The Chernobyl shelter industrial site, where the New Safe Confinement will be constructed (Photos: PMU)

Chernobyl 25 years on: Time for a "giant" leap forward

BY DICK KOVAN

After 25 years, the construction of a giant new structure to cover the destroyed Chernobyl reactor and its iconic "shelter" is ready to start.

WITH THE ARRIVAL of the 25th anniversary of the Chernobyl disaster, real progress in the international effort to remove the remaining risks posed by the site can be seen on two fronts. The first concerns the plan to construct a new structure over the old "shelter" covering the destroyed Unit 4. The second involves the safe storage of the spent nuclear fuel from Units 1, 2, and 3, to allow those reactors to finally be decommissioned.

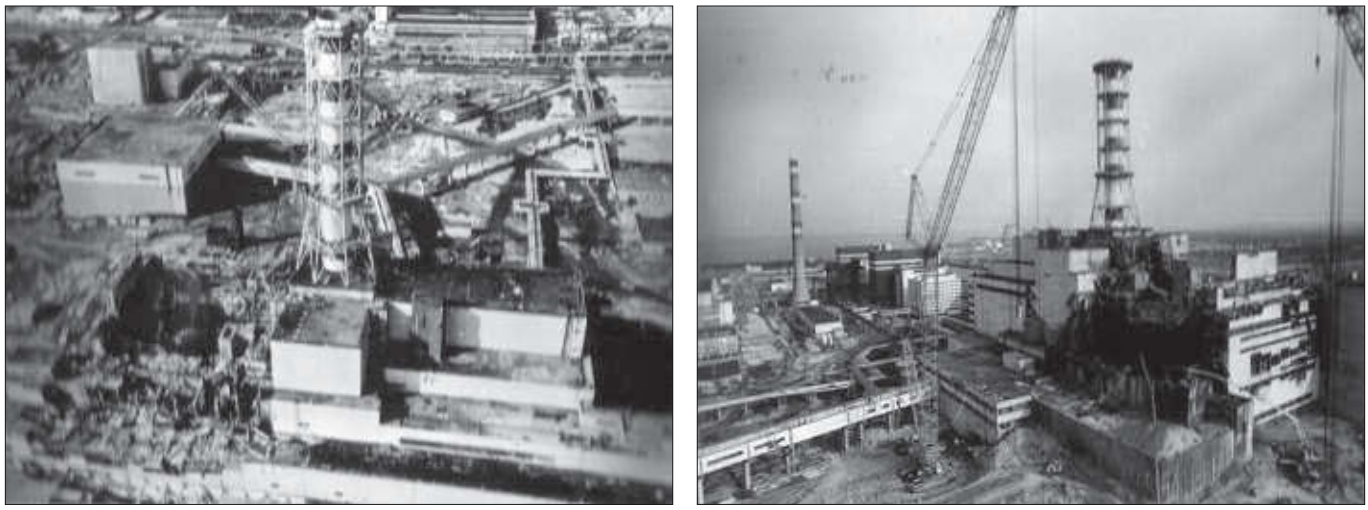
To accomplish the first task, the Shelter Implementation Plan (SIP) was devised, setting out a program to first make the old shelter safe, and then to build a new one. The new steel structure will be more than 100 meters high (328 feet), which is tall enough to house the Statue of Liberty. Called the New Safe Confinement (NSC), the structure will be assembled on site, at a distance from the highly radioactive Unit 4, and then slid into position, covering the remains of the reactor building and the old shelter.

The second major task is vital for the decommissioning of the entire Chernobyl site. The spent fuel assemblies from Units 1, 2, and 3 are now stored in the reactors and in an interim storage facility (ISF-1), which does not meet today's safety standards. A new facility, the Interim Spent Fuel Storage Facility 2 (ISF-2), will provide a crucial decommissioning component.

