many years. The most common reactor and therefore the type on which most experience has been gained is the Pressurised Water Reactor (PWR). This, therefore, is the preferred option for most countries.

Regular safety re–assessments on nuclear units have led to the granting of operating life extensions beyond those initially designed. In the US, life extensions from 40 to 60 years have been authorized on 20 units. Similar extensions to operating lives are expected to be applied to practically all other power units.



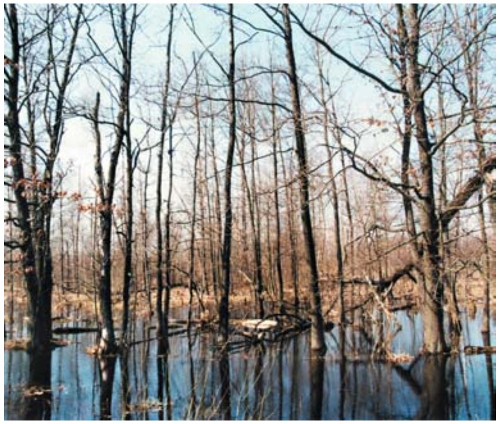
In Russia, the operational life of five nuclear units has been extended.

Nuclear energy experts believe that the 21st century will witness a renaissance of world nuclear energy due to its safety and efficiency improvements.

The effects of radioactive contamination in Ukraine have steadily decreased over the 20 years since the Chornobyl accident. This is due to the natural decay of radionuclides, measures taken to limit exposure to radioactivity and to the creation of safe living environments within the contaminated territories.

But even today radioactive contamination within the Exclusion Zone affects every aspect of the environment.

Due to the redistribution and migration of radioactive nuclides, new secondary sources of contamination are emerging and their impact on the environment beyond the Exclusion Zone is difficult to predict.



The Exclusion Zone will continue to be contaminated for many years. This represents a potential danger to people living within, or close to, the Exclusion Zone. For this reason one of the most urgent tasks to be addressed is to gain, through a comprehensive research program, a thorough understanding of the complex processes involved in the transport of radionuclides through the environment. There is no uniform pattern to the distribution of radionuclides throughout the Exclusion Zone.

Radioactively–contaminated areas are as likely to be found at the outer edges of the Exclusion Zone as they are close to the Chornobyl Power Plant. This, and the lack of defined methodology on assessing the suitability of land for agricultural use together with gaps in legislation, means that it is difficult to make decisions on rehabilitation projects and on returning the area to economic use.

Paradoxically, the challenges faced in overcoming the consequences of the Chornobyl accident have presented new opportunities for the world's community.

Studies into the distribution of radionuclides during the initial period of the accident are of value to simulations not only for nuclear accidents but also of the consequences of terrorist acts.

For example, in planning actions to counter potential nuclear–related terrorist threats, the experience of evacuating more than 100 000 people and further resettling around 300 000 is particularly useful. The same holds true for the know–how gained through regularly monitoring the health of three million people – accident liquidators, evacuees and those who live in contaminated areas.

For forecasting the effects of a so–called 'dirty bomb' and planning counter–actions, the study of the impact of different radiation doses on large populations is of paramount importance.
The Chornobyl Exclusion Zone represents a unique test facility where it is possible to study:

- Methods of early diagnosis of radioactive contamination
- Means of personnel and population protection in case of emergency
- Methods of decontamination and deactivation of residential areas/settlements
- Methods of restoring contaminated areas for the production of clean agricultural products and livestock
- Joint exercises by emergency services under realistic radiological situations.

There are many different facets to international cooperation but currently one of the most important is the issue of collective security. Within this sphere nuclear safety is paramount due to the trans–boundary risks that could be posed by a serious nuclear accident.

The Chornobyl accident showed how such an event could have world–wide implications. Norms and requirements governing nuclear power plants safety are set up by international conventions and agreements to which Ukraine is a party and by the nuclear–related legislation of individual states.

Apart from concentrating on new nuclear plants and nuclear fuel cycles a common international trend is the optimization of operational capabilities of existing nuclear plants. This includes upgrading technical characteristics, life–time extensions, developing innovative technologies, and improving economic performance.

Public attitudes to nuclear power will be influenced by proven high standards of operational safety, reduced volumes of radioactive waste and by minimizing radioactive discharges into the environment.

