UNITS 1-4 OF PAKS NUCLEAR POWER PLANT

SERVICE TIME EXTENSION OF PAKS NUCLEAR POWER PLANT

ENVIRONMENTAL EFFECT-STUDY

PLAIN SUMMARY

February 2006, Budapest

More detailed information is available at local governments.
TABLE OF CONTENTS

1 Introduction
   1.1 Facts and Information about the Present Situation at Paks
   1.2 Tendencies in Nuclear Energetics Industry – an International Overview

2 Technological Features of Paks Nuclear Power Plant
   2.1 Buildings of the Nuclear Power Plant
   2.2 Technological Equipment of the Process of Production
   2.3 Production Supporting Activities
   2.4 Industrial Nuclear Emission and Environmental Control Activity
       2.4.1 Control System
       2.4.2 Public (Civil) Control

3 The Planned Service Life Extension
   3.1 The Possibility of Service Life Extension
   3.2 Service Life Extension and the Environmental Effect Study
   3.3 The Accomplishment of Service Life Extension

4 The Environmental Effects of the Nuclear Power Plant
   4.1 Characterization of the Radioactivity of the Environment
   4.2 Traditional Characteristics of the Conditions of the Environment
       4.2.1 Quality of Air
       4.2.2 Characteristics of the Climate
       4.2.3 Surface Waters
       4.2.4 Geological, Hydrogeological Conditions
       4.2.5 Terrestrial Flora and Fauna of the Environment of Paks Nuclear Power Plant
       4.2.6 Waste Production and Elimination
       4.2.7 Environmental Flora and Fauna Conditions of the Nuclear Power Plant
       4.2.8 Environment of the Settlements
       4.2.9 Usage of the Land and the Region
   4.3 The Activity of the Nuclear Power Plant in the Formation of the Conditions of the Environment

5 Estimation of Prospective Environmental Changes Caused by Service Life Extension
   5.1 Preparations for Service Life Extension
       5.1.1 Radiological Effects
       5.1.2 General Environmental Influence
   5.2 Operation of the Extended Service Life Power Plant
       5.2.1 Radiological Effects
       5.2.2 General Environmental Effects
       5.2.3 Social, Economic and Environmental Health Effects
   5.3 Effects of Incidents
   5.4 Areas of Affection
   5.5 Decommissioning
   5.6 The Question of Effects over the Borders

6 Information Gathering and Controlling Possibilities of the Population of the Area

7 Suggestion on the Examinations of the Environmental Effects of the Extended Service Life of the Nuclear Power Plant
   7.1 Radiological Emission and Environmental Control Systems

More detailed information is available at local governments.
7.2 Common Environment Control Systems

8 Consequences of the Cancellation of Service Life Extension

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It was defined in 2001 as one of the strategic goals of Paks NPP that the units of the power plant working presently should be operated after their planned operating time (i.e. after 30 years). **The present work is a clear summary of the environmental effect study prepared about the extension of the NPP's service life.** The environmental effect study was prepared on the basis of the K5K3742/05 reference number resolution of Lower-Danube basin Inspectorate for Environment, Nature and Water (LDb IENW / ADv KTVF) issued on 3rd May 2005 – accepting the preliminary environmental study – and on the requirements of the 314/2005 (XII. 25.) executive decree. The licensing of the planned service life extension requires both an environmental and a nuclear licensing procedure, and also the modification of the NPP's operational permit. The first step of this licensing procedure – just like that of any other activities – has to be the acquisition of the environmental licence. Figure 1. shows the whole licensing procedure of the service life extension.
Service Time Extension of Paks Nuclear Power Plant

Az ábra aláírása: 1. ábra Az engedélyezés folyamata = Figure 1. The licensing procedure

Az ábra szövegei:
Környezetvédelmi engedélyezési eljárás = Environmental Licensing Procedure
ADv KTVF = LDb IENW (Lower-Danube basin Inspectorate for Environment, Nature and Water)

Szakhatósági hozzájárulások = Consents of Technical Authorities
More detailed information is available at local governments.

Plain Summary 2006.02.06
The effect study was prepared on behalf of Paks NPP by ETV-ERŐTERV Inc. (1094. Budapest, Angyal Street 1-3.) and ECO Inc. (1013. Budapest, Attila Street 16.) with the help of

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subcontractors during 2005. Consequently, 31st December 2004 was regarded as the closing date (as the so called Basis Interval) in the case of the data utilized in the environmental effect study.

1 INTRODUCTION

One of the greatest achievements of the 20th century is the peaceful utilization of nuclear energy i.e. the use of nuclear power plants. The building of Hungary’s only nuclear power plant was prepared from the 1960s by scientists and engineers following the steps of Ede Teller, Leo Szilárd and Jenő Wigner and was realized by about 15 000 construction workers and mechanics in the 1970s and 80s. The four units of the NPP started energy production between 1983 and 1987 and since then the NPP has been working continuously, according to plan.

In the course of site selection, several aspects were examined eg. that of environmental protection, besides the situation of the site within the country, the density of the population, the geological conditions, transport possibilities and the coolant-water supply. Out of the four possible places (Bogyiszló, Dusnok, Paks and Solt), finally the NPP was established within the administrative area of Paks, south – south-east from the town, by the river Danube. (See Figure 2.)

Figure 2. The location of the site of the NPP (on a map and on a space photograph)
Az ábra szövege: The site of the NPP

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Service Time Extension of Paks Nuclear Power Plant

From the start of the NPP (i.e. from 1983) until the end of 1991 the NPP was operated by Paks Nuclear Power Plant company. On 31st December, 1991 Paks Nuclear Power Plant PLC was founded privately, as the legal successor of the former company. At present, the NPP is held by Hungarian Power Companies Ltd. (MVM Rt.) in almost 100%, some stocks are held by the local governments and one golden stock is held by Hungarian Privatization and State Holding Company (ÁPV Rt.).

**The NPP produces almost 40% of home electric power production** so it is a major participant in the utilization of energy sources in our country. (See Figure 3.)

![Figure 3. The Electric Power Balance of Hungary](image)

In Hungary the NPP is still the cheapest way of electric power production. In 2004, the NPP sold electricity at the Hungarian electricity market for 8.60 forints per kilowatt-hours while in 2005 for 8.32 forints. The NPP was able to keep its significant price advantage compared to the other power plants during the last two decades, thus facilitating the favorable variation of the prices of home electric power.

The increase of the cost-price of Paks electricity is permanently less than the rate of inflation, in spite of the fact that the NPP pays almost 20 billion forints a year in the fund which will provide money for the storage / disposal of radioactive waste and for the future decommissioning of the NPP. So the cost-price of electricity produced in the NPP contains the funds of the storage / disposal of radioactive waste and of the future decommissioning of the NPP.

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1.1 Facts and information about the present situation at Paks

The NPP was built with 4 pressurized water reactors that use water as coolant. (See Figure 4.) The pairs of reactor units can be found in semi-detached buildings. At present, all units are operating. As a result of the serious incident which happened on 10th April, 2003 – and which was not in connection with the normal way of operation – Unit 2 has not worked until August, 2004 but since 3rd September, 2004 it has been operating and participating again in the Hungarian electric power production. The incident happened in the cleaning tank placed temporarily in the No. 1 pit of the unit. The cleaning tank had been constructed, produced and operated at Paks by a German – French company. The competent authorities of the NPP are responsible for the deficiencies of control.

The information in connection with the incident were made public, primarily with the help of the press. The loads did not exceed the ultimate values in the nearest inhabited areas during the incident.

Az ábra aláírása: 4. ábra A paksi reaktorok (szerkezeti vázlat) = Figure 4. The reactors of Paks (a draft of their structure)
Az ábra szövegei:
Felső blokk = Upper unit
Reaktor főosztósik tömítőelemei = ?
Reaktortartályon belüli berendezések = Equipments within the reactor vessel
Aktív zóna = Active area
Reaktortartály = Reactor vessel
ábra vége

The consequences of the incident are being abolished according to plan, safely and in a professional way by the specialists of the NPP and by Russian experts. The abolishment of the consequences of the incident and the re-start of the units are carried out by Paks NPP lawfully and in harmony with the related authorities in a special procedure. According to plans, the removal of the damaged fuel elements from the pit will start in the second half of 2006. The creation of a new controlling and operating environment is in progress in the NPP which guarantees that similar incidents must not happen in the future neither as an inner fault, nor as a fault of outside contractors.

The abolishment of the consequences of the incident is funded by the NPP only, so there weren't any changes in the consumer's price of electric power because of the incident in Paks. Experiences up to the present (including the environmental consequences of the serious incident mentioned above) show that the operation of the NPP has only changed the condition of the environment in a small degree. The utilization of nuclear energy is More detailed information is available at local governments.
significantly more environment friendly than the traditional ways of energy production based on fossile fuels (coal, oil, natural gas), because the NPP does not emit gases that enhance the greenhouse effect or any other environment-polluting materials. If the energy production of Paks was substituted by a modern coal-fuelled power plant, 10 million tons of carbon-dioxide would be emitted to the atmosphere during a year and at the same time, almost as much oxigen would be used up as that is issued by the Hungarian woods during the same period. So the operation of the units of Paks makes it possible to fulfil the Hungarian environmental-protection obligations taken on in international agreements.

The weight and role of Paks NPP is revalued by the obligatory shutting down of the environment polluting Hungarian power plants, by the little free capacity of transmission lines which limits electricity import and by the problems of the acquisition of the traditional sources of energy.