These projects are funded by the United States and the other members of the G7, the European Union, and other donor countries. In 1997, the European Bank for Reconstruction and Development (EBRD) was charged with managing the funds and overseeing the project, together with Ukraine authorities. As this seemed an appropriate time to provide an update of international work on the projects, the EBRD has produced an anniversary publication, *Chernobyl 25 years on.*

Project milestones

A milestone in the preparations for these complex projects was reached on September 17, 2007, with the awarding of contracts for both projects by the Chernobyl nuclear power plant. The contract to design and build the NSC was signed with the Novarka consortium, which consists of the French companies Vinci Construction Grands Projets and Bouygues Travaux Publics. The contract for the construction of ISF-2 was signed with U.S.-based Holtec Internation-



A 1986 aerial view of the destroyed Unit 4 at Chernobyl (left), and the start of construction of the original sarcophagus

al. Once the contracts were signed, the companies began working to develop the detailed designs and obtain approval from the regulators. For Holtec, this was achieved at the end of 2010, and the company has begun its work. Although Novarka is not expecting to receive final authorization for the NSC until the end of the year or in early 2012, it should be able to undertake some work on the structure during 2011. The current schedule anticipates that the construction of the NSC will be completed in the summer of 2015.

One of the reasons that approval for the NSC design has taken so long, explained Balthasar Lindauer, deputy director of the EBRD's Nuclear Safety Department, is that "it is a first-of-a-kind project, and no standard regulations exist against which the design can be reviewed." Lindauer also noted that quite a number of regulatory authorities in Ukraine are involved in the review process. For all nuclear safety and radiation protection issues, he said, the State Nuclear Regulatory Inspectorate of Ukraine is the key regulator. Under the current licensing system, however, the nuclear regulator must take into account comments and views of other regulatory authorities—for example, those responsible for health and safety, fire protection, construction, and environmental protection. Ukraine has another review agency, Lindauer said, for which there is no equivalent in the West. UkrInvestExpertisa is an organization that reviews all projects in which public money is invested. It provides a second layer of regulatory review, collecting inputs from all other regulators, and presents an integrated opinion.

Finding agreement with Ukraine

The Chernobyl explosion, which occurred in the early hours of April 26, 1986, left few options other than to try to contain the destroyed unit. Under extremely hazardous conditions, a steel and concrete structure was hastily built over the reactor within a few months of the accident. The structure—named "shelter object" by the Ukrainians but dubbed "the sarcophagus" by the news media—was always intended as a temporary measure until a more permanent solution was possible. Over the years, harsh weather conditions have led to serious decay of the structure, which still contains 95 percent of the reactor's nuclear inventory.

Having taken full responsibility for dealing with Chernobyl after the breakup of the Soviet Union in 1991, the newly independent Ukraine needed a considerable amount of assistance to deal with the site. While offers of help were forthcoming from the international community, efforts to agree on a plan with Ukraine did not move forward until the mid-1990s. A breakthrough finally came in May 1997, when the European Union and the G7 reached an agreement with Ukraine on the SIP. Later that year, the Chernobyl Shelter Fund was established to finance the plan.

SIP development

The basic goals of the SIP are, in the short term, to reduce the risk posed by the degrading shelter to people and the environment and, in the longer term, to create an environmentally safe space around it, allowing the remains of the reactor and the shelter to be dismantled and removed.

Given the uncertainties about the actual state of the shelter, the SIP did not initially involve a detailed program but provided a way forward, setting out, according to the EBRD report, "a step-by-step approach to the fundamental technical problems faced at Chernobyl and allowing for the development of solutions as knowledge about the actual situation increases." The following five basic technical goals were set for the SIP:

- Reduce the probability of collapse by stabilizing the shelter.
- Reduce the possible consequences of a collapse accident.
- Improve nuclear safety.
- Improve worker and environmental safety.
- Create an environmentally safe site.

The early years of the SIP were focused on engineering and investigative studies of the shelter in order to increase the knowledge base on its condition. A wide variety of essential work was also carried out, particularly the building of the infrastructure that would be needed for future projects. Since then, the concept for a giant structure covering the shelter has been developed.

