ISIF

Interim
Storage
of Irradiated
Fuel

FOREWORD

The Act on the Atomic Energy of 1996 stipulates: „Final disposal of the radioactive waste, and interim storage and disposal of the spent fuel, together with the activities related to the tasks of decommissioning the nuclear facilities shall be dealt with by an organisation appointed by the Government, as their solution is a national interest."

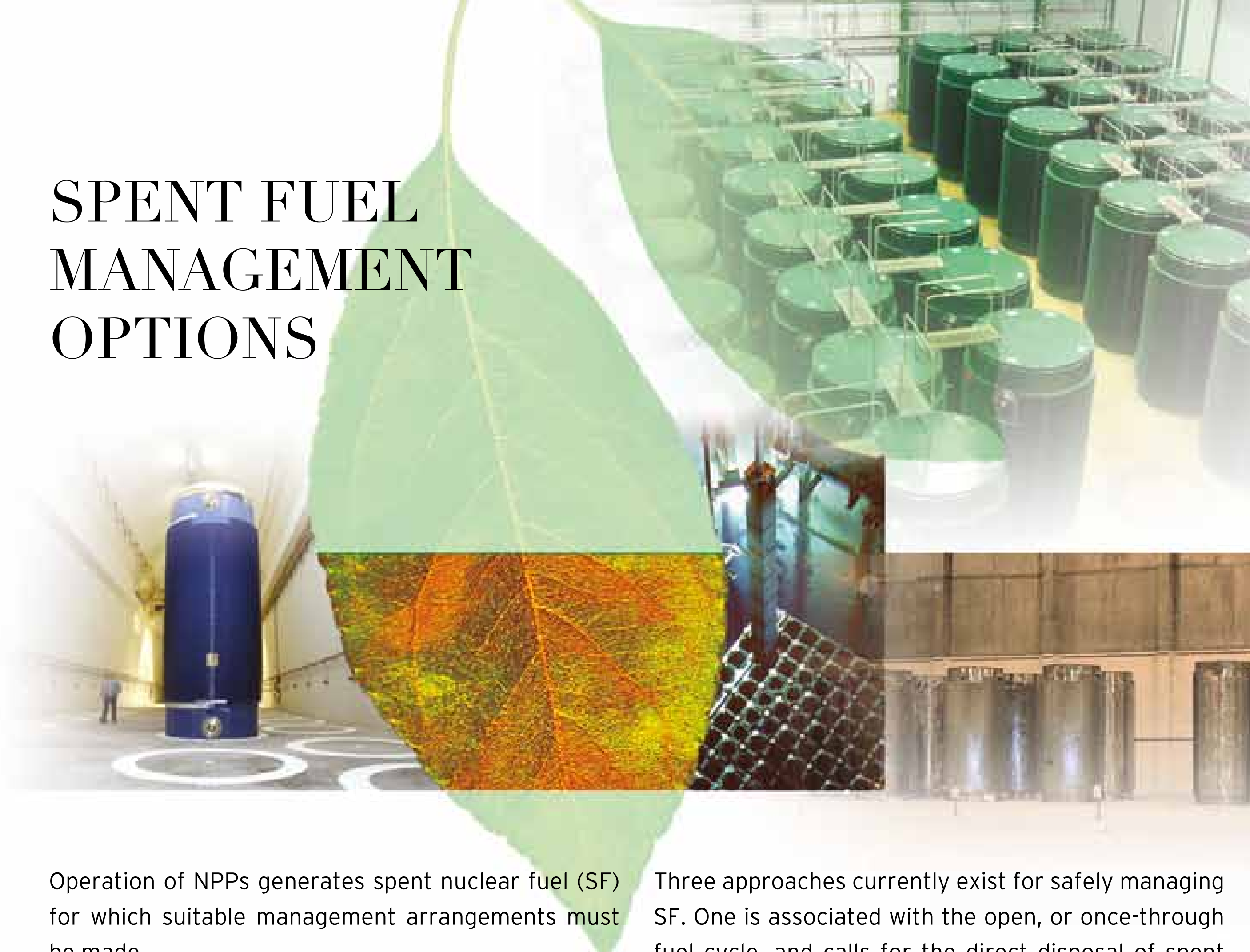
A company called Public Agency for Radioactive Waste Management (which has transformed into Public Limited Company for Radioactive Waste Management as of 2009) (hereinafter called as PURAM) was established by the Hungarian Atomic Energy Agency on the 1st of July 1998 to undertake design, construction and operation work.

As a result of operation of the Paks nuclear power plant (NPP), in average 400 spent fuel assemblies are generated annually. A certain part of the spent fuel assemblies were shipped back to Russia in the period between 1989 and 1998. The shipments to Russia became more and more difficult and expensive, therefore it became necessary to provide for interim storage of the spent nuclear fuel in Hungary. The Interim Storage of Irradiated Fuel (ISIF) was constructed on site of the Paks NPP. The facility has been commissioned in 1997.

In order to assure the continuous and reliable operation of the nuclear power plant, operation and the extension of the ISIF is of paramount importance. Due to the modularity of the storage there is a possibility for a step-by-step extension according to the operational needs of the power plant. One of the most important tasks of PURAM is to safely operate and extend the store.

According to the Act on the Atomic Energy, the fundamental scientific, technical knowledge and other information - including risks - related to the application of atomic energy shall be educated and disseminated to the public through public news services and through public education.
This publication also serves this purpose.

SPENT FUEL MANAGEMENT OPTIONS



Operation of NPPs generates spent nuclear fuel (SF) for which suitable management arrangements must be made.

