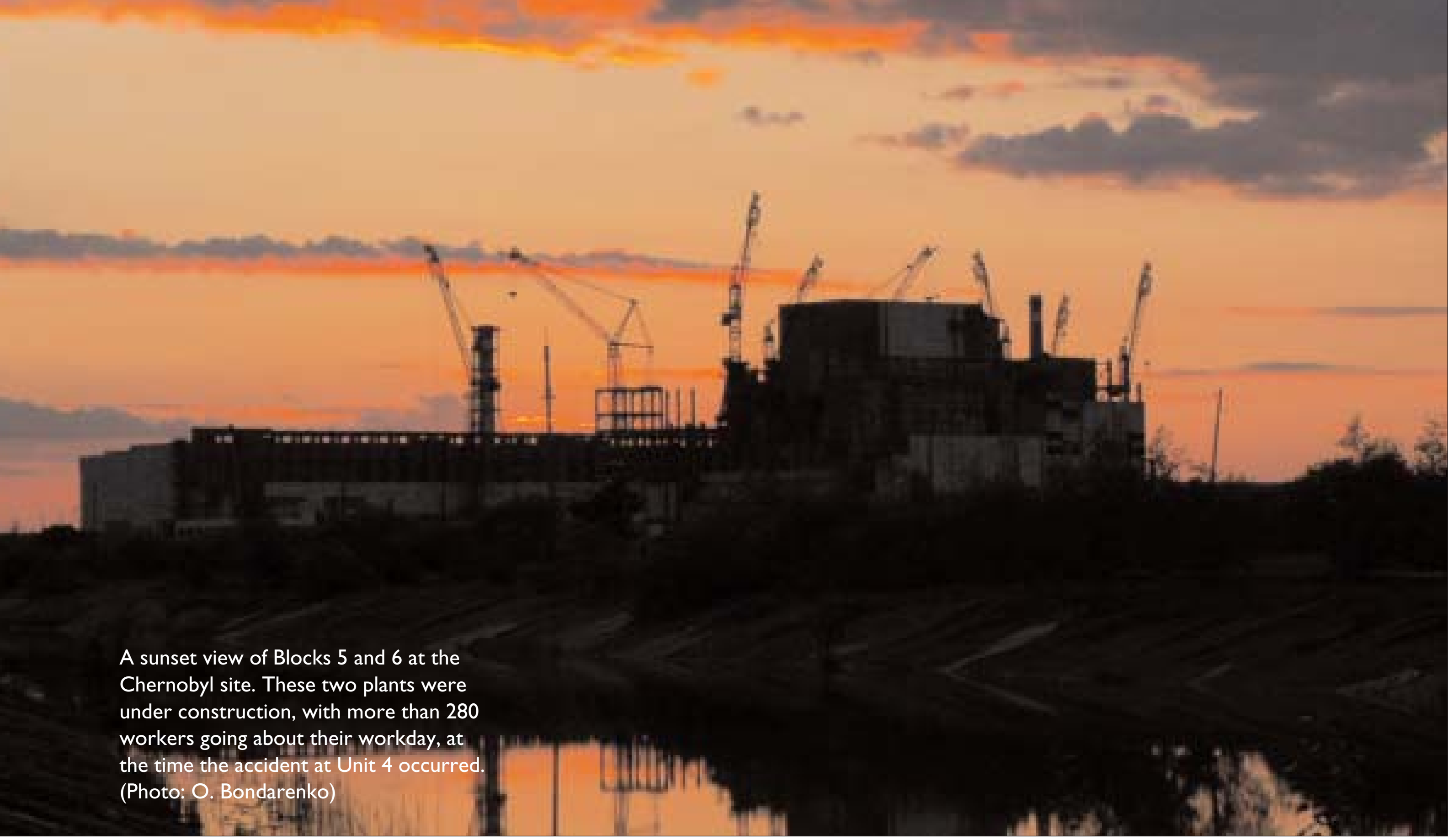


A sunset view of Blocks 5 and 6 at the Chernobyl site. These two plants were under construction, with more than 280 workers going about their workday, at the time the accident at Unit 4 occurred. (Photo: O. Bondarenko)

Chernobyl: Transforming an icon

BY DICK KOVAN

Twenty years after the accident at Chernobyl, stabilizing the shelter over the ruined reactor and protecting human health are top priorities.