In connection with nuclear energy production, the main problem is the storage of spent fuel and of radioactive waste. The low and intermediate level radioactive waste is stored on-site. The place proposed for their final disposal in Bátaapáti, at the southern limits of Tolna County, was characterized as suitable for this purpose by geologists. The site is still being examined. The readiness of the inhabitants for the reception is proper, at the polls held in July, 2005 90.36% of the voters supported the building of the repository. On the basis of the results of the examinations up to the present, the Parliament gave its theoretical consent to the construction of the repository. The environmental protection licensing is in progress, the preparatory works are carried out according to the schedule. On 18th January, 2006 the preparatory stage of the environmental protection licensing procedure was finished with the publication of the 3535/06 reference numbered resolution of Middle-Transdanubia Inspectorate for Environment, Nature and Water (KD KTVF) in which the authorities prescribed the accomplishment of an environmental effect study.

The interim storage of the spent fuel is solved for a period of 50 years in a facility built specially for this purpose: in the Interim Storage Facility for the Spent Fuel (ISFS). The facility, which is situated next to the site of the NPP, is possessed and operated separately from the NPP. The research about the final disposal of the spent fuel has already started, the clay formation at the western part of Mecsek Mountains seems to be a promising place.

The management of low, intermediate and high level radioactive waste and of spent fuel (interim storage, final disposal) does not form a part of our study because an environmental-protection licence is needed for these activities themselves. The tasks related to these activities and the decommissioning of the NPP together with the management of the related funds belong to the Public Agency for Radioactive Waste Management (PURAM) according to the 240/1997. (XII. 18.) executive decree.

Our NPP was established in a period when the international requirements in connection with nuclear safety have become notably stricter. The Hungarian was the first among the NPPs of the countries of the Eastern block which satisfied the modern international safety requirements even at the time of its establishment. The enhancement of safety have been a continuous activity in Paks since the time when the NPP was built and we have always paid (and still pay) extra attention to it. During the enhancement of safety the latest technological and
scientific results are utilized; besides, the NPP can come up to the increasing public expectations. There have been (and will be) prominent periods when a ()-like, large-scale rising of safety level was realized. For example, this was the most important, special program of the NPP between 1997 and 2002 which cost about 60 billion HUF.

Paks NPP, just like all nuclear power plants, is controlled regularly by the experts of International Atomic Energy Agency which is the professional organisation of the UN, and by the experts of the World Association of Nuclear Operators. The evaluations summarizing these controls always consider the nuclear safety features of the NPP, its technological state, the preparedness of the staff and their commitment to safety as good. The Western European Nuclear Regulators’ Association also controlled Paks NPP – on Brussels' request – in connection with Hungary's accession to the EU. When they closed their detailed survey, they made the assertion that the safety of the Hungarian NPP corresponds in all aspects to the units of western NPPs that are of similar age. In sum, it has been several years since this facility meets the requirements in connection with Hungary's accession to the EU.

Paks NPP is the biggest employer of Tolna County and of the South-Transdanubia region; in 2004, 2740 persons were working in the NPP and 863 persons in Atomix Ltd. owned by PNPP. The job of thousands of people is in indirect connection with the operation of the NPP, mainly in the field of services. Its a quarter of a century since Paks has become an “atomic city” and large-scale improvements have been made in the city since then. The PNPP pays 7-9 billion HUF tax to the central budget and the sum of local taxes varies between 1.5-2.5 billion HUF, 99% of which is received by the city of Paks. Paks NPP gives considerable support in a national scale to the fields of healthcare, education, culture and to the fostering of folk traditions on both riversides of the Danube. Civil organisations, various associations and churches are supported as well. A considerable sum is given to the regional development associations by the NPP yearly to provide the own risk necessary for the different tenders, thus helping local investments. The planned service life extension of the units of the NPP can facilitate the development of the area for the next decades.

1.2 Tendencies in the nuclear energetics industry – an international overview

At the end of the 20th century, 436 power plant reactors were operating which provided about 17% of electric power produced in the world.

In the 1990s, the nuclear energy industry touched bottom all over the world, new units were established in the Asian region only. However, in the near past the evaluations and perspectives of nuclear energy changed in the right direction which was facilitated by international environmental protection agreements and international discussions (like the Conference in Johannesburg).

The role of nuclear energetics is being restored at present by the renewal of the operation licenses of the units, by service life extension and by the enhancement of their capacity all over the world because this ensures the effective utilization of the given equipments. There are hardly any costs of investments in connection with the NPPs that have been working for a long time, the whole
cost of operation is low and fuel is not a dominant item of costs. The stability and reliability of
the producer's cost of the NPPs on the long run can be attributed to the latter fact. For example if
the price of nuclear fuel were twice as much as it is now (which is rather improbable), it would
only result in a 20% increase in the cost-price of the produced energy. International
experience shows that because of these reasons the nuclear power plants are competitive at the
market.

In the field of the evaluation of nuclear energetics the decisive turn came when the United States
of America announced its new energy policy according to which the USA is planning to give a
leading role to nuclear energy in the future. The operation licence of almost all NPPs will
probably be extended from 40 to 60 years. Until September 2005, 35 units received their licences
and the licensing procedure of 14 units is in progress. The enhancement of the performance is in
progress, too, in 2001 only, 12 units were allowed to accomplish such interventions.

Service life extension is a general tendency in the European Union as well. This fact was
affirmed evidently by the conference of the International Atomic Energy Agency held in
Budapest between 4-8th November, 2002.

58 units are operating in France with an output of more than 60 000 MW(e). The oldest units
have been operating since 1977, their planned service time is 40 years but their original operating
license is valid for an undetermined period. The NPPs are controlled in every 10 years by a so
called Periodic Safety Check. Now the French economy is preparing for the service life extension
of 13 units until 2020, then between 2020-2025 for the service life extension of another 24 units
or for the building of new units, if necessary. (Some plans of the latter have already been
prepared.)

In Great-Britain, more than 30 units are operating. It is generally accepted that they will operate
for their planned service time (which is 40 years here, too) but some units will probably be
operating for 45-50 years. The British companies and institutes operating the whole nuclear
industry do not want to give up producing nuclear energy on the long run; it is not impossible that
they will build new units further in the future.

The present government of Germany ensures that the NPPs will serve until their planned service
time, as well. This means that after 2020, 11 units are going to operate with an output of more
than 14 000 MW(e) which is 64% of the present capacity. In Switzerland, the public approval of
nuclear energetics is much better than in Germany. Five units are operating in the country, the
oldest from 1969 and the newest from 1984. As a result of the examination program started in
1991 the service time of the older units will probably be extended with 10 years while that of the
newer ones may be extended with 20 years according to the authorities. In the Netherlands, the
unit operating from 1973 with 449 MW(e) is planned to serve for its 40 years service time.

In the Finnish NPP in Loviisa (which is the most similar to Paks NPP from a technological point
of view) a modernizing and output enhancing program was accomplished in 1998 which
improved the nuclear safety level as well. Besides the planned service life extension, Finland is
the only European country where the establishment of new nuclear units is approved of; the
Parliament have given its consent to the preparations and the type has been selected.

More detailed information is available at local governments.
In the Eastern- and Central-European region, Slovakia is going to close down two older units in Bohunice so as to meet the requirements of the EU. The two younger units of Bohunice and Mohi NPP are going to be operated after their planned service life. In the Czech Republic, a 10-year service life extension is planned in Dukovany NPP. In Slovenia, the output of the unit in Krsko NPP has been enhanced by 6.3% as the result of a reconstruction program and the service life is planned to be extended. These facts show that in Central-Europe at least six units are going to be operated which are similar to Paks until about 2030.

The Russian nuclear energetic industry is very much interested in the service life extension of NPPs. Because of their resemblance to the units of Paks NPP, Kola and Novovoronyezs NPPs are very important. Out of the Russian units, Unit 3 and 4 of Novovoronyezs have acquired an operation licence for 15 years after its planned service life. In Kola NPP, the preparations has been accomplished for the service life extension. The Russian nuclear authorities have licensed the operation of Unit 1 and 2 for 15 years after its planned service life, too.

2 TECHNOLOGICAL FEATURES OF PAKS NUCLEAR POWER PLANT

Because of the volume limitations of an easily intelligible summary, the technological introduction of the operating NPP is restricted to the naming of the buildings and technological equipment and to the description of their functions. (The environmental effect study discusses the technological parameters in more details.)

2.1 Buildings of the Nuclear Power Plant

The most important facilities of the technological process of the plant can be found on the site next to and joined to each other, as it is shown in Picture 1. The following technological facilities need to be emphasized:

- **Main Buildings of the Plant** (The two main buildings are the technological centers of energy production. They include the pairs of reactors, the primary and secondary loops and the facilities and equipment connected to them. The specially constructed buildings have load-bearing, biological defensive, barrier functions and they isolate the reactors from the environment.)

- **Auxiliary Buildings** (They serve for the storage of radioactive waste produced by the water cleaning facilities and in the controlled area, as well as for the placement of the technological systems in connection with waste management.)

More detailed information is available at local governments.
* Diesel Generator Building* (It accommodates the diesel generators which guarantee the emergency electricity supply of the NPP.)

* Sanitary – Laboratory Building* (The personal traffic between the dressing-rooms and workplaces in the two main buildings goes through this place, as well as the light freight traffic of the laundries and the laboratories. This multi-function facility serves as a kind of “sluice” between the controlled area and the industrial area.)