In November 2002 the European Commission approved proposals for a new "nuclear package" that required the introduction of common nuclear safety principles which are currently the responsibility of the member–states. It confirmed existing standards related to safety and monitoring that comply with the principles and provisions of the IAEA and also the Western European Nuclear Regulator's Association (WENRA). The proposals aimed to set up an EU–wide approach to investment in nuclear projects, radioactive waste disposal and decommissioning funds. Utilization of the funds was intended to ensure that arrangements for the final decommissioning and for the treatment of nuclear waste from nuclear installations were the safest possible.

Nuclear energy provides 52% of Ukraine's electricity supply. This positions Ukraine amongst the world leaders in nuclear power production.

Recognizing the complexity of nuclear safety issues, Ukraine actively participates in the international arrangements for nuclear non–proliferation and counter–terrorism. The country is moving ahead to further improve its nuclear safety standards through Ukrainian legislation that conforms to European standards.

The role of nuclear power in the world economy will depend on how effectively the issues of handling radioactive waste (RAW) and the physical protection of nuclear materials is resolved.

Addressing these issues is particularly relevant to Ukraine that has significant accumulations of spent nuclear fuel and RAW, 90 per–cent of which is concentrated in the Chornobyl Exclusion Zone. The total amount of RAW to be disposed of could amount to 3–4 million cubic meters, 75 000 of which are to be placed in geological storage.

The issue of handling long–lived and high–level RAW has implications for nuclear energy throughout the world. Strategies being considered in Ukraine include constructing final disposal storage facilities in geological formations and transmutation (destruction by fast neutrons). In compliance with the new "nuclear package" a resolution on radioactive waste management is being proposed within the EU.

In accordance with this resolution, member countries would be required to give priority to the issue of geological disposal. Potential sites for RAW disposal are to be determined by 2008 with availability of facilities by 2018. EU member–states are also obliged to provide low–level RAW storage facilities.

The Chornobyl accident badly impacted on the health of liquidators, other affected people and their children that were born after the accident. The worsening economic situation in the Exclusion Zone, psychological tension and the radiation factor still continue to have negative impacts on the population's health. That is why providing a high standard of health care supported by appropriate medical research is a priority for the near future.

Constant monitoring of the health of these people can provide new scientific data on the radiation impact on humans. The application of this acquired knowledge to radiation safety will be of benefit to the nuclear industry in Ukraine and world–wide.

Diet that includes antioxidants and radioprotectors is important to the health care of the affected population. Treatment at health resorts and education programs on healthy life styles are also essential. Healthy living is stipulated by the Health Promotion Strategy that is implemented by the World Health Organization (WHO) in its public education campaign on health care with special emphasis on radiological safety.

To reduce the amount of radionuclides that people ingest with their food it is necessary to continue working to develop safe methods of reclaiming previously contaminated land for domestic and agricultural use and for breeding and rearing livestock within these territories.

Social protection of the population that suffered the consequences of the accident is of no less importance. Currently, people living in the contaminated territories receive several types of social benefit, namely: recreation and treatment programs at reduced costs, preferential taxation and additional payments to those who live in the contaminated territories. In future it will be necessary to maintain social aid, but with the emphasis on social rehabilitation.

Increasingly people from contaminated territories are demonstrating an understanding that the future lies in their own hands by becoming more personally involved in solving social problems. Today's challenge is to encourage these people to widen their skills, develop new businesses and engage in non–agricultural manufacturing.

Scientists from many countries studied the consequences of the accident, but the research was not adequately coordinated. As a result a wealth of valuable information was fragmented with different countries and organizations each retaining the results of its own research. Consequently the wider scientific community was denied access to much of the available data. The important task of the next phase in mitigating the consequences of the Chornobyl accident is to maintain comprehensive databases that consolidate accumulated information on the accident, its consequences, the lessons learned and experience gained.

There is a lack of authentic information on the accident elimination and on the on–going and completed projects at the Chornobyl site. Different target groups, such as decision–makers, medical practitioners, journalists and the general public also feel that there is a lack of information tailored specifically to their specialized needs.