THIS MONTH UKRAINE will commemorate the devastating explosion that occurred at Chernobyl on April 26, 1986. A powerful icon of that day is the massive, oddly shaped structure built on and over the rubble of the destroyed Reactor Number 4. The "Shelter," which is also known as the "Sarcophagus," confines some 95 percent of the plant's original radioactive inventory.

Other powerful images of that event come from the Chernobyl Exclusion Zone, the 30-km area around the plant that was heavily contaminated and whose population was evacuated. Striking pictures of damaged forests and farmland were later added to by images of a renewed but wild landscape teeming with vegetation, with only a few inhabitants, mostly older people—dubbed "self-settlers"—who were desperate to return to their homes, no matter what the risk.

Soon the Chernobyl icon will disappear from view beneath a new structure, the New Safe Containment (NSC), designed to protect the old, decaying Shelter and allow the complete dismantlement of the wreckage beneath. The images of the highly contaminated Exclusion Zone, however, are likely to remain for many more decades.

Despite the devastation of Unit 4, the other three units were still able to operate, and the station continued to produce power for another 14 years despite calls from around the world for their immediate shutdown.

Nevertheless, the international community was eager to help and immediately came to the aid of the people at the reactor site, as well as those living in the region. Many activities were initiated to help deal with the immediate aftermath, while cooperation mechanisms were established to deal with the long-term human and environmental consequences of the catastrophe. As long as Chernobyl remained the responsibility of the Soviet Union, until its breakup in 1991, international assistance was channeled primarily through United Nations agencies, which are still very active on many fronts.

The fall of the Soviet Union changed the situation. The newly independent Ukraine, whose economy was now even more desperate, needed a lot of help to deal with Chernobyl. Many international offers to assist with the long-term environmental consequences of the accident and to deal with the safety of the Shelter were easily implemented. Some offers, however, had strings attached that Ukraine found difficult to accept. For example, it was not willing to close the operating units at Chernobyl.

Calls to close down the operating plants were led by the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States), along with the European Commission. Eventually, a Memorandum of Understanding was signed with Ukraine on December 20, 1995, in Ottawa, by which the G7 promised economic help, including the financing of

ACKNOWLEDGEMENTS: Information for this article was collected from the magazine Insight*, the International Chernobyl Centre Journal (Issue 1(15), 2006), and from the Web site <www.chnpp.gov.ua/eng/index.pho?Ing=en>, a Ukrainian government site that provides news and details about the accident at Chernobyl and the work already done and in progress at the site. Thanks go also to Dr. Oleg Bondarenko, director of the State Specialized Scientific Enterprise Chernobyl Radioecological Centre, for the information he provided on the EcoCentre, and Ms. Ingeborg Hohe-Dorst, of Genitron Instruments, for her help in forwarding information and photographs for use in the article.*

power sources to replace lost Chernobyl capacity, in return for closing the station. Subsequent negotiations over Ukraine's demand for help in financing the construction of two uncompleted nuclear power units (Khmel'nitskiy-2 and Rovno-4), however, did not come to an agreement.

Ukraine finally shut down the last production unit at Chernobyl in 2000. The Ukrainian government was then faced with the task of dealing with the site, managing the nuclear waste and spent nuclear fuel, decommissioning the reactors, and making the Shelter safe. It also had to deal with the social and economic consequences of the disaster, including the maintenance of the region's infrastructure—especially providing livable conditions for the thousands of people needed to operate the plant and ensure the safety of the entire site, including the Shelter and all that it contained.