* Chemical- and Supplementary Water Preparatory Building* (This building accommodates the technological and service systems that provide the desalinated water necessary for the NPP's operation and the chemical needs of the primary and secondary loops.)

* Ventilation Chimneys* (They emit the filtered and checked air of the primary-loop rooms which is transferred by the ventilation systems.)

* Intake Structures and Utilized Water Backtaking Facilities* (These structures serve the intake of coolant water for the NPP and then the sending of warm technological waters into the receiver.)

* Hydrogen Generator, Fleet of Hydrogen- and Nitrogen Tanks* (Its task is to produce hydrogen for the cooling of the generator and the safe storage of hydrogen in tanks.)

This list does not include the community facilities, offices, storing rooms and other buildings that can be found on the site because they are not of crucial importance from the aspect of the NPP's activity.

### 2.2 Technological Equipment of the Process of Production

Out of the technological facilities, the reactor and the primary loop are crucial from the aspects of both the operation and of service life extension so they are discussed here in more details.

In Paks Nuclear Power Plant four VVER-440/213 type reactor units are operating which are of Soviet construction. These reactors belong to the class of pressurized water reactors (PWR). The name comes from the Russian translation of „Water-Water Energetic Reactor“, the number 440 refers to the original nominal electrical power output of the reactor, which was 440 MWs. Currently, the overall power output of the NPP has increased from the original 1760 Mws to 1866 MWs. If the planned output enhancement is accomplished, the overall power output can reach 2000 MWs.

**Reactor types using pressurized water technology are still the most popular all around the world.** In these reactors the coolant water does not have any direct contact with the outside world, it circulates in the primary loop which includes the reactor itself. The primary loop coolant water i.e. the heat generated in the active area is transferred to the steam generators by six coolant loops which are around the reactor. There the heat is transferred from the secondary side of the steam generators by the secondary loop coolant water. The water boils in the steam generators and the steam produced operates the turbines. The secondary loop is closed, just like the primary one (see Figure 5.)

More detailed information is available at local governments.
The NPP is constructed with two twin-units. The upper part of the buildings are customary industrial buildings with general technological machineries. The reactor with the primary loop and the steam generators are placed within the lower part of the buildings. The reactor is surrounded by radiation protection shielding. The lower part of the reactor building forms a separate, closed space by each units. The separate parts of the buildings (the so called hermetic rooms) are connected to the emergency and localization systems of the reactors.

5. ábra Az energia termelés és megvalósításának folyama

Az ábra alátársása: Figure 5. The process of energy production

Az ábra szövege:
Gőzfélesztő = Steam generator
Reaktor = Reactor
Turbina = Turbine
Generátor = Generator
Dunavíz = Water from the Danube
Turbina kondenzátor = Turbine condenser
Fűtőgőz = Heating steam

More detailed information is available at local governments.
The fuel of the reactor is uranium dioxide (UO2), which is compacted to cylindrical pellets of about 9 mm height and 7.6 mm diameter (see figure 6.). The uranium pellets are inserted into a 2.5 m long and 9 mm diameter tube (cladding) made of a zirconium alloy, which is filled with helium and then sealed hermetically. This is a fuel rod.

Since it would be practically impossible to change and move about 40 thousand fuel rods, the rods are bundled into assemblies. The cross section of the WWER-440 fuel assemblies is a hexagon and each contains 126 fuel rods. Altogether 349 assemblies can be inserted into the reactor core and 312 out of these are fuel assemblies. In order to control the chain reaction going on in a WWER-440 type reactor, absorber rods made of borated steel are applied, whose sizes are equivalent to that of the fuel assemblies.

Just like Western-European reactors, the safety systems of the Hungarian NPP follow the principle of “defence-in-depth” which means that there are several safety barriers between the environment and the nuclear fuel elements. Besides passive defence there are systems of active defence as well. In case of failure, all control rods are automatically inserted into the reactor core and within 12-13 seconds they stop the chain reaction. However, a significant amount of heat is produced further on due to the decay of radioactive fission products and this heat production can be as high as 7.5% of the nominal power in the first moments. Therefore, cooling of the core is absolutely necessary after the stoppage of the reactor as well. If the cooling system is damaged, a supplementary, emergency cooling must be provided, even after the reactor stops. Melting of the fuel which is left without cooling would result in release of radioactive fission products and other (e.g. Transuranic) isotopes and this must be avoided by all means.

The most serious design failure of the nuclear power plant is the rupture of a primary circuit main pipe. (The likelihood of this accident is very low, though: 1/100 000 per year.) In the case of such a serious accident the loss of normal core cooling is worsened by the phenomenon that, since water at the rupture is at very high temperature but the outside pressure is low, it immediately starts to boil and floods the surrounding space with highly radioactive steam. Of course, release of radioactive steam must also be avoided. This purpose is served by the so called hermetic room and localization system. The so called hermetic room is a part of the building which contains the coolant loops of the reactor. It has 1.5 m thick concrete walls, which on the one hand shields against radiation and, on the other hand, prevents steam from getting out up to 1.5 bars pressure. (Figure 7 shows how the reactors and the connected technological equipment are situated.)
Az ábra aláírása: Figure 7. The center of the technology: the Reactor Building and the Turbine Hall

Az ábra szövege:
1 Reactor vessel
2 Steam Generator
3 Refuelling machine
4 Cooling pond
5 Radiation Shield
6 Supplementary feedwater system
7 Reactor
8 Localization tower
9 Bubbler trays
10 Deaerator
11 Aerator
12 Turbine
13 Condenser
14 Turbine hall
15 Degasser feedwater tank
16 Feedwater pre-heater
17 Turbine Hall Overhead

More detailed information is available at local governments.
18 Control and instrument room

In order to avoid steam pressures higher than 1.5 bars (that is to avoid the damage of the reinforced concrete building), a steam pressure reduction system has been developed, which consists of a localization tower and a sprinkler system. Steam produced in case of a main pipe rupture, along with the air of the hermetic room, flows to the localization tower, where it flows through trays filled with borated water (>12.5 g/dm³). Meanwhile, steam condenses and thus the pressure of the hermetic room drops. The sprinkler system sprays borated water to the hermetic room. This causes further pressure decrease. Boric acid is necessary because the condensed water may later get into the reactor and the neutron absorbing ability of boron helps to prevent the chain reaction from starting again.

In the case of a primary circuit pipe rupture, the cooling of the reactor core is ensured by the emergency core cooling system (ECCS). The ECCS is made up of a low and a high pressure part. The low pressure unit pumps water of 7.2 bar pressure and 12 g/l boric acid concentration into the reactor. The high pressure ECCS helps the restoration of the normal operational cooling by injecting borated water of 40 g/l concentration at 132 bars pressure. Besides these, a passive ECCS is also available, which does not need electricity to operate.

There is a shared turbine building for the four reactor units with two turbines for each unit which means 8 turbines on the whole. The main transformers are placed near the turbine building, in a safe distance from it. In case of normal operation and maintenance Paks NPP is absolutely independent of all outside services from the aspect of infrastructure.

The majority of the safety systems requires electric power, so one might obviously ask what happens in case of the loss of electricity supply. Three diesel generators are built to each reactor units, which automatically start in case of a serious incident and ensure voltage supply to the important equipment.

The auxiliary systems in connection with the primary loop and their functions are the following:

- **Supplementary Water and Borating Control System** (Its task is to supplement both the planned and unplanned leakages of the primary loop, to guarantee the balance of the primary coolant and the compensation of the slow changes in radioactivity by the extraction of boric acid solution. In case of incidents, the system adds boric acid to the primary loop as part of the reactor protection operation.)

- **Water Cleaning Systems** (For the safe and proper operation of the technological equipment of the primary loop, the primary coolant needs to be cleaned regularly. The water cleaning tasks related to the primary loop are carried out by autonomous systems.)

- **Controlled Leakage System** (Collects the leakages of the primary loop and then takes it back to the system through the supplementary water system.)

- **Intermediate Cooling Systems** (Some parts of the main equipment of the primary loop that need constant cooling are in direct contact with the primary coolant. So between the coolant water and the equipment that needs to be cooled there is a closed-system intermediate coolant loop, where the pressure of the coolant loops reduces towards the interior and the pressure of the system that needs to be cooled is the lowest.)
Service Time Extension of Paks Nuclear Power Plant

- **Cooling Tank and its Coolant Loop** (The task of the cooling tank is to store the spent fuel assemblies for five years after they were removed from the reactor. It has an autonomous coolant loop.)

- **Secondary Coolant Loop** (Its task is to guarantee the transferral of heat from the primary loop by steam generators, to transfer the steam to the two turbo-generators and to transfer the condensate back to the steam generators. In case of cooling down and in case of emergency, the secondary loop guarantees the transferral of heat from the primary loop through steam generators.)

- **Safety Coolant Water System** (Its task is to supply the equipment that need safe and constant cooling by normal operation of the unit, and to supply those equipment that serve for the normal and emergency cooling down of the unit.)

- **Ventilation and Air-Conditioning Systems** (According to the basic radiation-protection ventilation planning strategy of the buildings and rooms of the NPP, the areas that are not contaminated with radioactivity are separated from those that are potentially contaminated. These systems guarantee the proper extraction and treatment of the air from the potentially contaminated areas and ensure the industrial conditions necessary for the operation of the equipment and for the stay of the staff.)

- **Emergency Systems** (They begin to work in case of an emergency. They guarantee that the emergency is averted automatically and they prevent the radioactive contaminations from getting out into the environment.)