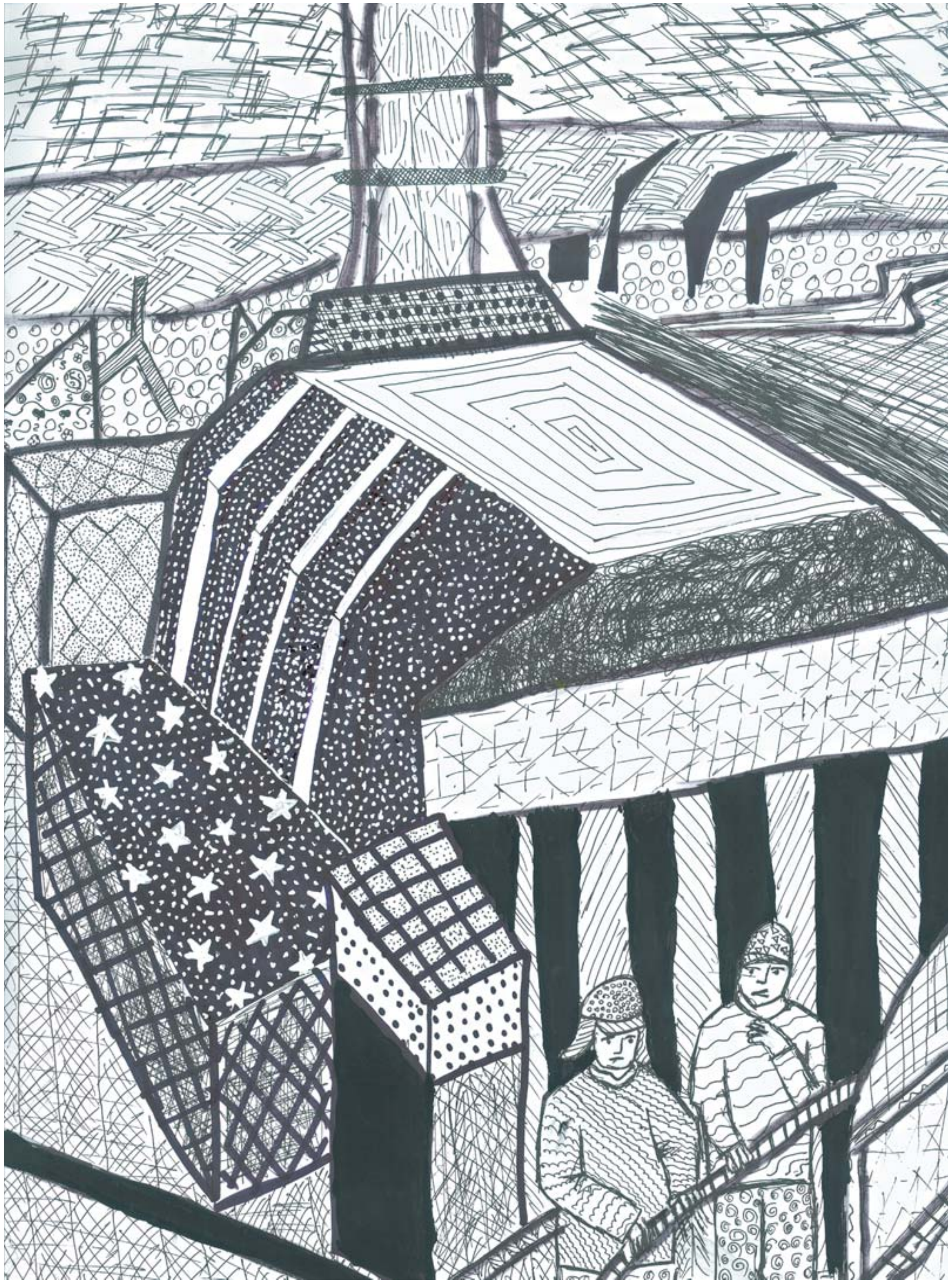
This calls for the organization of the access to and exchange of information between different target groups. These include scientists, politicians, nuclear industry experts, public organizations, NGOs, etc. International conferences and workshops, such as the international conference on "Health and Environment: Global Partners for Global Solution" *(www.worldinfo.org)* and International Science Workshop "Radioecology of the Chornobyl Zone" *(www.chornobyl.net)* may become a good vehicle for such an information exchange.