Once the SF has been discharged from the reactor, it is normally cooled for some period of time in a water pool. This allows the radioactive decay of the shorterlived radionuclides and an associated reduction in the emission of heat resulting from the decay processes. Because most at-reactor storage pools have limited capacity, usually only for a few years of arisings, it soon becomes necessary to decide on a national policy for safe management of the SF.

Three approaches currently exist for safely managing SF. One is associated with the open, or once-through fuel cycle, and calls for the direct disposal of spent fuel in a deep geological repository.

The second approach is associated with the closed fuel cycle and involves the reprocessing of SF and the recycling of recovered plutonium and uranium in new fuels.

The third approach is commonly called the „wait and see" approach, whereby SF is placed in long-term interim storage pending a decision as to its ultimate reprocessing or disposal.

SF storage is a necessary step for all three options.

VAULT CONCEPT

Various types of wet and dry storage facilities are in operation or are under consideration in different countries. Most strategies now consider dry storage for the longer term because of its inherent passive nature and low operating costs. Dry spent fuel may also be more amenable to conditioning for disposal. The dry storage may be large, massive structures as in the case of a natural convection vault, or may be smaller, incrementally added individual units as in the examples of the metal cask, the vertical or horizontal concrete silos, and the dry wells.

The vault is an above ground reinforced concrete building, containing arrays of storage cavities suitable for containment of one or more fuel units. Radiation shielding and protection is provided by the concrete structure. Heat removal is normally accomplished by circulation of air or gas over the exterior of fuel units or storage cavities, and subsequent exhausting of this air or gas directly to the outside atmosphere or cooling the air or gas via a secondary cooling system.

It is considered a self-regulating system, since the more heat is transferred into the cooling air exhausting through the ventilation stack the higher is the air inlet flow into the vault as a result of the thermal-siphon effect, thus providing sufficient cooling with no requirement for any active mechanical system or operator control.

The cost per unit of fuel stored is relatively large for a small capacity vault, but decreases as the capacity of the vault is increased.

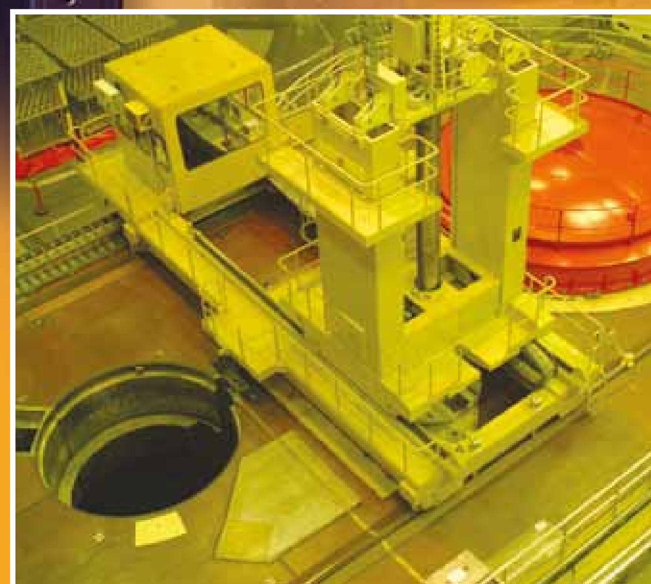
The vault concept was one of the first dry storage options considered for SF studies and operates presently in Canada, France, UK, USA and in Hungary.

HUNGARIAN SOLUTION

The Paks NPP is the only nuclear power plant in Hungary, it consists of four units, each equipped with a 440 MW WWER-440/V-213 type reactor. The four units were put into operation in the years 1982, 1984, 1986 and 1987, respectively.

The design service life of the units is 30 years. One of the most important engineering tasks of the present days is the extension of this service life by 20 years.

Each unit generates 115 spent fuel assemblies annually, which are stored in the spent fuel pools at the reactor halls. The weight of one year's discharge is 14 tHM for a unit. The total weight of a fuel assembly is 215 kg.



The pool storage capacity at Paks NPP was expanded almost twofold by re-racking, during 1984-1987, after the first units were commissioned.

The nuclear power plant is continuously increasing the burn up level of the fuel, and accordingly decreases the anticipated quantity of the SF assemblies that will be generated during the planned lifetime of the NPP.

According to the presently available data, the storage of some 17,900 spent fuel assemblies will need to be provided during the total period including the 30-year design lifetime and the additional 20 years service life extension.

The original design assumed that the SF assemblies be transported back to the Soviet Union after a five-year decay period. At the beginning of the 1990's, the

shipments back to Soviet Union had economical and political difficulties and was finally interrupted in 1998. During 1989-1998, 2331 SF assemblies were shipped back to the Soviet Union, and later to Russia.

Since the possibility to return irradiated fuel assemblies became increasingly uncertain, the construction of an interim storage facility on the site of Paks NPP became necessary. In 1990, the management of NPP decided to implement the option of interim storage as a solution of the problem.

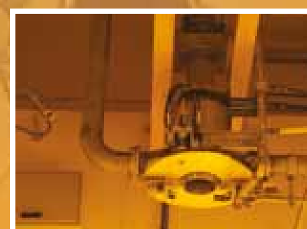
As a result of a wide-range research and evaluation work, the NPP commissioned the English company GEC Alsthom to build a dry storage facility. The NPP Paks signed a contract in 1992 for the licensing design of a modular vault dry store located at NPP's site. One of the advantages of this type of storage technology is that the number of storage vaults can be increased in modules.