- **Electricity Equipment** (The two turbo-generator transformers that belong to the reactor units and joined on the 400 kV side are joined to the 400 kV national electric power network. The diesel generators ensure the safety energy supply.)

- **Control Technology** (Serves for the control of the safety parameters and for keeping them within safe limits.)

- **Industrial Emission and Environmental Control System** (Fulfils the emission- and environmental radiation protection control of the NPP. See the details later on.)

There are several other technological systems within the plant that do not have an effect on nuclear safety and/or that are not related directly to production but there is a chance of environmental pollution in case of their malfunction. The most important ones of these technological systems are the following:

| - Industrial Waste Water Collecting, Lift-Over and Canal System | - Turbine Oil System |
| - Industrial Sludge Pool (caustic sludge, chemical and oil tanks) | - Oil Decanting Station and Emergency Emptying System |
| - Chemical Decanting and Special Chemical Preparatory | - Engine House and Feeding Pump Oil System |
| - Chemical Transferring and Feeding Systems | - Lubricant, Dead Oil and Diesel Oil Systems of Safety Diesel Generators |
| - Chemical Waste Water Throw-Out Pipes | - Communal Waste Water Pipes |

More detailed information is available at local governments.

Plain Summary 2006.02.06
2.3 Production supporting activities

Only the most important activities related to the producing process are introduced here:

- **Storage and treatment of radioactive waste**

  Through the discharge culvert and the air chimney radioactive isotopes are emitted by the power plant, but the rate of emission never exceeds the planned and strictly controlled limits. During the normal operation and maintenance process radioactive waste is generated, either. In the controlled security zone of the power plant every type of waste is regarded as radioactive until it is not proved to be non-radioactive by careful measurements.

  Low and intermediate level **solid radioactive waste** is treated (selected, compressed, sludge is solidified). Until the construction of the final repository the solid waste is temporarily kept in the main and auxiliary buildings of the power plant.

  The **waste water** produced, whose emission is preceded by careful chemical and radiological classification in every case, is collected in control tanks. If the water found emittable, it gets into the Danube through the discharge culvert. The emission limit values are never exceeded. Paks NPP has already finished the extension of the liquid waste container fleet.

  The systems used for treating **airborne emissions** are to clean the air extracted by ventilation systems and derived from technological blow-downs. Cleaning is carried out by aerosol and iodine filters, then the air gets into the atmosphere through the 100 meters tall chimney of the units and the 30 meters tall chimney of the sanitary laboratory. According to the measurements, up to 2003 the components under official limitations have not reached the 0.1-0.7% of the yearly emission limit value. In 2004, after the introduction of new measurements, the emission rate of the power plant was the 0.27% of the limit value (liquid 0.15%, airborne 0.12%).

  **High activity solid waste** is kept in packages providing recoverability.

- **Storage and treatment of hazardous materials**

  At the power plant a significant amount of chemicals are used for different operations which are occurred in the diesel engine-room, the nitrogen and hydrogen plant, the gas bottle storage building, chemical extraction plant and the water-treating plant. The storage, utilization of these chemicals and the elimination of the waste happens as prescribed. The necessary amount of hazardous materials stored does not potentially endanger the power plant as there is a proper distance between the reactor and storage buildings.

- **Water supply**

  Most part of the water supply of the power plant is taken from the Danube, but water of the waterworks and the bank-filtered wells is also used. The yearly amount of social water-consumption is approximately 260,000m³. The drinking water supply is provide by the
Waterworks of Csámpa. The amount of cooling and technological water is taken from the Danube is 100-110 m³/s, which is 12.5% of the lowest discharge rate of the Danube and 5% of the average discharge rate of the river. The amount of the water taken from the Danube never reached the rate permitted.

- **Canalization**
  The power plant has separated canal systems for communal and industrial waste water. Waste water derived from social establishments and the building of the sanitary laboratory is collected by the communal waste-water system. The sewage-treatment plant, which consists of 2 structure lines, is situated on the east of the power plan units. Its capacity is 670+1200 m³/day. The technology used is the total oxidating, sludge activation sewage treatment. The extra sludge gets onto the sludge-desiccation bed in order to be dewatered. The desiccated sludge is eliminated following radioactive concentration tests.

  The **industrial waste-water system** collects non-communal and technological waste-water. These waste-waters get into the sludge reservoir pool. The cleaned water passes through a spillbox by gravity and gets into the discharge culvert.

  The **precipitation water** canal system consists of connecting pipes, backbone pipe lines and outlets. It is to drain away the precipitation water from hard and green surfaces such as roofs, pavings, roads and green areas.

### 2.4 Industrial Nuclear Emission- and Environmental Control Activity

#### 2.4.1 Control System

The nuclear environmental protection of the nuclear power plant covers the control of the radioactive emissions of the power plant, namely the determination of their amount and composition, and the continuous monitoring of the radiation conditions of the environment of natural and artificial origin. This is provided by the new Emission and Environmental Radiation Protection Control System (Kibocsátás és Környezeti Sugárvédelmi Ellenőrző Rendszer, KKSER), which has been worked out for today with the reconstruction of the previous control system having been in process since 1998. This system provides enough data as far as amount and reliability are concerned to judge the environmental effects, and to take the necessary actions if needed, in all conditions of operation of the nuclear power plant (normal operation, incident, nuclear accident).

The most important areas of control are the following:

- measurement of airborne and liquid emissions in the ventilation chimney, in the fleet of water collecting tanks and in the sluices;
- measurement of meteorological characteristics;
- measurement of the radioactive concentration of air, soil, groundwater and natural vegetation (grass);
- measurement of the activity of the different samples (water, sludge, fish) of surface waters (the Danube and the fishponds) and the rainwater gathering channels;
Service Time Extension of Paks Nuclear Power Plant

- measurement of the activity concentration of certain food samples (milk);
- measurement of the dose, dose output of environmental gamma radiation.

The above task is carried out by the Industrial Environmental Radiation Protection Control System (Üzemi Környezeti Sugárvédelmi Ellenőrző Rendszer, ÜKSER). The activity of the industrial control system is carried out partially through laboratory sample measurements, and partially through the telemetry of the emission control systems and the environmental radiation protection control systems. (The Official Environmental Radiation Protection Control System (Hatósági Környezeti Sugárvédelmi Ellenőrző Rendszer, HAKSER) is totally independent of the above system; it has got measurement and sample holes of its own.)

The industrial emission and environment control system was established between 1977 and 1982; during the execution of the reconstruction the previous system was stripped off gradually. After the reconstruction, on 31st August 2005, with the finishing of the trial runs the new control system was put in operation officially, as well. Due to the reconstruction the environment control system became more reliable; its measurement range became wider; it provides more data, and it fulfills the strict requirements connected to the secure operation, determined in the standards. The arrangement of the elements of the system is shown by Figure 8.
A mérőrendszer részei:
- A légnemű kibocsátás ellenőrző rendszer
- „A” (9 db), „B” (1 db) és „G” (11 db) típusú állomáshálózat
- Meteorológiai mérőtorony
- Vízmérő állomások (3 db)
- Üzemterületi dózisfelmérő mérő (18 db)
- Központi adatfeldolgozó, gyűjtő és megjelenítő rendszer

Az ábra aláírása: Figure 8. The arrangement of sampler and telemetre stations near the NPP.
Az ábra szószedete:
távmérő és mintavevő állomás (A típusú) = telemetre and sampler station (A type)
mintavevő állomás (B és C típus) = sampler station (B and C type)
vízmérő és mintavevő állomás = flood-measuring post and sampler station
meteorológiai mérőtorony = meteorological instrument tower
az ÜKSER központja (KAR) = the ÜKSER Centre
Környezetellenőrző Laboratórium = Environment Control Laboratory
mintavevő állomás (G típus) = sampler station (G type)

A mérőrendszer részei = Parts of the telemetre system
- A légnemű kibocsátás ellenőrző rendszer = Airborne emission control system
- állomáshálózat = Station system
- Vízmérő állomások = flood-measuring stations
- Üzemterületi dózisfelmérő mérők = On-site dose-meters
- Központi adatfeldolgozó, gyűjtő és megjelenítő rendszer = Central data processing and gathering system

More detailed information is available at local governments.
Beyond the measuring systems the laboratory examination of many natural samples (air, grass, soil, milk, fish, surface water, groundwater, etc.) is carried out as well. The applied methods enable the determination of extremely low radioactive concentration as well. The examination of the environmental elements and food is carried out by the laboratories of the Radiological Monitoring and Data Acquisition Network, working within the frames of the National Public Health and Medical Officer Service. One of the 7 laboratories carrying out the examinations operates in the Public Health Service of Tolna County. The industrial emission and environment controlling activity of the nuclear power plant is controlled by the environmental inspectorate every week.

2.4.2 Public (Civil) Control

Besides the measuring and control systems of the power plant and the authorities there is a special grid in the power plant area, which is independent of the other two mentioned above. The Civil Control and Information Association (Társadalmi Ellenőrző és Információs Társulás – TEIT) set 13 detectors within a 12 kms radius circle around of the power plant, mostly at local government buildings or near them. The detector measurements are analysed monthly by the local civil defence. Paks NPP gives free run of the results of its own measurements without knowing those of the local governments. The TEIT makes the data public without any preliminary cross-check of the two sets of measurement results in the local and regional newspapers. In the past ten years there has not been a significant difference between the two sets of results recorded that is the best proof of the antipollution and environmental monitoring activity. In the beginning of 2006 Paks NPP replaced the whole civil measuring system with the latest, most up-to-date apparatus.