The following are examples given in the EBRD report of some of the SIP work that has been completed to prepare for the NSC.

Stabilization

Because the original shelter was only a makeshift solution when it was constructed in 1986 and its condition continued to deteriorate over the years, efforts to prevent its collapse took top priority. An early emergency measure taken was the repair of the beams supporting the roof of the shelter, thereby eliminating the most imminent threat to the structure. A range of major and minor measures followed to stabilize the old shelter inside and out. Between 2004 and 2008, further work was done on the roof and the western wall of the shelter, with about 80 percent of the roof load being transferred to a new external support structure. Extremely challenging tasks inside the shelter, such as the installation of new structural supports in the ventilation stack, were also carried out, reducing the risk of collapse.

Worker protection and safety

Given the conditions at the site and in the region, a substantial investment was made to improve worker health and safety. A radiological protection program was put in place and an emergency plan for accidents was developed. State-of-the-art biomedical protection and screening programs have been set up, radiation protection equipment

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has been procured, and training courses have introduced a new safety culture among the workforce.

A new state-of-the-art facility has been built, offering the more than 1400 site workers medical and radiation protection facilities and an ambulance. In the neighboring town of Slavutych, where most of the site workers live, a hospital wing has been refurbished and equipped with modern facilities.

Monitoring

A recently completed task that will significantly improve nuclear safety is the major upgrade of the existing nuclear monitoring system. The new Integrated Automated Monitoring System monitors key parameters such as radiation levels, seismic activity, and the integrity of the structure, providing real-time information on the condition of the shelter to support the safe maintenance of the facility. The new system collects, processes, and maps information from four primary systems: the nuclear safety monitoring system, the stationary radiation monitoring system, the structural state monitoring system, and the seismic monitoring system. The installation of this hugely complex system was finished in 2010.