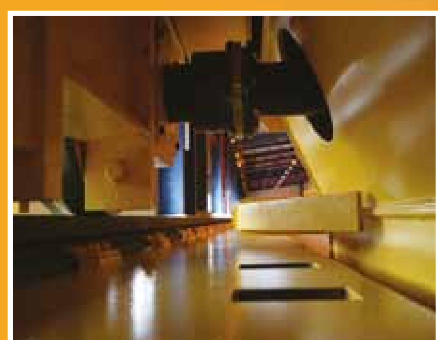
The first three-vault module and the reception building of the storage facility, which is capable of storing spent fuel assemblies for a period of minimum 50 years, was completed by 1997. This was followed by the hand-over of a four-vault module in 2000 and another one in 2003, and later the construction of a new five-vault module was completed in 2007, thus making the storage facility capable of providing a total storage capacity for 7,200 spent fuel assemblies.






DESCRIPTION OF THE STORAGE FACILITY





The site of the Interim Storage of Inradiated Fuel situated adjacent to the plant site of Paks Nuclear Power Plant Ltd., 5 km south of Paks city, and 1 km west of the River Danube.

The facilities of the ISIF have been constructed at a distance of 500 m south of the geometric centre of the power plant units. The foundation level of the ISIF is designed to an elevation to prevent the facility to be flooded even in case of the maximum flood level. The site of the ISIF falls within a flight exclusion zone of 3 km diameter and 7,000 feet (2,133 m) altitude around the Paks NPP.

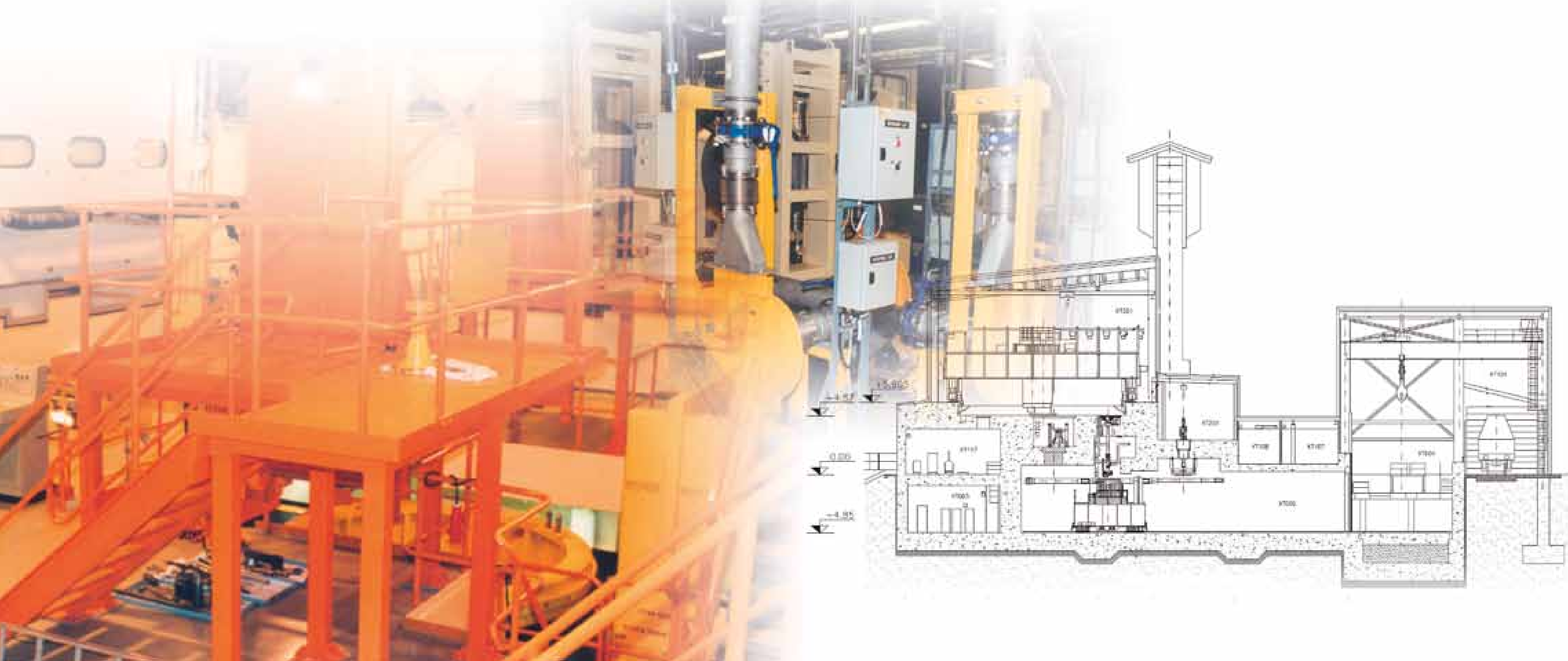
The design earthquake levels were used with a conservative approach. A horizontal seismic acceleration value of 0,25 g, and an earthquake recurrence frequency of 10,000 years, describing the seismicity of the site, was specified in the resolutions of the licensing authority.