Representatives of the population of Paks check the water quality of the Danube with the help of the water laboratory situated in the village of Bátya. The apparatus used there is suitable for correct activity measuring of surface, ground and precipitation waters, either. The results of these measurements are also made public in the press.

Radiation protection indicator systems, which are set at the most busy points of Kalocsa, Paks and Uszód are to inform the population directly. The apparatus informs the inhabitants of the right time, the air temperature, the instantaneous rate of background radiation and its daily and weekly fluctuation. The information is presented in a plain, illustrated way. In the case of any official or non-official nuclear related statement, the population is immediately able to make certain of the stability of environmental conditions and its probable changes. Further environmental radiation protection indicator systems, which were won by successful applications with the help the national environmental protection fund, operate in the area of Gerjen, Dunaszentgyörgy and Paks.

In the region of the power plant the inhabitants and their elected leaders and syndicates take part in controlling the effects of the nuclear power plant with the help of suitable apparatus, up-to-date technological background and an adequate set of information.
3 THE PLANNED SERVICE LIFE EXTENSION

In order to fulfil the long-term energy need of the country in a practical and reasonable way – taking the described international tendencies into consideration – the extension of the operating time of the units of Paks NPP is well-founded. By this extension, the stability of the supply of the population can be guaranteed and the price of the energy can be kept on the lowest possible level in the long run as well. So the management of the power station has started the necessary preparatory and grounding works with the approval and support of the owners, the Hungarian Electricity Works and the Hungarian Privatization and State Holding Company.

To reach the determined goals, the NPP intends to gain public support with wide-range, objective provision of information. According to the results of the polls carried out in the country the social acceptance of the operation of Paks Nuclear Power Plant is permanently high (65-75%), which provides a fair basis for the development ambitions of the power plant. (See Figure 9.)

![Figure 9. The indicators of the polls](image)

Az ábra aláírása: Figure 9. The indicators of the polls
Az ábra szövege: Base = All of the voters, A/14. Question

Nuclear security plays the most important role At Paks, during both the operation and maintenance, and during the execution of the planned future activities. The leaders to be of the power plant put across this priority in their environmental, production, management and property policy decisions consequently.

More detailed information is available at local governments.
The Hungarian National Assembly discussed the proposal concerning the service life extension in November 2005. After the Government declared its approval of the extension, the Parliament took notice of the information with a vote of 96.6%, and gave its conceptual support to the service life extension in the Government Decree No. 85/2005. (XI. 23.)

3.1 The Possibility of Service Life Extension

Service life extension is a task which can rely on the features of the construction/production of the NPP, on the technical sizing spares of the main equipments and of the whole construction and on the experiences of the regular technological checks. The safety of the NPP is a crucial condition of service life extension. As a result of the overall safety enhancement program finished in 2002, the safety of the NPP meets the requirements in connection with the units operated in Western NPPs which are of similar age. The safety of the NPP is continuously kept at a level that meets the national and international requirements. However, technological safety cannot be characterised by constant parameters. The new recognitions and experiences define new requirements and the proper solutions for them need to be find.

Examining the possibility of the planned service life extension, Paks Nuclear Power Plant estimated the tasks of knowledge acquirement, of licensing and the technological tasks that should be carried out, and in the first step it made an execution investigation prepared, covering all the establishments and technological apparatuses (“The Execution Analysis of Service Life Extension of Paks Nuclear Power Plant”, Electric Power Industry Research Institute, 2000.). The execution investigation covered the processing of the international experiences connected to service life extension of NPPs, the detailed examination of the technical conditions of the power plant and the estimation of the technical and security actions needed for the extension and their costs.

The execution study proved that the NPP can be kept in operation for another twenty years – after the thirty years’ service life that was planned when it was established. The extension of the operating time does not have any technical or security obstacles, and economically it is unequivocally advantageous. According to the execution study the planned service life extension is based on keeping the function capability of the long-life, non-changeable system elements (eg. reactor main building, reactor vessels, steam generators). The required technical conditions of the other system elements (eg. pumps, wires, apparatuses of control technique) can be provided by maintenance, renewal and change; their safety functions can be checked with trials.

Paks Nuclear Power Plant made the above execution study revised from technological and economic points of view between 2004 and 2005, the result of which did not alter the previous statements considerably.

The planned service life extension is an activity that has to be permitted by the authorities. According to the Nuclear Safety Regulations (NSR), in order to keep the units of the nuclear power plant in operation after the planned service life the operating licence has to be renewed.

More detailed information is available at local governments.

Plain Summary 2006.02.06
The intention of extending the planned operating time has to be announced to the National Atomic Energy Agency’s Nuclear Safety Directorate (NAEA NSD) four years before the expiry of the planned service life, together with the program concerning the establishment of the conditions needed for the operation after the planned service life. The request for the operating licence concerning the further operation has to be handed in to the NAEA NSD in the case of each unit one year before the expiry of the operating licence pertaining to the planned service life the latest. To this the technical documentation has to be enclosed, as well as the other official permissions required by the Act CXVI of 1996, concerning nuclear energy, among which the most important is the environmental licence. The nuclear licence for service life extension can only be issued in possession of the environmental licence.

3.2 Service Life Extension and the Environmental Effect Study

In this case the procedure of effect study refers to a facility which has already been operating and not to one which is being planned now. It is not necessary to transform or to rebuild the buildings of the NPP, neither to modify the working technologies nor to carry out any other significant interventions for service life extension. In the present case – as opposed to the general practice of effect studies – we are not going to construct a new building but we are going to operate further the given NPP which is working presently in an environmentally friendly way, keeping the proper safety level, of course. In order to do so, the investigation of the present equipments of the NPP, their continuous control, and the exchange or renewal of the aging equipments and accessories is necessary.

The present environmental effects and effect processes in connection with the NPP will be definitive in the future as well, there will not be any new ones. So in the evaluation of the future activities the acceptability of the present environmental effects will be crucial. Thus the whole environmental licensing process – and so the effect study, as well – emphasized the introduction of the present conditions and the evaluation of the present environmental effects.

Besides the evaluation of the present conditions, it is necessary to take into consideration the environmental effects of the investigation, modernization and transformation of the technological system itself, in other words, environmental effects of the preparation for the service life extension. On the other hand, it was necessary to examine separately how the cumulating environmental effects of the NPP are going to change as a result of the predictable 20-year service life increasement (see waste production). The main goal of environmental effect studies is to estimate in advance the changes that will probably take place in certain elements / systems of the environment as a result of the planned activity, and to characterise them according to the changes caused in the ultimate bearers of the effects. The most important thing is to follow the active factor -> direct effect -> indirect effect process, i.e. the process of influence.

So that we will be able to do so, first it is necessary to define the active/influential factors of the activity and the processes of influence resulting from them (see Figure 10.).

The recognizable processes of influence in connection with the present operation helped us follow this process because in the present case these processes and those in connection with the
operation after the planned service life were the same. These processes were evaluated in the environmental effect study.

### 3.3 The Accomplishment of Service Life Extension

It can be asserted on the basis of the technological condition survey that
- there aren't any technological or safety obstacles in the way of the operation of the NPP for 50 years
- the control, maintenance and regular renovation practice of the NPP makes service life extension possible in the case of most of the equipments without any prominent costs
- in a small proportion of equipments and systems needs reconstruction because of aging or considerable obsolescence
- in the case of some systems the extension of capacity might be necessary (eg. the storage of waste)
More detailed information is available at local governments.
Service Time Extension of Paks Nuclear Power Plant

The processes of the environmental effects of the NPP

Az ábra aláírása: 10. ábra Az atomerőmű működésének környezeti hatásfolyamatai = Figure 10.

Az ábra szövegei:
Érintett körny.-i elem/rendszer = Affected enviromental elements / systems
Levegő = Air
Felszíni és felszín alatti vizek = Surface and sub-surface waters
Föld = Soil
Élövilág – ökoszisztémák = Fauna – Eco-systems
Művi elemek = Artificial elements
Települési környezet = Neighboring Settlements
Zaj, rezgés = Noise, vibration
Táj = Land

Hatótényező = Active Factors
1. Radioaktív kibocsátások a működés során = Radioactive emissions during operation
2. Hagyományos légszennyező-anyag kibocsátás a működés fázisában = Emission of traditional air-polluting materials in the operating phase
3. Hőkibocsátás a légterbe = Heat emission into the atmosphere
4. Érőmű léte, urbánhatása = The existence of the NPP, its urban effect
5. Haváriás légszennyezés = Average1 air-pollution
6. Vízkivétel (hűtő- és szociális vízigény) = Water out-take (coolant- and community water need)
7. Beépített és burkolt felületek léte = The presence of surfaces that are paved and built on
8. Radioaktív kibocsátások a működés során = Radioactive emissions during operation
10. Meleg hűtővíz kibocsátás = Warm coolant-water emission
11. Haváriás vízszennyezés = Average water-pollution
12. Az atomerőmű, mint építmény léte = The existence of the NPP as a building
13. Hagyományos hulladékok keletkezése a működésnél = Production of traditional waste during operation
14. Radioaktív hulladékok keletkezése a működésnél = Production of radioactive waste during operation
15. Haváriás talajszennyezés = Average soil-pollution
(nincs közvetlen hatás) = (there's no direct effect)
16. Létesítmények állapotfelügyelete és állékonyságvizsgálata = The condition-control and stability survey of the facilities
17. A létesítmény léte = The existence of the plant
18. A létesítmény működése = The operation of the plant
19. A létesítmény léte = The existence of the plant

Közvetlen hatás = Direct effects
→ Háttérterhelés változása = Change of background radiation

1 damage caused by the NPP
More detailed information is available at local governments.