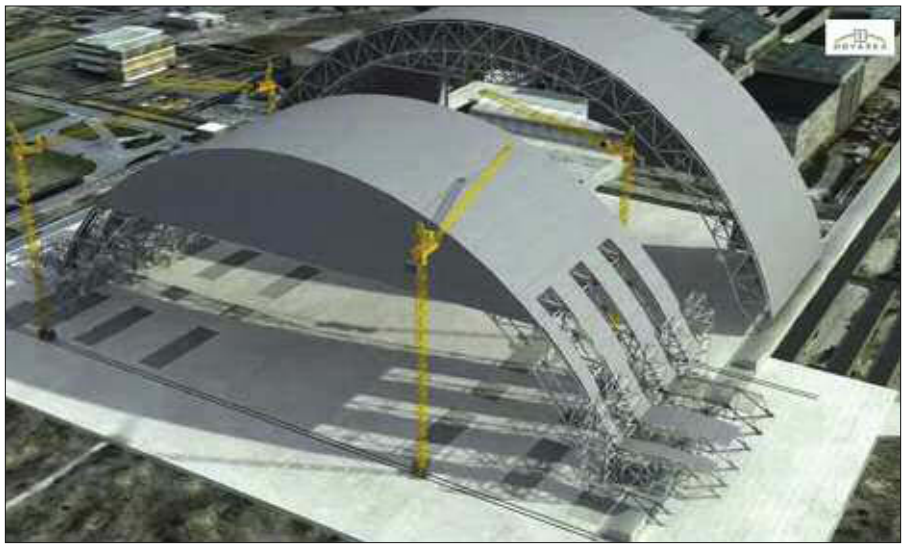
Site services

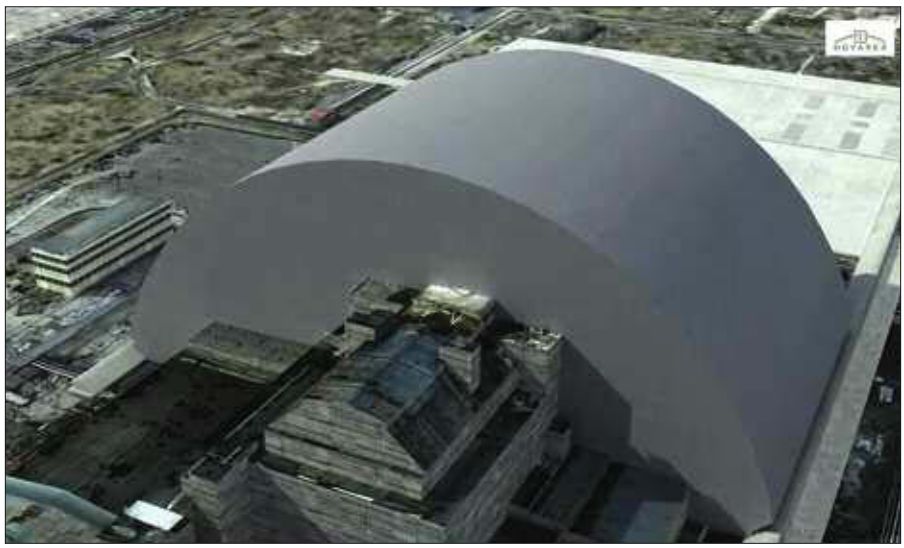
To carry out the complicated shelter project under the difficult conditions at the Chernobyl site, some major facilities have been put in place to allow for the efficient execution of construction activities. Road and rail connections had to be built or improved in order to provide good access to the construction area, and services such as power, water, drains, and communication have been extensively refurbished.

The New Safe Confinement

The NSC will be an arch-shaped structure with a span of 257 meters, a length of 164 meters, and a height of 110 meters, and will weigh 29 000 metric tons. Designed to seal off the old shelter, the NSC will prevent the incursion of water and snow, protect against the escape of radioactivity, and create the conditions under which the deconstruction of the reactor and the shelter can take place. To do this work, the NSC will be equipped with two cranes with a lifting capacity of 50 metric tons each. The dismantled shelter components will then be processed inside the new structure, which is designed for a service life of at least 100 years.

The detailed design of the NSC has been largely completed. Although work on the new structure will begin only once the design receives regulatory approval, Lindauer expects that the consortium will be able to carry out actual work on the NSC in the





The computer-generated renderings above are stills captured from a video produced by Novarka, the consortium contracted to design and build the New Safe Confinement, the structure that will enclose the destroyed Unit 4 at the Chernobyl site and the sarcophagus that currently surrounds it. **Top:** One segment of the arched structure is shown as completed, and the second segment as under construction. **Middle:** Once construction of the second segment is completed, the two arched sections will be moved together and the seam sealed. **Bottom:** The completed structure will be moved on rails over the Unit 4 sarcophagus. The entire video is available for viewing at <www.ebrd.com/pages/news/features/chernobyl.shtml>. (Graphics: Novarka)

The northern belt of the New Safe Confinement's foundation

near future. "The [review] process has been structured so certain design packages can be reviewed and approved independently," he said. "The main concern now is to optimize the whole process so that some important work can start soon." This should include the fabrication of the structure's steel sections, which, according to the current schedule, should begin in the second half of this year so that the assembly of the arch can start in early 2012. The Ukrainian authorities are helping to ensure that this schedule can be achieved, he said.

At the same time that these activities are going on, a considerable amount of radioactive debris removal and excavation work for the foundations is also taking place. Site clearance, Lindauer explained, was decoupled from excavation work to ensure that workers involved in excavation did not have to deal with any kind of high-level waste. This was also a reason to start these activities as early as possible, he said. The location of fuel or other radioactive materials spewed out during the accident is not very well known, so there is a real risk of striking material from the reactor during excavation. "Indeed, we have found a lot of contaminated material and high-level radwaste and fuel particles as well," Lindauer said. "Each time this occurs, work has to stop while the contractors leave the site and Chernobyl plant staff come in with shielded equipment to remove the material. This can sometimes take a considerable amount of time, which has to be allowed for in the schedule."