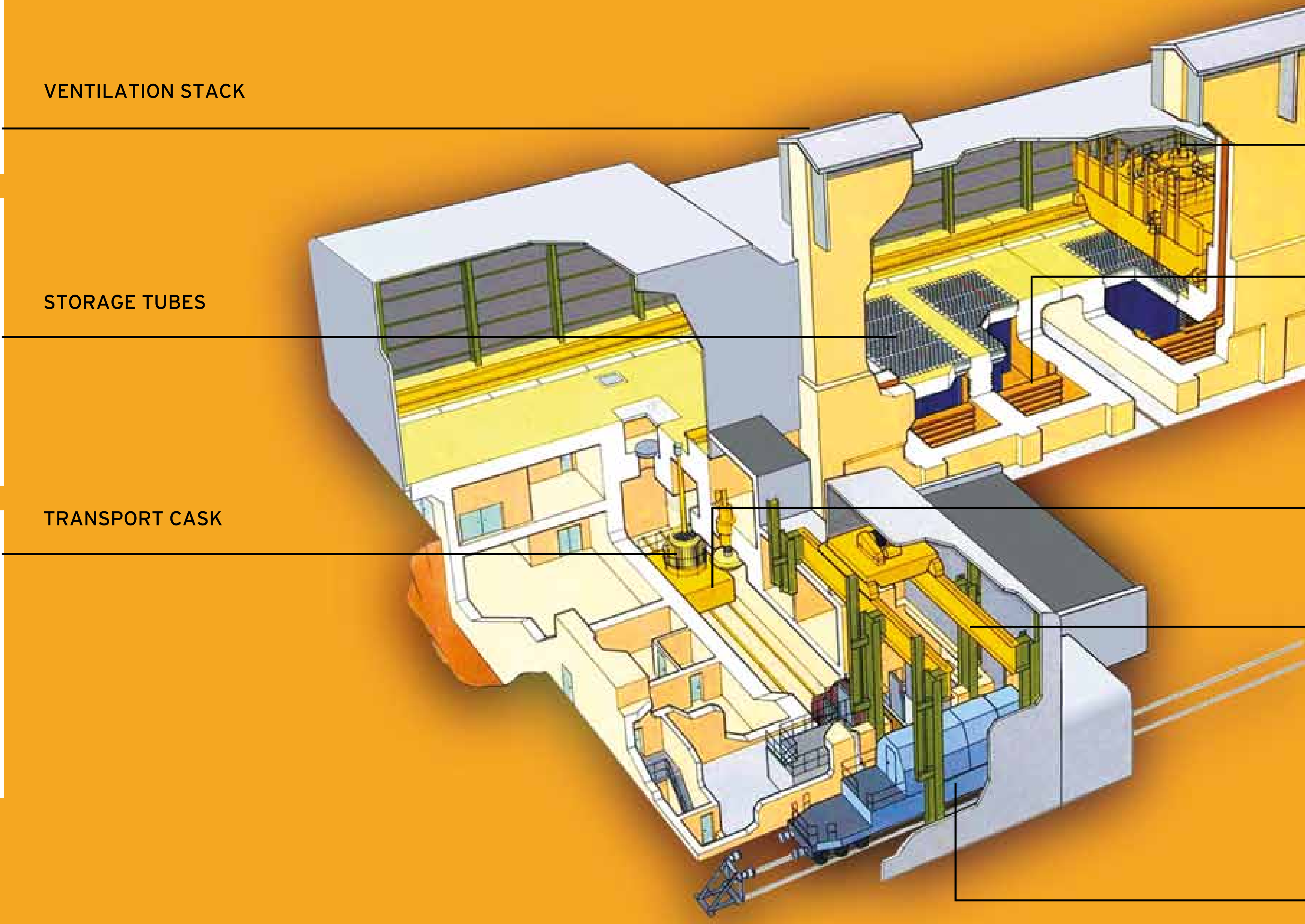
The store itself can functionally be divided into three major structural units. The first one is the vault module where the spent fuel assemblies are stored. This vault module is a structure enclosed by thick reinforced concrete walls and shell structures filled with concrete, the basic function of which is to provide radiation shielding.

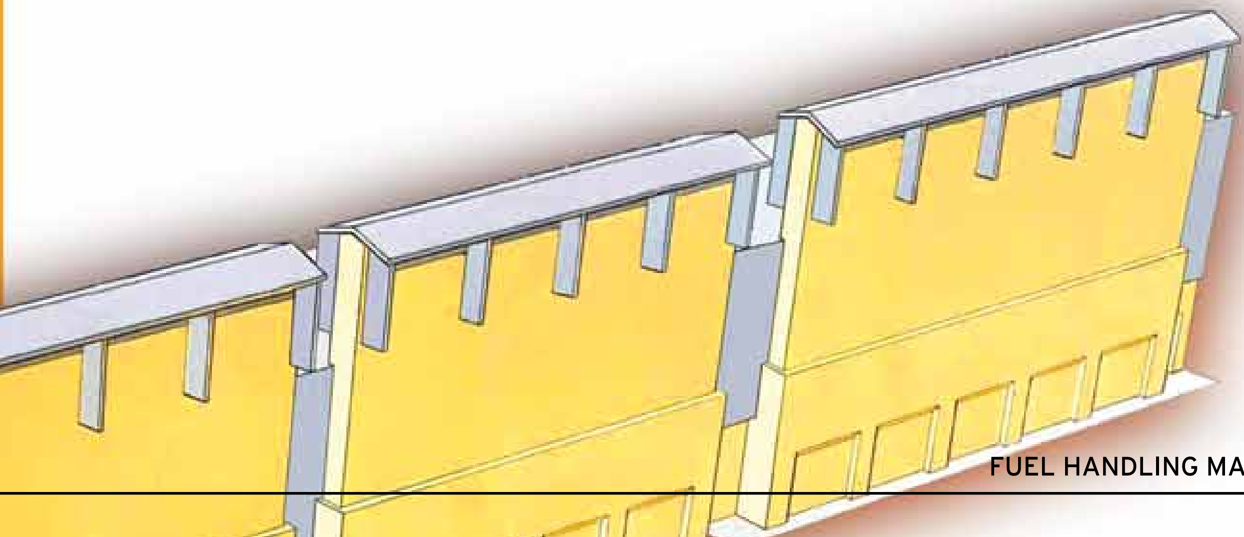
Each vault is capable of accommodating 450 spent fuel assemblies. The cooling required to remove the residual heat generated by the fuel assemblies is provided by a natural-draught-driven air flow developing across the vaults and the connecting ventilation stack. The ISIF provides for the vertical dry storage of irradiated fuel assemblies in a concrete vault module. The principal components are a concrete and structural steel vault module housing an array of steel fuel storage tubes each with a removable steel shield plug. Each Fuel Storage Tube houses a single fuel assembly. Nitrogen is used in the tubes to provide an inert atmosphere. The reinforced concrete structure of the vault is covered by a structural steel building to form a charge hall.