Plain Summary 2006.02.06
Service Time Extension of Paks Nuclear Power Plant

→ Service Time Extension of Paks Nuclear Power Plant

More detailed information is available at local governments.
Egység használatok időszakos korlátozása = Occasional limitation of certain utilizations
Biztonsági problémák = Safety problems
Használatok korlátozása = Limitation of utilizations
Kockázat növekedés = Risk increase
Használatok korlátozása = Limitation of utilizations
Biodiverzitás csökkenése = Reduction of bio-diversity
Fenntartási igény növekedés = Increase in the need of maintenance
Normál üzem biztosítása = Providing normal operation
Szerves fejlődés lehetősége = The possibility of organic development
Használatok lehet. javulása = Improvement of utilization possibilities
Kellemetlenség = Inconvenience
Életkörülmények változása = Change in living conditions

The assumption of service life extension is a prepared and running system of lifetime-engineering and ageing effect handling, what is able to upkeep the required technical status and function of machinery by monitoring of ageing course, makes required arrangements according to monitoring results, runs the reactor in ageing-safe operation and assures the conditions (like maintenance, repair, renovation, exchange) of operation. This system has to introduce during the original operation time, irrespectively of service time extension. In the process of nuclear safety licensing we have to prove that lifetime-engineering and ageing effect handling system warrants the required technical status. The essential elements of this system exist in daily routine of the NPP, and the most important instruments, for example the monitors to measure the radiation havoc of reactor vessel and ageing of steam-generator, are implemented from the beginning of operation time of NPP. As we know now , the biggest inventions and arrangements necessary for the service life extension and partly to reach the planned operation time are follows:

- **Reactor vessel** (see Fig 2.): in the case of Unit 1 and 2, it may be necessary to level the temperature of water in emergency cooling system of the vessel. The welded seams of Unit 1 have to strengthen by heat treatment.
- We have to monitor the **upper mainfolds of the reactor vessel** of cracks of ageing and of pressure corrosion.
- We have to monitor the mainfolds of volume-compensatory device of tired material havoccs and of pressure corrosion.
- We have to replace the **inside rod set** in all four reactors, and in the case of the **mechanics of control rods** a consciousness planing is necessary.
- The tension causes ageing of the rotating parts of **main circular pumps**. Replacement of these parts will elongate the service time.
- We have to check the embrittlement of the castings of **main stoping valves**.
- We have to replace the **armatures of main steam-system**, because of their attrition.
- We have to replace the **high pressure preheaters** with new types (ferrit pipes, steel cases). The main reason of it is the erosion of the fed-water side and the safety level requirements of 10% power enhancement.
- General replacement of controls of **transfer equipments** because of the fast developing of this technology.

More detailed information is available at local governments.

Plain Summary

2006.02.06
4. THE ENVIRONMENTAL EFFECTS OF THE NUCLEAR POWER STATION

4.1. Characterization of the radioactivity of the environment

In 1981-82 a basic level measurement was carried out in the environment of the nuclear power station, which covered air, fall out, soil, groundwater, water and sludge of the Danube, flora, fish and milk samples and measurement of the dose rate. The method of the examinations was almost the same as the environment control system being in operation at present, so the data of the times before and after the establishment of the power station could be compared with each other. The results of the basic level measurement corresponded with the expected results, namely significant concentration values could not be observed.

During its operation the nuclear power station emits radioactive contaminated substances into the air and the Danube, the amount of which is controlled by strict official ultimate values. The most important statement that we can make on the basis of the measurements is that the nuclear power station complied with the official ultimate values in all respects, with quite large reserves, with the exception of the amount of tritium ($^3$H) leaving with the liquid emission. About the emissions we can state the following, considering environmental areas:

**Earth surface air, fall-out:**
- In the first decade primarily the radioactive isotope of silver appeared in the samples. Later its traceability fell back considerably, and by the end of the ‘90s it has been restricted to only a few cases. Sometimes some corrosion products ($^{54}$Mn, $^{58}$Co, $^{60}$Co) also appeared in the samples, in very small amounts (typically in orders of magnitude of parts per thousand/hundred mBq/m$^3$). In recent years one of the isotopes of cobalt ($^{60}$Co) has appeared (in a few percents of the monthly average samples, in a maximum of 10-20 samples yearly).
- Radio iodine coming from the power station could not be traced in any cases, either in aerosol, or in elemental iodine filtering samples - with the exception of the emission connected to the serious incident of 10-11 April 2003.

**Soil and grass samples:**
- Radioactive isotopes of natural origin or coming from global fall-out appear significantly in the measurements in the cases of both sample types. The data are irrespective of the emissions of the nuclear power station; however, they match the values found in the relevant literature.
- In the soil the isotope of cesium ($^{137}$Cs) could always be detected, and the isotope of strontium ($^{90}$Sr) was often traced; these are the results of global fall-out, in accordance with the things mentioned before. In the grass samples both isotopes were present in most cases, too. The same emissions cannot be detected significantly in the air.

More detailed information is available at local governments.
Radioactive isotopes coming from the power station (eg. $^{110m}$Ag, $^{54}$Mn, $^{60}$Co) could be detected only in a few of the 900 samples examined during the 23 years, and only in a very small amount - in a maximum amount of a few Bq/kg.

**Samples collected in the Danube:**
In the firth of the warm water channel, around the place where it pours into the river and south of that place, towards the direction of the flow of the river the isotopes can pile up. So in theory concentration values that are much higher than those of measured in the water could appear, and they can be measured more easily. That is why; the collection of samples is carried out here and in a place north of here – in order to compare the samples.

- From the beginning, the isotope of cesium ($^{137}$Cs) could be traced in all of the sludge samples, and in most cases the isotope of strontium ($^{90}$Sr) could also be detected. The values measured before 1986 and the later values of the isotope of strontium are primarily coming from the global fall-out. In the results of the measurements we cannot observe a tendency connected to the flow of the river, so it is impossible to determine the contribution of the power station.
- In the sludge samples collected at the firth of the warm water channel and the sample hole south of it some radioactive isotopes could be detected in 1-20 cases between 2000 and 2004. In most cases the isotopes of cobalt ($^{60}$Co – max. 6 Bq/kg), strontium ($^{90}$Sr – max. 3.8 Bq/kg) and cesium ($^{137}$Cs – 109 Bq/kg) could be traced. The isotopes of cesium and strontium in the environment of the power station are basically of global (Csernobil) origin.

**Water, sludge and fish samples of the fishponds:**
The environment control of the power station collects samples from the fishponds beside the power station and around Paks regularly, which can get radioactive substances partially through the water supply (ponds beside the power station) and partially through the air. The sample collection covers water, sludge and fish.

- The total beta activity concentration of the water samples belong to the range of natural surface waters (0.1-0.5 Bq/dm$^3$). The same can be stated in the case of tritium (1-5 Bq/dm$^3$) as well. In the samples no gamma-radiant radioactive isotope coming from the power station could be detected.
- The situation is similar in the case of the sludge samples as well; only the radioactive isotopes of natural origin can be traced. Similarly, in the oven-ready fish and chitterlings there were no gamma radiant isotopes coming from the power station above the traceability limit of 0.5 Bq/kg.

**Milk samples:**
Milk samples are collected from the cattle breeding estates south of the power station (Dunaszentgyörgy, Gerjen) by turns in every month, the activity concentration of which is measured by gamma-spectrometers. So far no radioactive isotope coming from the power station could be detected, considering the traceability limit of 0.5 Bq/dm$^3$.

More detailed information is available at local governments.
Groundwater:
At present, in the company seat of the power station sample collections are carried out from the 40 groundwater monitoring wells every month.

- In the company seat of the power station, mainly in the groundwater below and around the main building and the auxiliary buildings tritium of technological origin started to appear in the middle of the ‘80s. In 1993 an intensive series of tracing examinations was started in order to determine and gradually eliminate the possible technological irregularities, unorganized places of leaking and emerging. Due to the intervention the highest activity concentration of recent years did not, or slightly did exceed the value of 1 kBq/dm$^3$. The sum of the tritium concentration values of the groundwater wells shows a decreasing tendency as well, as far as time is concerned. On the basis of these we can state that the tritium contaminated water of technological origin gets no more into the groundwater.
- The contamination that got into the groundwater before is located primarily below and around the No. 1 auxiliary building and the main building of Units 1-2. The beta-radiant tritium contamination was spreading and diluting gradually with the movement of the groundwater, so today it forms a “tritium-cloud” below the industrial area. At the imaginary outer borders of the main and auxiliary buildings the activity concentration can reach 100 Bq/dm$^3$; however, farther from these, at the borders of the industrial area it is rather low, maximum 10 Bq/dm$^3$, or it is background level.
- In the past two years it became possible to carry out isotope-specific investigations that are more sensitive than the wells containing automatic sample collecting apparatuses. These measurements showed that in the groundwater no gamma-radiant isotopes of artificial origin could be detected above the traceability limit.

