PKS – THE HUNGARIAN ATOMIC CITY

The town of Paks is located in the middle of Hungary, beside the Danube River, approximately 120 kilometers from Budapest. In the antiquity its territory was occupied by a Roman military settlement named Lussonium. The town’s history of several centuries was determined by agriculture, trade and fishing. Since the construction of the nuclear power plant the settlement, built on hills, has enjoyed a boost of development.

This city was designated by the 1966 governmental decision to construct the first and so far the only nuclear power plant of Hungary. The foundation stone of the four-unit power plant was laid on October 3 in 1975 and was started the construction.

Milestones of the Plant’s Lifetime

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>Governmental Decision</td>
</tr>
<tr>
<td>1975-1987</td>
<td>Construction</td>
</tr>
<tr>
<td>1982-1987</td>
<td>Units 1-4 Start-up</td>
</tr>
<tr>
<td>1991-1994</td>
<td>AGNES Project</td>
</tr>
<tr>
<td>1995-1999</td>
<td>Safety Enhancement Measures</td>
</tr>
<tr>
<td>2001-2008</td>
<td>Radioactive Waste Repositories</td>
</tr>
<tr>
<td>2003</td>
<td>INES 3 Event</td>
</tr>
<tr>
<td>2002-2012</td>
<td>Power Upgrade Project</td>
</tr>
<tr>
<td>2002-2009</td>
<td>Operational Life Extension Project</td>
</tr>
<tr>
<td>2006-2009</td>
<td>ISI Program Review</td>
</tr>
<tr>
<td>2012-2017</td>
<td>End of Design Life (Units 1-4)</td>
</tr>
<tr>
<td>2032-2037</td>
<td>End of Extended Life (Units 1-4)</td>
</tr>
</tbody>
</table>

PKS - THE NUCLEAR POWER PLANT

The Paks Nuclear Power Plant has four second generation VVER-440/213 type, pressurized water cooled and water moderated units with six loops. The reactors of Paks have been manufactured at the Czech SKODA Works. The 149 mm thick steel vessel has a diameter of three and half meters, its height – together with the supplementary systems – amounts to 23 meters.

Reactor’s Technical Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of loops</td>
<td>6</td>
</tr>
<tr>
<td>Thermal power:</td>
<td>1375 MW</td>
</tr>
<tr>
<td>No. of turbines:</td>
<td>2</td>
</tr>
<tr>
<td>Generator’s power:</td>
<td>2 x 230 MW</td>
</tr>
<tr>
<td>Unit electric power:</td>
<td>470-508 MW</td>
</tr>
<tr>
<td>Primary circuit:</td>
<td>12.4 MPa, on 297 °C</td>
</tr>
<tr>
<td>Secondary circuit:</td>
<td>4.46 MPa on 267 °C</td>
</tr>
<tr>
<td>Core dimensions:</td>
<td>2.5/2.88 m</td>
</tr>
<tr>
<td>Fuel:</td>
<td>42 t Uranium Dioxide</td>
</tr>
</tbody>
</table>
The total installed capacity of the four units of the Paks Nuclear Power Plant is 1960 MW as a result of performance step-up. It means on average 38-40% share in the domestic production.

The Paks nuclear energy generating facility operates primarily as a base load power plant, operated continuously within the limits of strict safety regulations to its utmost capacity. In 2006 the power plant produced 13457 GWh, the other domestic production was 22333 GWh, and Hungary imported additional 7200 GWh.

**RADIOACTIVE WASTE REPOSITORIES**

All over the world, the environment protection expectation is growing firm that each country owning nuclear power plants has to take care of spent fuel storage, and the radioactive waste repository. The necessity of the spent fuel and the radioactive waste storage construction is specified by the Hungarian Nuclear Act. The Paks NPP had to pay provision, which is one of the significant cost components since the start of the operation.

**INTERIM SPENT FUEL STORAGE FACILITY**

The construction work of the Interim Spent Fuel Storage began in 1995, within the site of the Plant. The modular enlargeable surface building was planned by the British GEC Alsthom, and was constructed by Hungarian subcontractors. The facility is able to store the spent fuel for 50 years in natural air flow-cooled thick walled hermetic steel storage tubes.
LOW AND MIDDLE LEVEL WASTE REPOSITORY

The opening of the low and middle level waste repository is scheduled to 2008. This expandable granodiorite host rock subsurface disposal is able to store safely 20,000 cubic meters solid or liquid radioactive waste for 600 years.

The site of the final disposal facility for the spent nuclear fuel has not been selected yet.

INES 3 EVENT – THE FUEL CLEANING INCIDENT

In the reactors of unit 1, 2 and 3 magnetite deposits on the surface of the fuel assemblies led to the decrease of reactor power. Therefore the fuel assemblies needed chemical cleaning. In April 2003 cleaning tank was installed by subcontractor’s specialists in the maintenance shaft.

The first 6 cleaning was successful, but during the 7th cleaning cycle the tank cover was not lifted immediately at the end of the cleaning process, because other important maintenance work was being carried out.
The coolant temperature has been increasing in the tank, and steam was generated in the tank upper part with increasing volume and radioactive gas release was detected in reactor hall. The locking mechanism of the tank cover was opened, cold water entered the tank and the fuel suffered a thermal shock due to temperature difference. 3.6 tons of fuel elements were damaged or broken. Small quantity of radioactive gases entered the reactor hall airspace and was released to the atmosphere via 100 meter high vent stack. The airborne radioactive release was observed only by one of 8 automated measuring stations. After a short while the sensitive instruments did not indicate deviation from the natural background radiation. During the days after the event the Austrian Global 2000 environmental protection organization among others performed and it was made public correctly that the environment status was not changed.