As Children See It

Shevchenko Hanna "We remember…"

Syrbu Oksana
"Shelter Object Enhancement"

Kondratenko Denis "My Dad at work"

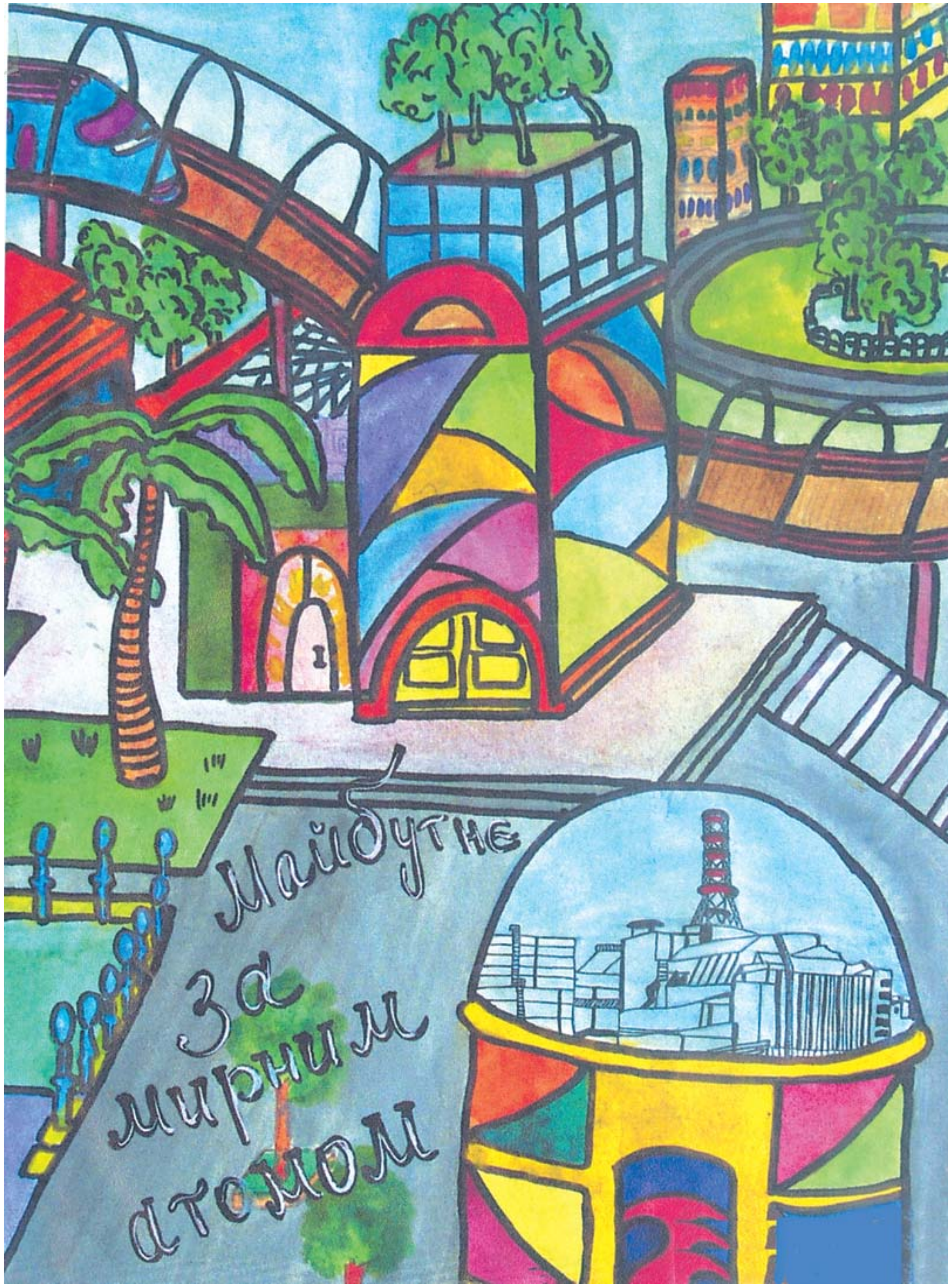


Pupils of the Arts School "Aqua"
"Shelter Object Construction"

Gladyr Olga
"My father works at the ChNPP"

Mishchuk Darya "Peaceful atom – is the future"