In summary:
The measured values of the environmental activity concentration arising from the radioactive emissions of the nuclear power station are orders of magnitude smaller than the concentration of natural radioactive isotopes and the amount of artificial radioactive isotopes coming from elsewhere in most cases. So the normal operation of the nuclear power station did not enhance the radioactive concentration of the environmental areas significantly so far. The same can be stated on the basis of the dose measurement investigations as well: namely according to the dose measurement examinations concerning the long time period and the wider environment of the power station the level of the environmental gamma-radiation did not increase to a detectable extent during the 23-year industrial operation of the power station.

Both the airborne and the liquid emissions stayed in a favorably low level during the operation of the nuclear power station, complying with the strict official ultimate values. The measurements proved that the nuclear power station did not have directly measurable effects on the radiation conditions of the environment.

It follows from the previous things that the dose loading of the population arising from the emissions was about 1 part per thousand of the official ultimate value, and 1 part per ten thousand of the radiation load arising from the natural background radiation.

More detailed information is available at local governments.
4.2. Traditional characteristics of the conditions of the environment

4.2.1. Quality of air

The area of Paks belonged to the clean aired areas of the country even before the establishment of the nuclear power station. In the territory of the town the concentration of the examined non-nuclear pollutants (sulfur-dioxide and nitrogen-dioxide) was only 2.5-4 times higher than the background pollution. The reason for this is that in the area there is no significant source of pollution that affects the area or has got local effects. In the settlement the air polluting effects of traffic and industry were not considerable, either, so the main source of pollution is the heating of the settlement.

According to the measurements of the Hungarian Meteorological Service the background pollution of the environment of Paks belonged to the moderate, less loaded zones according to the zone classification determined by the legislative rules, even during the operation of the nuclear power station. The pollution increase is only significant from the point of view of nitrogen-dioxide compared to the conditions before the power station was established, and this refers to the traffic that became the main polluting factor. The moderate loading of the air of the area was also supported by our investigations carried out on the spot, in the direct environment of the nuclear power station.

Examining the non-nuclear air pollutant emissions of the power station (security diesel machines, painting room) we could state in the case of the present conditions that these emissions of pollutants are not significant in the direct environment, either.

4.2.2. Characteristics of the climate

The company seat of the nuclear power station is characterized by the warm, dry, continental climate of the plains, so the oscillation of the air temperature and the fall, and the variability of the climatic elements are not surprising. The company seat is one of the driest areas of the country, since it is lying in the fall shadow of the Bakony Mountain and the North Hungarian Mountains. Considering the average of the country, it is situated on the border of the area getting the most irradiation, but accordingly the eradiation loss is also great. It is characterized by strong warming during the days and strong cooling during the nights. The dominant direction of the wind is northern, north-western in the company seat.

The establishment of the nuclear power station and the starting of its operation could have affected the microclimatic conditions. Primarily we have to make theoretical suppositions here, since examinations connected to this were not carried out before the establishment of the power station. The results of the meteorological measurements having been carried out since the nuclear power station was established has not detected typical changes in the measured parameters.

The theoretical effects can be put into two large groups: one of them is the effect group connected to thermal loading (eg. upwelling caused by the thermal loading, cloud and mist formation, vapor

More detailed information is available at local governments.
deposit), and the other is the urban effect occurring in the environment of built-in areas (eg. the higher average temperature of the built-in, paved areas, the change of the evaporation conditions). In order to detect the microclimatic effects of thermal loading five automatic measuring stations carried out measurements for two years within the frames of the company seat monitoring program. On the basis of their results we could state that the effects of the warm water channel could only be detected in the cases of low air temperature and western winds in the direct environment of the channel; however, only to a negligible extent (1-1.5 °C plus temperature and 3-5% plus relative vapor content in the station below the place where the warm water pours in, compared to that of above this place).

4.2.3. Surface waters

The environmental effects of the power station on the Danube can arise from the water taking and the emission of used waters (non-nuclear and nuclear contaminated industrial water, communal sewage, thermal loading). This goes hand in hand with the changes of the river bed and the quality of water and the modification of the ecological conditions.

Changes of the river bed
In the environment of the company seat the Danube is slightly lower course type, namely in theory the bed tends to fill up, rather than to deepen. However, the tasks of the river control (the speed increase caused by the narrowing and the increase of the fall of the river caused by the shortening) caused the increase of the river’s ability of carrying river drift, so a process of bed deepening started, one of the main reasons for which was the industrial gravel exploitation above the power station, beyond the things written down before. After stopping this activity a slow process of filling up, bed regeneration started. The ford of Baráka (1522-1521 river km) is determining because of its effects on the cooling water supply of the power station. The improvement of the ford is carried out with the help of local damming, building of diversion works and breakwaters, which provides an appropriate result from the point of view of cooling water supply as well. The taking of water influences the changes of the river bed continuously, the power station has to take this into consideration in the future as well.

Water quality
Today the water quality of the Danube in the area of Paks belongs to the water quality class I-II on the basis of the indexes of oxygen circulation and the organic material content, and it belongs to the water quality class II-III on the basis of its nutrient content for plants. Usually in the sample holes below the power station (Fajsz, Baja, Mohács, Hercegszántó) the water quality is not worse than in the sample hole above the power station (Dunaföldvár). So the used water emission of the nuclear power station does not change the classification of the water quality of the Danube. So the water quality does not change considerably because of the effects of the power station.

The effects on the water of the Danube were also checked with pointed field examinations from the point of view of water chemistry between 1999 and 2003. These examinations supported and refined the results of the official water quality investigations. According to the results:

More detailed information is available at local governments.
Service Time Extension of Paks Nuclear Power Plant

- the effects of the used waters of the power station along the section of the river could only be detected in the changes of the water temperature and to a small extent in the changes of the dissolved oxygen concentration (minimum) and the oxygen saturation (maximum);
- the seasonal differences are characteristic, eg. in the case of the measurements carried out at the end of August the oxygen saturation, the biological oxygen demand, the chlorophyll-A and the pH gave more unfavorable results than in the case of the measurements carried out in autumn (at the beginning of October). However, in the case of the nitrates the situation was just the opposite.

Beyond the so-called routine water chemistry examinations the investigation of indexes, with the help of which the other possible effects of the warmed up cooling water of the nuclear power station can also be traced was carried out as well. According to the examination results of the organic micro pollutants the analysis of all the aromatic hydrocarbons coming from mineral oils showed the appropriate cleanness of the water of the Danube. The pollution of the sludge samples was within the acceptable limits as well.

In the water of the Danube the amount of the poly-aromatic hydrocarbons (PAH) and poly-chlorinated biphenyls (PCB) corresponded with the average pollution level of the Danube. Remains of gas oil pollution and traces of combustion products can be detected; however, they are present in low concentration. Out of these the pollutants existing in the highest concentration are coming from heating and traffic, so they are not due to the activity of the power station. Practically, in the sludge the pollution rate corresponded with the average pollution level of the Danube.

So the pointed investigations show that the effects of the used waters of the power station along the section of the river could be detected from the points of view of water temperature, oxygen indexes and certain micro pollutants, components characteristic of oil and domestic sewage. However, in most cases the pollution levels corresponded with the average pollution level of the Danube, or they slightly exceeded the average values.

**Thermal loading**

On the basis of measurements and aerial photographs (see Figure 11) we can state the following about the thermal loading of the nuclear power station considering the blending of the warm water:

- The jet of heat attenuates to a great extent in the direct environment of the construction work of the firth.
- In the fast blending of the jet of heat the considerable speed increase, the change of direction at the breakwater and the cross dam above the place of the pouring in and the blending connected to it (turbulent phenomena) play an important role.
- The jet of heat always goes down along the right bank of the river, and it goes into the areas among the reefs as well.
- The blending of the jet of heat happens in the 4-5 km long section following the place of the pouring in.
- The lower border of the spreading of the jet of warm water strongly depends on the temperature of the water of the Danube; the total length of blending decreases in parallel with the increase of the average water temperature.

More detailed information is available at local governments.
The allowable rate of thermal loading (temperature and heat scale) is controlled by official ultimate values ($T_{\text{max}}$ and $\Delta T$). Complying with these the harming of the flora and fauna of the waters can be avoided. In the lower water of the power station the increased temperature locally speeds up the decay of organic materials in the river that goes hand in hand with oxygen consumption and oxygen draining. However, this can be compensated by the hydraulic, blending conditions of the river and by its characteristically high dissolved oxygen content. Due to the pouring in of the warm water, the total amount of biomass found in the Danube is more than in the upper sections. The flora and fauna of the few-kilometer long section of the river below the place of the pouring in is one of the richest of the area, as far as the constitution of species is concerned. Due to the higher temperature the population of the head of fish also exceeds the average values (especially in winter months).

(Figure 11)
4.2.4. Geological, hydrogeological conditions

The seismicity of the company seat was one of the most often investigated characteristics of the past decade, as well as a company seat characteristic that have been re-evaluated in its grounds since the power station was established and influences the security of the power station. Beyond determining the standard earthquake the most important result of the researches of recent years – including the ten-year operation of the microseismic monitoring system of Paks – was the exclusion of the possibility of surface effects and the proof of the appropriateness of the company seat.

In the company seat below the upper humus containing layer there is a layer group that is about 25-30 m thick from the Pleistocene epoch, the upper part of which is well classified sand with fine construction, created by the floods. Its lower part is sandy gravel, gravelly, gravel containing sand. On the basis of the drillings the grain constitution strongly varies in space; the gravel content shows a strong spreading. The 30-50 m deep drillings undoubtedly clarified the situation of the surface of the Pannon layer group, which is situated 21-28 m deep below the ground level, 69-73 m above the level of the Baltic Sea.