The International Atomic Energy Agency investigated the event and found the followings:

- Serious deficiencies in cleaning tank cooling and control system design
- Aggressive schedule for design, fabrication, installation, testing of the fuel cleaning system
- Inadequate supervision of contractor during cleaning process by Paks NPP
- The annual dose limits for the general public resulting have not been exceeded
- Emergency responses of HAEA and Paks NPP were well coordinated and consistent

Nobody hurts, the damaged fuel assemblies removal was performed until January of 2007.

PAKS NPP’S STRATEGY

The operation of the nuclear power plant is an optimization task, the target function of which is the maximum of safety, profitability, public acceptance and the minimum of environmental impacts.

THE NUCLEAR SAFETY

The development of the safety culture and the safety systems are the most important priorities of the power plant. Safety improvements are from the beginning in the Paks nuclear Power Plant. Partly upon the recommendations of the chief constructor, but largely on our own motion, or on the basis of international precedents. In 1991 the Advanced and Generally New Evaluation of Safety (AGNES) project was the first survey and the further basis for the safety enhancement.
The major areas of the Safety Enhancement Measures:

- Improvement of the accident management,
- Increasing the reliability of the safety systems,
- Reduction of the component loads,
- Verification of the containment functionality,
- Increase of the seismic resistance,
- Improvement of the fire safety.

TRAINING AND EDUCATION

One of the most important elements of the safety is the continuously training and education of the personnel. The most important resource of the Paks NPP is its highly qualified, collected staff of specialists, which contributes outstanding results by conscientiously executing their tasks.

The Maintenance Training Centre is a facility exceptional in its kind all over the world. In the building housing the real full size plant equipment - reactor, steam generator and others components – precise maintenance and repair jobs can be exercised and new safe and effective technologies can be developed.

The Paks Nuclear Power Plant has a technical vocational secondary school in the town, and in cooperation with the University of Budapest operates a College for Power Engineering.

Operating specialists practice settings optimal modes of operation and eliminating low-probability breakdowns on computer-based unit simulator equipment made in a Finnish-Hungarian cooperation.
POWER UPGRADE PROJECT

As result of secondary circuit modernization the unit power was already increased from the original 440 MW up to 470 MW on each unit. The goal of the power upgrade project is 508 MW now. It means 8% increase of the reactor thermal power with hardware modifications, modified fuel, without any changes in safety margins. The implementation occurs in 2 steps. Operation at 104% for 2 months, and operation on 108%.

The unit number 4 reached the 108% in October of 2006; the unit 1 reached the goal too in autumn of 2007.

The power upgrading indicates additional 160 MW electric capacities on the 4 units without CO₂ emission, in addition to unchanged operational cost. The power upgrade cost is 160 US dollars per kW, only approximately quarter of an average gas turbine power plant’s construction cost (app. 600 USD/kW). The calculated payback time is 3 and half years!

OPERATIONAL LIFE EXTENSION PROJECT

In order to ensure that the Paks units can operate for further twenty years the expiry of the design service life, the Operation License needs to be renewed.

The objectives of the life extension projects:

- Current Licensing Basis Requirements
- Adequate Ageing Management
- Monitoring Maintenance Efficiency
- Extension of Environmental Qualification
The time schedule of the service life extension

Paks NPP must accomplish the technical implementation program of the Unit 1 in 2008 and need to be submitted to the nuclear regulator. Parallel to this the environmental permit for the service life extension shall also be obtained for all four units. Finally for unit 1, the Operation License will be required for the extended service life from 2012. For the other units the licensing procedure will take place in similar manner.

Besides the main activities, Paks NPP has to demonstrate that the plant practice is adequate, and ensures the safety of Long-Term Operation in general:
- Effective maintenance
- Replacement
- Reconstruction programs are in place
- In-Service Inspection program review:
- ASME adaptation:
  - Detailed comparison of ASME design requirements with the original Soviet standards
  - Design review according to ASME Section III
  - ISI program revision according to ASME Sections V and XI
  - On the field of inspection qualification Paks NPP follows the ENIQ methodology (IAEA guidance)

PROFITABILITY

At present, Paks Nuclear Power Plant is the largest and cheapest domestic electricity producer. From economical considerations the power upgrade and the service life extension are well substantiated, those two projects are the basis of the improving competitiveness even under the planned deregulated market conditions in 2008.

Additional competitive advantages are to be expected from the improvement of the corporate structure, improvement of the fuel efficiency, entering an integrated management system, cost saving approach such as condition based retrofit and reconstruction work, planning and evaluation of the maintenance efficiency, and from the Comprehensive application of Information Technology.

By this means, the price advantage of Paks electric power in the domestic production will further increase and Paks Nuclear Power Plant will be an indispensable element of the Hungarian energy system.

FUTURE OF EXISTING PLANTS, AND NEED FOR NEW CAPACITIES

In the following years Hungary has to shut down a numerous old and out of date hydrocarbon and coal power plants. The effects of the shut downs can be well read on the diagram. Hungary needs new capacity, Paks Nuclear Power Plant must operate as long as possible.
PUBLIC ACCEPTANCE

On the basis of the Eurobarometer survey Hungary is on high position in Europe in question of the acceptance of the nuclear power. The assistance of the atomic energy is 34 percent, 14% more than the European average. More, but not enough.

Are you in favor or opposed to the use of nuclear energy in (OUR COUNTRY)?

(EUROBAROMETER Energy Technologies: Knowledge, Perception, Measures - January 2007)