While the negotiations over the nuclear issue continued, substantial international help was forthcoming. Since 1995, the decommissioning of Chernobyl Units 1–3 has been supported by the world community through the Nuclear Safety Account, which is managed by the European Bank for Reconstruction and Development (EBRD). Separate from that, a strategy for dealing with the Shelter, called the Shelter Implementation Plan (SIP), was devised.

Workers do preparation work for the stabilization of the western wall. (Photo: *Insight*)

The SIP, which is the largest project being undertaken at Chernobyl, was developed in 1997 by a group of Western and Ukrainian experts as a road map for making the Shelter secure and environmentally safe and to provide a basis for international contributions. The SIP calls for stabilizing the Shelter by removing or strengthening unstable structures, constructing the new protective covering around the Shelter, and managing the radioactive waste. The SIP is financed through contributions from donor countries to the Chernobyl Shelter Fund, established in 1997 and managed by the EBRD.

By 2005, all major Chernobyl site infrastructure facilities and programs—radiation and industrial protection, medical training, and emergency response—had been completed. These facilities and programs ensure adequate protection during construction activities. Site services in the construction zone have been renewed and a clothes-changing facility constructed.

The SIP should reach a crucial point soon—the awarding of the contract for the construction of the NSC. Work can then focus on completing a detailed design and its licensing. The NSC is a massive construction project requiring untried skills and processes. The building of the structure also depends on the completion of stabilization work on the existing Shelter.

The stabilization project design was completed in October 2003 by a group of Ukrainian organizations called the KCK Consortium. The resulting contract to carry out the project was won by a Ukrainian/Russian consortium known as "Stabilization"—consisting of JSC Atomstroyexport, of Russia, and three Ukrainian companies—in July 2004. When completed at the end of 2006, it will eliminate one of the principal risks at the site: the collapse of the Shelter. For stabilizing the existing Shelter, an integrated monitoring system will be installed to survey the radiation situation, structural stability, and seismic

Although more than 100 000 people were evacuated from the area around the Chernobyl plant after the accident, some "self-settlers," including this woman and her dog, have returned to their homes in the Exclusion Zone, carrying on with their everyday lives. (Photo: *Insight*)

In the foreground, a new clothes-changing facility for contractors involved in the Shelter transformation activities. In the background, Chernobyl-4 enclosed in its sarcophagus. (Photo: *Insight*)

events. The program also involves substantial investments in waste management, site infrastructure, health and safety, and radiation protection.

The elimination of risks created by unstable engineering structures is a priority in the effort to transform the Shelter into an ecologically safe system. To date, two of the eight planned stabilization activities have been completed. The "Mammoth Beam," which supports structures on the south side of the Shelter, has been reinforced and stabilized, and the potential for deaerator stack collapse has been eliminated through the reinforcement of the previously installed support column props.

Personnel work under difficult conditions, which include year-round high humidity and uncomfortable temperature conditions, lack of circulating air, and insufficient and exclusively artificial lighting. The necessity of using individual radiation protection also causes physical and psychological problems for the personnel. But the main risk, of course, is exposure to radiation.

Finely dispersed radioactive dust containing transuranium elements, as well as large amounts of strontium-90 and cesium-137, is a specific kind of hazard found inside the Shelter. These radionuclides give off an extremely high radiobiological toxicity that can cause intense biological damage to human organs and tissues. The medical and biophysical condition of the personnel involved in the work is continuously monitored.

Once the stabilization is completed, construction of the NSC can begin. The NSC will confine radioactive material within the Shelter and isolate it from incoming rainwater. The Shelter will be protected from further degradation or collapse caused by adverse weather, and the environment will be shielded from the accidental release of radioactive dust.

The NSC's conceptual design was developed by a consortium of Bechtel (U.S.),

Information from the Exclusion Zone

Founded in 2000, the State Specialized Scientific and Industrial Enterprise Chernobyl Radioecological Centre (SSSIE EcoCentre) is a state enterprise of Ukraine located in the Kiev region on state property. It is overseen by the Ukraine Ministry for Emergencies and Affairs of Population Protection from the Consequences of the Chernobyl Catastrophe, which was established in 1996.