The second component is known as reception building in which the reception, preparation, and unloading of the spent fuel transfer cask takes place. This building is made up of a reinforced concrete substructure with basement and a structural steel superstructure forming a hall. The fuel handling systems and the various auxiliary systems are installed in this building. The transfer cask reception building is a separate facility adjacent to the first vault module. This part of the building accommodates the items of equipment required for the transport cask and fuel handling operations to be carried out prior to loading the spent fuel assemblies into the storage facility. It houses the equipment necessary to handle and position the transfer cask prior to fuel assembly removal/drying operations. The transfer cask reception building also houses service and plant rooms, ventilation systems and provides health physics facilities for operating staff and monitoring equipment.

The third component is the charge hall where the fuel handling machine travels during fuel transfer operations. The hall is bordered by the reinforced concrete wall of the ventilation stack on one side and by a steel structure with steel plate sheeting on the other side. The basic function of the sheeting is to protect the fuel handling machine against climatic stresses.




VENTILATION STACK
STORAGE TUBES
TRANSPORT CASK



FUEL HANDLING MACHINE

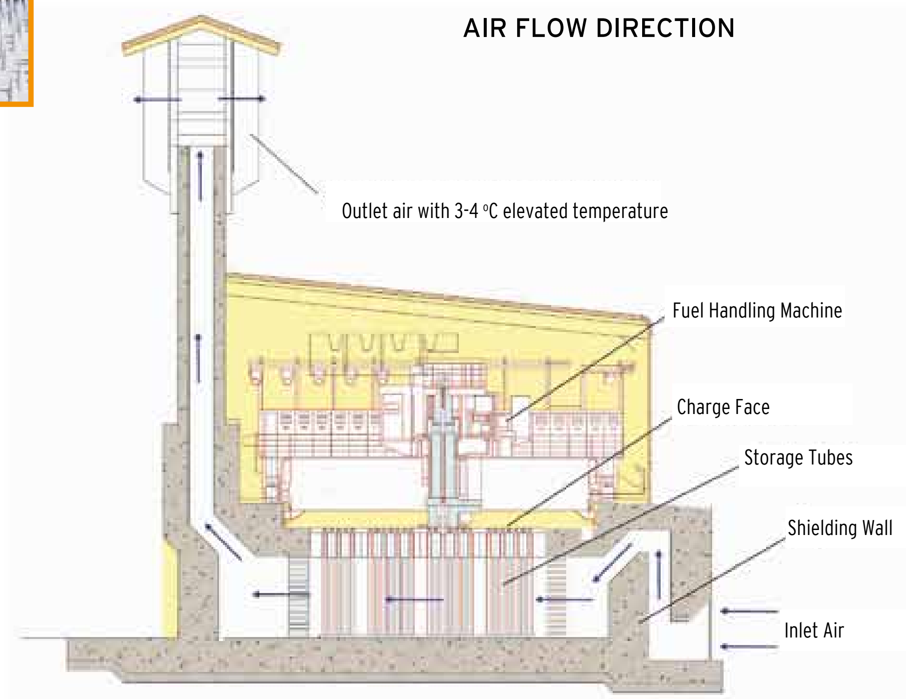
AIR GUIDE CHANNELS

TRANSPORT CASK
TRANSFER TROLLEY

CASK HANDLING CRANE

CASK TRANSPORT
WAGON

AIR FLOW DIRECTION



HANDLING OF FUEL ASSEMBLIES

After the expiry of a minimum 3-year decay period, the spent fuel assemblies are loaded into a water filled transport cask at the reactor.
Loading of the store with spent fuel assemblies takes place as follows. The water-filled C-30 type transfer cask containing 30 spent fuel assemblies is lifted from the railway wagon, used to transport the cask from the power plant to the ISIF, and transferred onto the cask transfer trolley at the cask reception area. Following the completion of various preparation activities on the cask the trolley moves to the cask loading/unloading port.
This loading/unloading port is an opening in the floor of the reception building and it interconnects this building with the charge hall. At this stage the fuel handling machine lowers the fuel grab through this port in which a fuel drying tube is installed. When the fuel grab is lowered into the cask it engages a fuel assembly and raises it into the drying tube. After completion of the drying process the fuel handling machine lifts the fuel assembly into its turret structure and moves to the designated fuel storage tube. Following the exact positioning of the machine at the tube entry the spent fuel assembly is lowered into the fuel storage tube.
Once the fuel handling machine has moved away from the fuel storage tube the air is evacuated from the tube and replaced with nitrogen; the tube remains connected to the built-in nitrogen service system. In the meantime the cask transfer trolley, referred to earlier, locates another fuel assembly underneath the cask loading/unloading port by rotational and longitudinal movements, and this next fuel assembly is loaded into the next designated storage tube by repeating the fuel handling operations above.
The total time required for the complete sequence of operations, i.e. for the loading of the 30 spent fuel assemblies into the store is 120 to 160 hours.