Design of auxiliary systems

The design package that is being reviewed consists of about 6000 pages, Lindauer said. The design includes foundations, the arch structure, inner and outer cladding, the crane systems, and other auxiliary systems. Quite a large part of the design effort deals with the auxiliary systems, which include fire protection equipment; power supply interfaces, including emergency diesel generators; interfaces for the integrated monitoring system; control equipment; and the ventilation system. The ventilation system for the annular space is crucial as it provides filters and dehumidifiers to keep a constant humidity of 40 percent. The humidity, Lindauer said, is a key factor in corrosion control, which is vital if the NSC is to function for 100 years. The ventilation system also creates a slight overpressure in the annulus to contain contaminated air on the inside.

The NSC does not contain radioactive waste handling or processing equipment, but the design allows for the possibility that such equipment might be installed at a later stage.

Lessons learned

One of the most important lessons taken from this project is that a good institutional, legal, and regulatory framework must be in place before anything else can happen, as clearly shown by the long delays throughout the project. The NSC project is unique, Lindauer said, and, it is hoped, will never have to be repeated. Much has been learned, however, and the experience should help avoid delays in the later stages of the project. For example, given the complexity of the issues involved, the technical decision-making processes, including those related to regulatory issues, have been very lengthy. Going through the approval process for the conceptual design has helped plant personnel, consultants, and contractors learn how to engage with the regulatory authorities in Ukraine, which has been very useful during the detailed design reviews.

Lindauer said that he believes that the authorities have also learned a great deal. As an example, he noted that meetings of the consortium, the plant staff, and the nuclear safety authority now go very well.

New spent fuel storage facility

The construction of the new interim storage facility, ISF-2, is a key requirement for the decommissioning of Units 1, 2, and 3, as it will provide safe and secure storage for

Equipment in place for the new Integrated Automated Monitoring System, which monitors radiation levels, seismic activity, and structural integrity

the spent nuclear fuel generated during the operation of the three units, which continued until December 2000 when the last one, Unit 3, was finally closed. Spent fuel is currently stored in ISF-1—an interim wet storage facility that was constructed when Ukraine was part of the Soviet Union—and in storage pools at each reactor. Until the fuel is removed and placed in the new ISF-2 dry storage facility, safety and operational functions, such as cooling, must be maintained in the old storage pools.

Like the NSC, ISF-2 must operate for a period of at least 100 years, storing more than 20 000 irradiated fuel assemblies plus fuel components. The project will use existing concrete storage modules and a building on the site for processing the assemblies. Processing includes cutting, drying, and inserting the spent fuel into storage containers.

Holtec International took over the contractor's role when the project was, according to the company, "beset by technical problems" and "had reached a dead end." Holtec's design for the facility was approved in 2010 by the regulator, as well as the other authorities, and in October, the Assembly of Contributors, which represents the donor countries, also authorized the work. It is expected that construction will be completed by 2014.

Project costs

Considering all of the engineering work that has been completed already, the EBRD has said that for the first time, reliable cost estimates can be made. According to the latest projections, the completion of the SIP requires an additional €600 million (about $870 million) and the construction of ISF-2 another €140 million (about $203 million).

The EBRD is quite confident that the figures are accurate, Lindauer said, following the careful cost exercise that was done last year. This was particularly important for the donors, who are facing renewed calls for additional funding to complete the projects and want to be certain that the estimates are solid. The exercise for the first time was based on real engineering costs, not just estimates done by project managers.

The end point

The EBRD's involvement in Chernobyl is limited to the completion of these two projects. In fact, the last task of the SIP—the dismantling of unstable parts of the old shelter—has been taken over by Ukraine. The operation of the NSC, the eventual dismantling of the old shelter, and associated waste management tasks are the responsibility of the Chernobyl nuclear power plant and Ukraine. And so, the commissioning of the NSC, which should take place in 2015, is the end point for the EBRD and the donor community. NN