The EcoCentre is made up of two main governmental organizations: the Chernobyl Scientific and Technical Centre for International Research (CheSCIR), and the Scientific and Industrial Enterprise for Regional Monitoring of the Environment and Radiation Control (RADEC). The EcoCentre is best known for its work in the areas of radiation dosimetry and ecological radiation monitoring in the Exclusion Zone around the Chernobyl site. It also participates in local and international research work.

More specifically, the EcoCentre provides radiation dosimetry of personnel (internal and external irradiation and radionuclide levels), objects, territory, and transport vehicles and loads (including radiation sources and radioactive waste). Ecological monitoring includes observance of radioactive contamination from alpha, beta, and gamma emitters in the air or on surfaces, on the ground, in sewage and manufacturing wastewater, soil, flora and fauna, and foodstuffs in locations where "self-settlers" reside without authorization. Also constantly monitored are the parameters of the radiation situation in the Exclusion Zone through the use of an automated monitoring system that is soon to be updated.

Staffing at the EcoCentre, which is directed by Oleg O. Bondarenko, stood at 283 at the beginning of 2005, including more than 100 employees with a university-level education. The specialists at the facility have participated in the preparation of a number of instructional and technical documents on ecological and radiation safety.

Work regulations cover 109 different areas, including temporary radioactive waste burial sites in the Exclusion Zone. The EcoCentre maintains four stationary dosimetry control points, through which numerous transport vehicles pass each year.

Battelle (U.S.), Electricité de France (France), and the KCK Consortium. The design was reviewed by specialists and went through a public consultation process, and on July 5, 2004, the Ukrainian cabinet gave the go-ahead. The NSC will consist of an arch-shaped structure measuring 257 m wide, 150 m deep, and 108 m high. It will be assembled in a safe area near Unit 4 and then slid into position over the old Shelter via specially built rails. This method aims to minimize radiation exposure for workers on the site. The NSC is designed to provide a solid containment for the remnants of the reactor for at least 100 years and will be fitted out to undertake work to ensure confinement and to transform the old Shelter into an ecologically safe system, such as dismantling or reinforcing unstable structures, removing the remaining nuclear fuel and fuel-containing material, and undertaking radioactive waste management activities.

The equipment and structures in the NSC will include:

- Internal and external structures and access paths.
- Cargo-lifting and transport machinery.
- Life support and environmental control systems, clean pathways for personnel, and equipment and transport decontamination points.
- Equipment for fragmenting dismantled structures, and transport containers for contaminated debris and larger items.

The Elia preserve, lush with vegetation, located within the Exclusion Zone, on the border with Belarus. (Photo: O. Bondarenko)

The elimination of risks created by unstable engineering structures is a priority in the effort to transform the Shelter into an ecologically safe system.

Construction is now expected to begin in 2007, with completion in three to four years. Because of price escalation since the start of the program, the budget to complete the SIP is now at more than $1 billion and could easily increase to $1.25 billion.

International projects

In addition to the SIP, there are several other projects being carried out with international financial assistance, primarily through the EBRD-managed Nuclear Safety Fund, but also with the help of the U.S. Department of Energy and the European Commission. These include a second interim spent fuel storage facility (ISF-2), the Industrial Complex for Solid Radwaste Management, and the Liquid Radioactive Waste Treatment Plant.

Continued

Individual dosimetry covers approximately 6500 Exclusion Zone workers each year, and about the same number are monitored for cesium-137 content. The EcoCentre also provides written reports on radiation doses of people from Ukraine and other countries of the Commonwealth of Independent States.

The EcoCentre samples some 4500–5000 probes a year as part of its radiation-ecological monitoring program, and also performs 10 000–11 000 radionuclide analyses. The radiation-ecological monitoring in the Exclusion Zone covers 146 observation points (including personnel workplaces, landscape testing areas, hydrological points, near-surface atmosphere air sampling points, and radioactive fallout points), 138 groundwater observation wells, 11 settlements, and 28 points of the automated monitoring system.