MONITORING AND INSPECTIONS

RADIATION PROTECTION

Operational monitoring, sampling and the subsequent laboratory assessment of samples, and personal health physics monitoring are included in the radiation protection system of the ISIF.

The operational radiation protection monitoring is provided by installed dose rate measuring detectors and aerosol monitoring network. In addition, various portable radiation protection devices are available for the operational staff.

The airborne discharge of the ISIF is monitored with the use of isokinetic sampling system and continuous aerosol monitoring equipment. Beside the activity concentration of the gamma-isotopes, tritium, ^{14}C, ^{90}Sr and alpha-emitters are measured. The liquid discharges of the storage facility are drained into the waste water system of the nuclear power plant, after assessing the samples taken from the tanks. The majority of the laboratory inspections are performed by the health physics laboratory of the ISIF. The discharges of the store facility are minimal.

It is demonstrated by the discharge monitoring results that the annual cumulative liquid and airborne discharges arising from the operation of the facility were of some fractions, ie. as little as 0.02%, of the relevant limits in 2009.

The personal health physics monitoring is performed with the use of film dosimeters, as required by the authorities, TLD and electronic dosimeters.

ENVIRONMENTAL PROTECTION

Since the sites of the ISIF and the nuclear power plant are adjacent to each other, the environment monitoring system of the ISIF is integrated in that of the NPP. The sampling station, equipped with telemetry devices installed next to the ISIF site, has been integrated into the similar system of the power plant. Environmental dose rate monitoring, aerosol activity concentration measuring, and aerosol/fall-out sampling functions are fulfilled by this station.

The entire network, along with the meteorological data obtained by the power plant's meteorological monitoring system, enables the completion of dispersion model calculations for various discharges. The samples taken by the sampling station of the ISIF are processed and assessed in the environmental monitoring laboratory of the nuclear power plant.

GUARDING

The ISFS facility is a nuclear installation. The safeguarding of the facility is provided by the Armed Security Service of PURAM, as part of the physical protection system. The established physical protection system complies with all requirements specified by the international and national legislation and in the relevant licenses. The used security system prevents any uncontrolled access or exit of persons and vehicles to and from the ISFS site and ensures that no nuclear material can fall out of control. The access of persons and vehicles to the ISFS site is strictly controlled and is subject the same conditions as for the nuclear power plant.

REGULATORY CONTROL

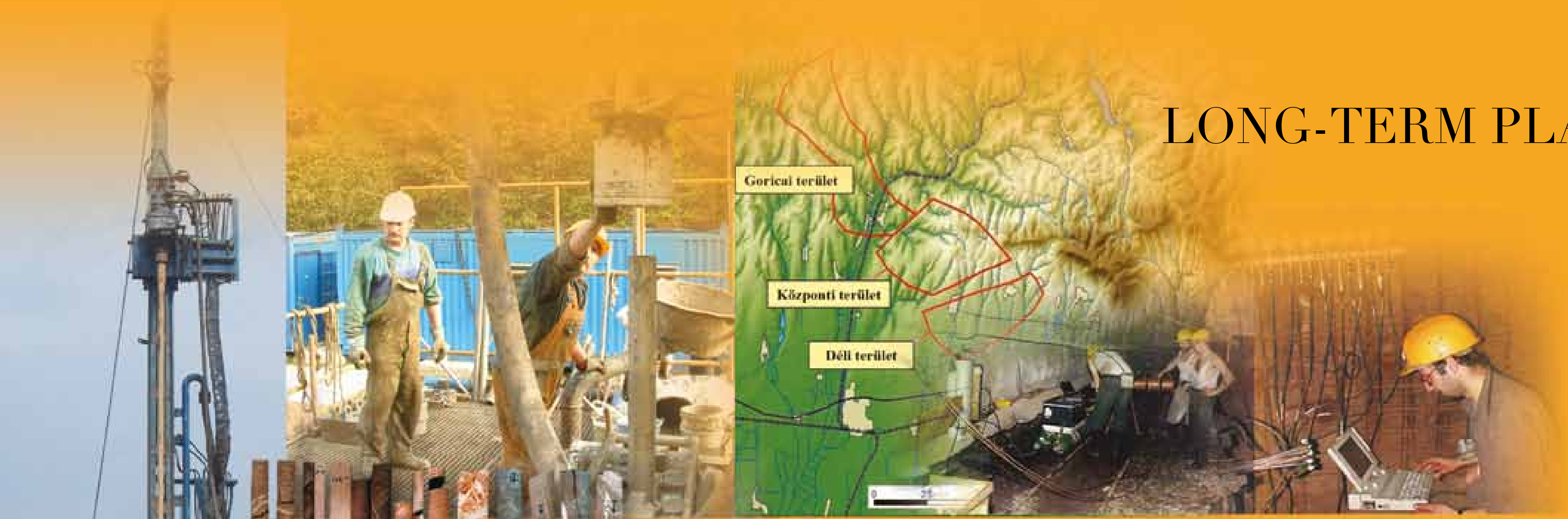
The operational limits of the ISIF were approved by the licensing authority. The reports prepared in relation to the operation and the safety of the ISIF shall be submitted quarterly and annually to the authority.
The Operation License and the Environmental Permit of the store facility was issued by the Hungarian Atomic Energy Agency, and the South Transdanubian Environmental, Conservation and Water Inspectorate, respectively. The Environmental Permit specifies the limit values for the airborne and liquid discharges from the ISIF. The results of the discharge and environment monitoring activities shall be reported to the authority on a monthly basis.