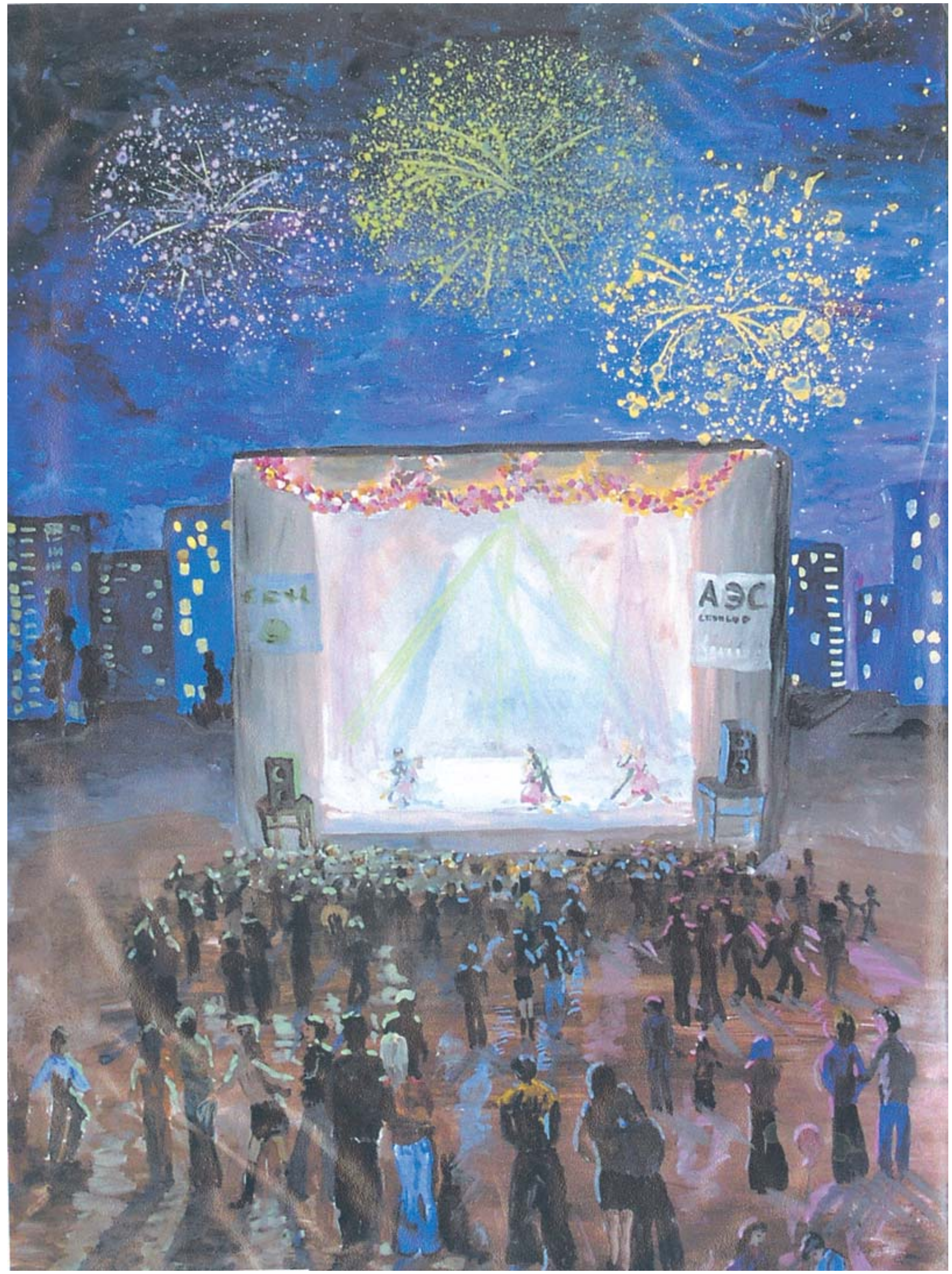
Svarychevska Julia "We need much strength to make Ukraine flourish"



Gavryshchuk Alina
"Peaceful atom – is the future"

Gladneva Yana "Slavutych – Pripyat"

Gladneva Yana "Atom – the life of Ukraine"



Pupils of the Arts School "Aqua"
"Holiday in Slavutych"

Novoselskaya Darya "The Chornobyl Center"

Pupils of the Arts School "Aqua"
"Evening in Slavutych"

Semikopova Tetyana "My favourite quarter"

Teteryna Hadiya "My dear angel! Take care of Slavutych"

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UKRAINE AND THE WORLD: THE CHALLENGE OF CHORNOBYL

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