Information about the radiation situation in the Exclusion Zone is provided to organizations and the general population through a variety of publications, including the *Bulletin of Ecological State of the Exclusion Zone and the Zone of Absolute Resettlement* and the newspaper *Visnyk Chornobylia*, mass media outlets, and an automated telephone system. Daily and weekly information is also provided to the appropriate government agencies.

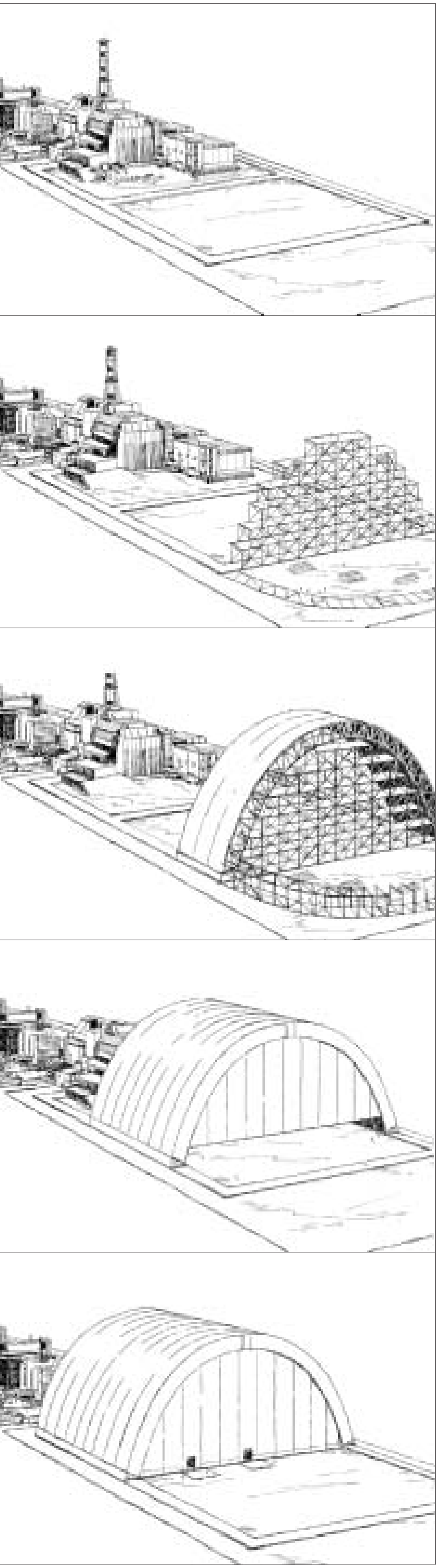
Monitoring system upgrade

Ukraine, with assistance obtained through the European Union's Tacis organization, will be upgrading and modernizing the automated monitoring system used in the Exclusion Zone at the Chernobyl site. The Tacis Program provides grant-financed technical assistance to 12 countries of eastern Europe and central Asia.

A contract awarded at the end of December 2005 to the consortium of Ukratom Instruments, of Ukraine, and Genitron Instruments, of Germany, covers a complete overhaul of the old radiation monitoring system. Specific updates include:

- 39 new dose rate sensors (to replace 29 old ones).
- Nine new aerosol samplers (to replace four old ones).
- Radio communication (to replace an old wire communication system) for data transmission between measurement locations and the central data unit.
- A new central unit.
- An aerosol monitor.
- A meteorological station.
- Modeling software.

It is estimated that the entire project will be completed by June 2007.



Left: The New Safe Confinement structure, which will be assembled in stages (as shown in drawings) near the destroyed Unit 4 reactor. It will slide over the old structure on rails, and will be fitted with equipment to disassemble the old shelter. (Drawings: NSC Consortium, with permission of EBRD)

While some delays have been experienced by these projects, the most critical concerns the ISF-2, which is needed to allow the prompt defueling of Chernobyl-3, as construction of the NSC cannot begin until then.