SAFEGUARDS

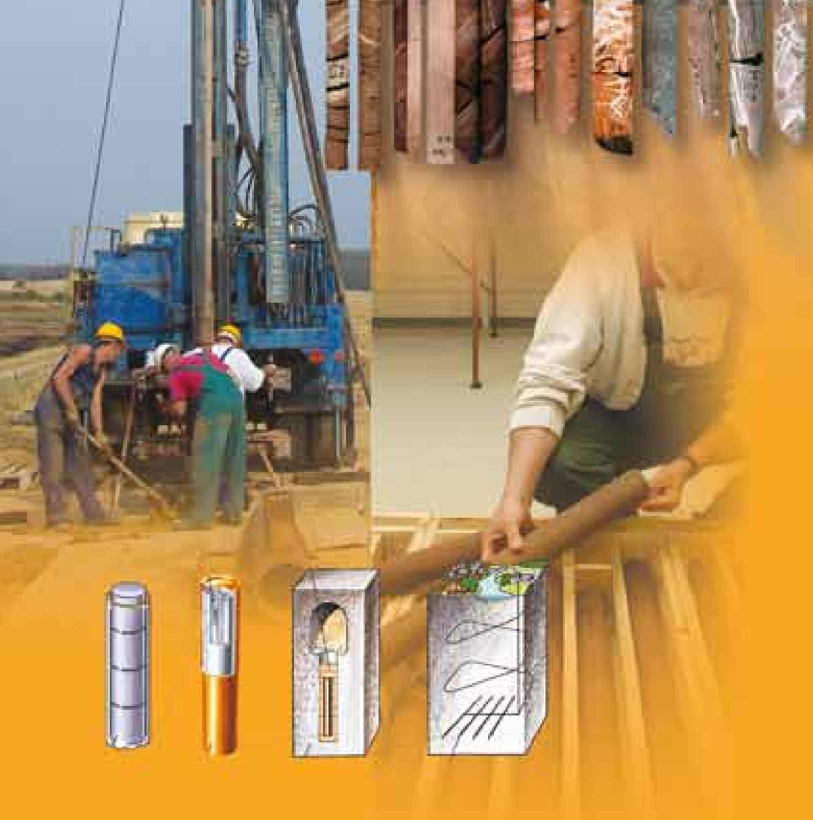
The fulfilment of obligations undertaken in international conventions in relation to the control of nuclear materials and operations involving nuclear materials is possible by keeping the nuclear materials under comprehensive control. Inspections are carried out to an annual inspection schedule by IAEA and EURATOM, but these organisations also have the option to initiate inspections on random basis.
The scope of the control has been specified in the protocol signed by the Government and the IAEA. In normal operating conditions the IAEA conducts supervision based on a yearly plan, but unannounced inspections can also be carried out.
One of the most important area of the safeguards control is the record keeping of the nuclear fuel. An inventory of the nuclear fuel stored at the ISIF should be prepared annually.
Inventory report is prepared every year and a separate report on the variation in the stocks shall also be submitted. The number of the surveillance cameras is 10 at present. This number increases with the construction of new vault modules. Separate archives are generated for IAEA with the use of cameras installed onto the Fuel Handling Machine, and can be used for the identification of fuel assemblies with their serial number.

EXTENSION OF THE FACILITY

Considering the design service life of Paks Nuclear Power Plant and the quantity of the spent fuel assemblies generated each year and those that have been stored in the facility, it is envisaged that a total number of 24 storage vaults will need to be constructed during the period up to 2017, which is the end of the design service life of Paks Nuclear Power Plant. The presently applied triangle lattice arrangement of the storage tubes in the vaults will be replaced with a quadratic lattice, thus providing 527 storage places rather than the currently available number of 450. The 24-vault facility will be capable of accommodating and storing 11,416 spent fuel assemblies. The construction design allows for the extension of the store facility. A total number of 37 storage vaults will need to be constructed to allow the receipt and interim storage of the 17,900 spent fuel assemblies, which are expected to be generated during the design plus the extended service life of the power plant.



LONG-TERM PLANS

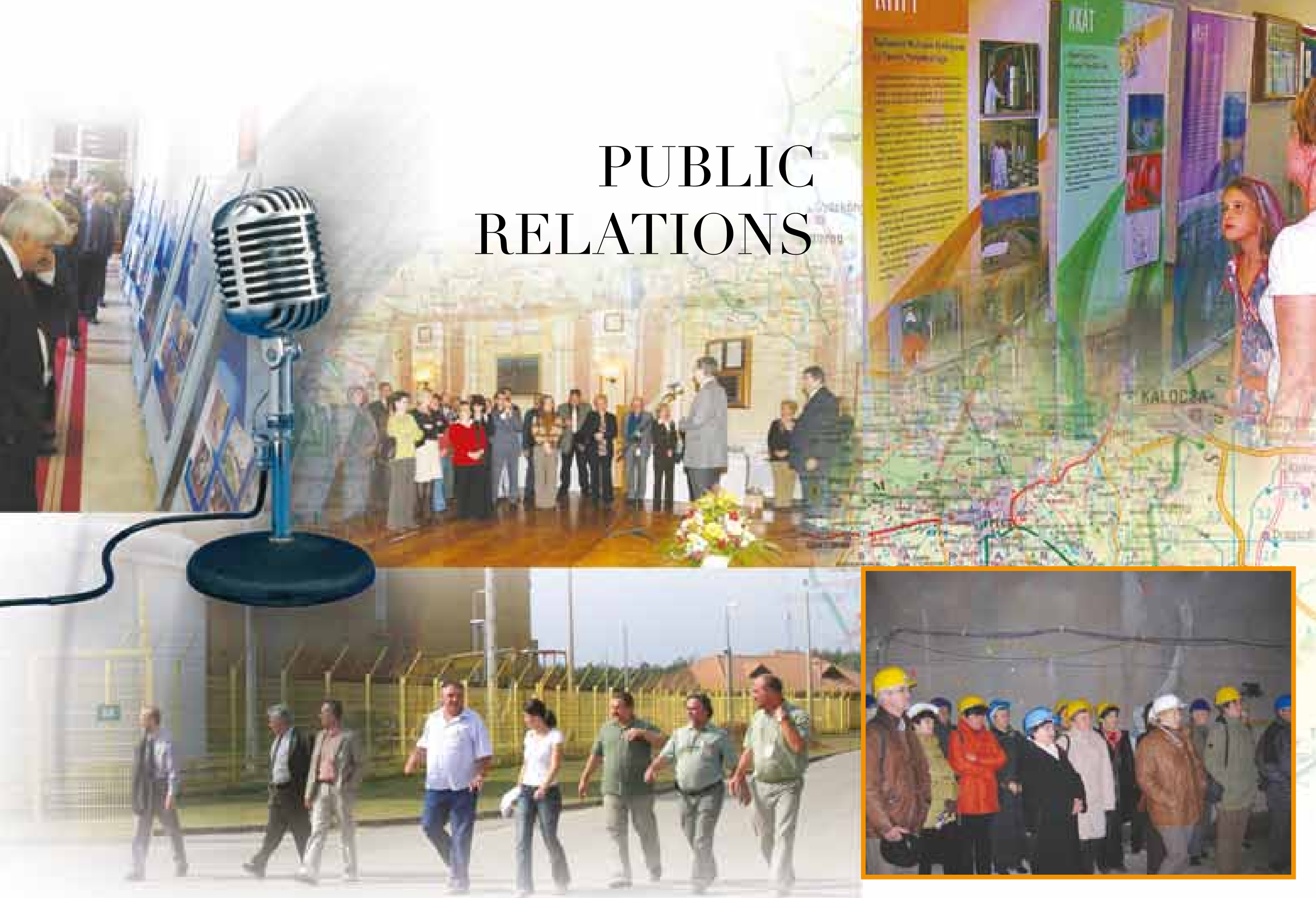


The storage facility, after the planned extensions, will be capable of storing the spent fuel assemblies generated during the service life of the power plant, in a safe manner for a several decade long period. This period can be used for the development of a solution for the final disposal of the spent fuels.

The required operations commenced late in the 1990 's. The exploration work focussed onto the Boda Aleurolite formation in Mecsek Mountain. It was demonstrated during the early stage of the exploration work that this clay-stone formation is most likely suitable for the construction of a waste repository facility for the disposal of spent nuclear fuels and long lived high-level radioactive wastes.

The work within the back-end of the nuclear fuel cycle in Hungary is carried out in due consideration of the developments achieved in the international practice. The conceptions regarding the back-end of the fuel cycle are summarised by PURAM in their document titled "Substantiation of a New Program for the Management and Disposal of Radioactive Wastes and Spent Nuclear Fuels". According to this document, the direct disposal of spent nuclear fuels in Hungary shall be preferred as reference scenario, but, if a different scenario, an adequately safe and more economical solution is developed in the international practice, it will have been possible for a long time to examine and consider this new solution.

PUBLIC RELATIONS



PURAM's communication activity is aiming mainly at establishing and enhancing the confidence and support of the population. The fundamental aim of all actions, events and programmes has been to establish a long-term relationship between the local communities and PURAM, and to continuously keep the local residents interested and confident in the development. The basis of the partnership is the trust of the local residents. To fulfil the social control of the NPP and the ISIF, municipalities living in the 12 km vicinity of the facilities established the Social Control and Informative. Association (TEIT). In collaboration with the representatives of Paks NPP, we have continued our PR activities with the TEIT in an effort to maintain a supportive social atmosphere, which is inevitable to smooth operation and expansion of ISIF facility. Municipalities associated in the TEIT are of the firm opinion that if the construction and the continuous extension of the ISIF is necessary, then it must be done in such a way that people have a reassuring feeling about the safety of the facility. At the same time the self-governments in the vicinity should get financial support. The activity of TEIT so far has proved that all the efforts they made have not been in vain. It was demonstrated by the results of the so far performed work of TEIT that the Local Governments could successfully cooperate in enforcing their own interest, for strengthening the confidence of our population. Preparation for the disposal of HLW also belongs to PURAM's tasks. One of the most feasible options for Hungary is the deep geological disposal, hence the previously studied area for HLW disposal in the West Mecsek area is worth considering for further investigations. PURAM's information work has concentrated on emphasising the results obtained so far and to communicate the future ideas. Consequently, PURAM kept a continuous contact with the mayors participating in the work of the Public Information Association of Western Mecsek (NymTIT) and with the civil organisations. At the briefings and meetings leaders of the NymTIT are provided with detailed information concerning the development of the strategy and the planned site investigation programme.

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