The ISF-2 is intended for the long-term (at least 100 years) storage of spent fuel assemblies and spent absorbers. The facility is needed because the existing spent fuel storage facilty (ISF-1) has insufficient capacity to hold all the assemblies from the three units. The ISF-2, therefore, holds the key to the start of decommissioning activities. The original turnkey contract was won by the French consortium of Framatome ANP/Campenon Bernard-SGE/Bouegues. As with most of these contracts, Ukrainian subcontractors undertake civil and erection work and manufacture the equipment.

Construction of the facility was suspended in April 2003 when design problems pertaining to fuel management were identified. A main concern was the safe handling of leaking fuel assemblies containing water. Because of the effect this would have on the rest of the site activities, plant engineers were forced to seek an alternative. With the help of Russian engineers, it should now be possible to store substantially more assemblies in the ISF-1 by using a more compact pattern. This will, however, be costly, because it will require a new safety case for allowing compacted storage, the manufacture of additional equipment, and greater radiation exposure to personnel. Eventually, the second facility will also be needed, as the service life of the ISF-1 will end in 2016.

The ISF-2 is intended for the long-term (at least 100 years) storage of spent fuel assemblies and spent absorbers.

The design and construction of the Industrial Complex for Solid Radwaste Management is being carried out on a turnkey basis by RWE Nukem, of Germany. Three facilities are incorporated in this complex, which is intended to manage material accumulated during operation of the station, as well as solid radwaste generated during decommissioning and at the Shelter. The three facilities are:

- A retrieval facility, where all categories of solid radioactive waste will be retrieved from the solid waste storage silo and loaded into canisters for transfer to the sorting facility.
- A sorting and processing facility, where all categories of solid radioactive waste will be sorted, and low- and intermediate-level waste will be processed. This facility will also provide interim storage for long-lived intermediate- and high-level radioactive waste.
- A specially equipped, near-surface disposal facility for short-lived low- and intermediate-level solid waste. This facility is located away from the station at the "Vector" complex within the Exclusion Zone.

Construction should be completed by the end of 2008.

The Liquid Radioactive Waste Treatment Plant deals with liquid radioactive waste accumulated during operation and decommissioning of the station, as well as operational waste generated at the Shelter. Liquid radioactive wastes are retrieved from existing storage facilities and are sent through a cementation process. Construction is being carried out on a turnkey basis by a consortium consisting of Belgatom (Belgium), Ansaldo (Italy), and SGN (France).

The Industrial Heating Plant, commissioned in 2001, provides a heat supply for the site following the shutdown of Unit 3. This includes hot water and steam production for operation of the spent fuel and radwaste management facilities and other equipment and systems remaining in operation, and for buildings and facilities. Construction had been suspended in 1993 for four years until the U.S. Department of Energy agreed to provide the needed funding for the plant's completion.

A Ukranian perspective

While the world remains focused on the 20th anniversary of the Chernobyl accident, another milestone—the fifth anniversary of the shutdown of Unit 3, the last operating reactor at the site—was reached on December 15, 2005. As described in *Insight* magazine (Issue 1(15), 2006), Ukrainian President Viktor Yushchenko paid a visit to the site to mark the occasion. His tour of the Exclusion Zone included a trip to the town of Chernobyl, where he laid flowers at the memorial to the heroic firemen who were the first to face and fight the severest nuclear accident ever.

Ukrainian President Viktor Yushchenko (seated, at center) discusses issues with Chernobyl staff in the Chernobyl-3 control room during his visit in December 2005, the fifth anniversary of that unit's shutdown. (Photo: *Insight*)

Yushchenko said that the man-made accident was a humanitarian catastrophe that has destroyed a whole "cultural cluster" in Ukraine. During his visit, discussions were held about the land recovery and the preservation of the local Polissya culture, as well as the work at the site: construction of radwaste treatment facilities, decommissioning of the three reactors, and making the Shelter safe and environmentally secure. The economic implications of these activities, both in the short and longer term, were also considered. "Now we have a goal," he said, "which is to commence the process of fuel removal, and then start decommissioning." NN