Only the soil of the layer situated 10-20 m deep tends to liquefy. The pressure of 130 kPa of the main building slightly modifies the soil liquefying potential. We do not have to reckon with the damage of the shallow substructure if there is an appropriately thick, stable covering layer above the liquefying layer. So we do not have to reckon with global soil liquefying below the main building – taking the probability of $10^{-4}$ years (according to the recent researches $10^{-6}$ years) into consideration.

In order to keep track of the conditions of the soil and the groundwater, a soil and groundwater monitoring system was established in the nuclear power station. During its operation soil pollution was detected several times. Before 1995, pollution was discovered two times, in the environments of the repository for sludge (oil) and the wound up dye contaminated waste repository (metals). The removal of the pollution was carried out in both cases. Since 1996 an environmental damage assessment and several environmental revision processes have been carried out in the company seat. The power station did away with the recognized and measured pollution, the reasons were discovered and the experiences were taken into consideration in the reconstruction.

4.2.5. Terrestrial flora and fauna of the environment of the Paks Nuclear Power Plant

The Paks Nuclear Power plant as an industrial establishment with a large company seat requires a relatively large space. Its establishment altered the narrow environment to a great extent, so it influences its flora and fauna as well. Before the start of its building both in the company seat and in the place of the building estate there was no natural vegetation, but mostly fields and
vineyards. Those parts of the flood plain of the Danube beside the power station, which are full of softwood groves, bush willow woods and sludge plants, and which are moody from the point of view of the landscape as well evoke the picture of the vegetation of the past even today. (See Picture 3)

(Picture 3)

3. fotó felirata:
**Picture 3. Flood plain of the Danube beside the power station**
In spite of the considerable anthropogenic (human) influence, some valuable natural spots, open sand grasslands remained in the environment of the nuclear power station, as well as pioneer and swampy meadow vegetation occurring in the secondarily formed place of growth; vegetation of swamps, swampy meadows, groves (Old and New Brinyó); alder swamp woods; the wooded pasture of Dunaszentgyörgy and the flood plain of the Danube beside Paks. For example, the old European oak tree in Picture 4 is the living memory of the hardwood groves of the past. In these areas the pointed researches discovered several protected plant species (see Pictures 5-7), and the fauna is also more valuable here.

(Picture 4)
The damaged areas are still carrying a certain proportion of the animal species of the sand and loess steppes characteristic of the one-time fauna of the Great Hungarian Plain – this is partially proved, and partially supposed. Primarily the tolerant species that are capable of tolerating the bothering of their places of living could weather the fast narrowing of their places of living.

(Pictures 5-6-7)
Picture 5. The yellow wort (Blackstonia acuminata) has become scarce by our days, so it enjoys the protection of the law. A great amount of it was discovered within the 1 km wide range of the power station.
Picture 6. In the direct neighborhood of the power station, in a damaged place of growth a considerable population of one of our protected orchids, the *Epipactis palustris* is growing.
7. *fotó felirata:*

**Picture 7.** The protected **late-coming pink (Dianthus serotinus)** is native to the lime containing sand steppes of the Carpathian Basin, and it can be found in several places around the power station.

### 4.2.6. Waste production and elimination

In the nuclear power station not only radioactive, but also non-radioactive solid and liquid waste is produced. Out of the solid types of waste the occurrence of hazardous and non-hazardous production (industrial) waste and communal waste is typical. The nuclear power station established its industrial waste collecting facilities, as well as the system of the collection, treatment, interim storage and elimination of waste; waste collection and elimination is carried out according to the legislative rules. Waste management is carried out methodically, in a previously decided way; the primary goal is to hand over the waste for recycling. For example, more than 90% of the industrial waste is recycled.

In 2004, during the activity of the nuclear power station 914.2 tons of non-hazardous industrial waste and about 361.5 tons of hazardous waste was produced. **Extreme environmental pollution connected to hazardous waste has not occurred during the operation.** The distribution of the different types of hazardous waste in 2004 is shown by Figure 12.

(Figure 12)

More detailed information is available at local governments.
12. ábra szószedete:
olajos iszap (kocsimosó) = oil-contaminated sludge (car wash)
elektronikai hulladék = electronic waste
fénycső = luminous tubes
nyomdai hulladék = typographical waste
festékes göngyöleg = paint pack
bontott tetőszigetelés = demolished roof structure
olajos föld, kő = oil-contaminated soil, stone
kommunális szennyvíziszap = communal sewage sludge
fáradt olaj = dead oil
olajos rongy = oil-contaminated rag
egyéb = other
ioncserélő gyanta = ion-exchange resins

12. ábra felirata:
Figure 12. Types of hazardous waste occurring in the greatest amount in 2004

The amount of the produced communal waste was about 433.2 tons in 2004, which was received by the Communal Waste Store of the Town of Paks, and it also received the soil and building rubbish produced in the area during the building work.
The communal liquid waste is received by the sewage purifying area of the power station. The purified sewage is received by the Danube.

According to the measurements and examinations the pollutant concentration of sewage is lower than the ultimate values of pouring it into the surface waters. The condensed sludge is brought to the slime-thickener bed, the surface of which is about 1200 m², through the pipes for carrying sludge in order to remove more water from it.

In the power station non-radioactive contaminated wastewater is also produced, this consists of the water of the preparatory and auxiliary processes, the wastewater of the catchment basin, the

More detailed information is available at local governments.
technological oil-contaminated water and the sporadic washing water. The industrial wastewater is also received by the Danube. The water quality of the warm water channel is continuously checked by the environmental protection inspectorate; the ultimate values were not exceeded in any cases.

4.2.7. Environmental noise conditions of the nuclear power station

The power station is situated far from the inhabited area; there is no farm or other permanent place of living within its 1 km wide range. The company seat is surrounded by agricultural areas (fields, orchards, vineyards, lands, pastures) and forests, so in the direct area of affection we do not have to reckon with noise loading. In the indirect area of affection we have to take the traffic arising from the transportation of the workers and the other traffic of the power station into consideration. Some of this traffic happens in route 6, and some of it happens in the road sections crossing some parts of Paks. The extra noise loading arising from this is negligible. The noise caused by the operation of the power station does not exceed the relevant ultimate values anywhere in the establishments to be protected against the noise beyond the company seat (because of their great distances).

4.2.8. Environment of the settlements

From the 19th century on Paks has fitted in the Hungarian settlement structure as a small town, as a multifunctional (agricultural, industrial, commercial, servicing) country town; it formed close economic, agricultural product providing relationships with the capital city. Because of its close relationships with the capital city Paks was modernized relatively early – like the whole area along the Danube. This development stopped in the first half of the 20th century. However, with the establishment of the nuclear power station the population of Paks increased considerably within a short period of time; the urban development was booming. At the same time the settlement became a one-functional town. So the situation of Paks is very special compared to the similarly large towns. It enjoys the advantages and suffers from the disadvantages of the fact that the economy and employment of the town is determined by a large company at the same time. Moreover, the determining company is not an average participant of the economy, but it is unique in the country from several points of view. The developments of the town and the Paks Nuclear Power Plant have closely been connected for several decades. In the recent decades several developments in Paks have been carried out with the considerable support of the power station as a “connecting investment”. (See point 4.3.)

The development of the economy was influenced by the existence of the power station to a considerable extent; the one-sidedness has increased in recent years as well. Almost every participant of the industry is directly or indirectly connected to the power station. At the same time the livability, the infrastructural and economic state of development of the settlement exceeds the levels of both the direct environment and the similarly large Hungarian towns considerably.

Due to the establishment of the power station the settlement structure and the profile of Paks have changed considerably. A modern town center was built to emphasize the significance and the town status of the town. However, the “old town”, the medieval street network and the traditional More detailed information is available at local governments.
structure of the settlement remained. The development was carried out in the untouched areas, so beside the old town a new town was built that is also modern in appearance. The building estate established for the employees of the power station was built on a loess plateau. Its direction is southern, so it faces the nuclear power station. The equipment and configuration of the building estate from the point of view of architecture and green areas generally exceeds the average levels of other building estates built in the same time period in other places.

4.2.9. Usage of the land and the region

The most important characteristics of the usage of the region and the structure of the land can be summarized briefly in the following:

- The situation beside the Danube, almost in the plains and the agricultural cultivation, primarily the cultivation in large terraces is determining from the points of view of the usage of the land, the structure of the land and the landscape as well. So the environment of the settlement of Paks was labeled as an area of growing, and since the nuclear power station was established it has been labeled as an area of production. (See Figure 13)

(Figure 13)

13. ábra A Paksi Atomerőmű közvetlen környékének területének ábra, 2005-ös állapot

13. ábra szószedete:
Legfontosabb színek magyarázata = Explanation of the most important colors
Út- és vasúthálózatok = Road and railway networks
Repülőtér = Airport
Városi zöldövezetek = Urban green belts
Sport-, szabadidő- és üdülőövezet = Belts for sports, leisure time and holiday
Lombhullató erdő = Deciduous forest

More detailed information is available at local governments.
The deciduous forest is a form of the usage of the region that covers vast areas (above 10%), as well as the pasture and the natural grassland (above 6%). On the one hand the forest spots are situated beside the Danube, and on the other hand they appear on the tops of the hills as mosaics, mixed with grasslands.

Similarly to the previous ones, the rivers, channels also cover vast areas (about 6%), as well as the places of living (about 4%).

The areas covered by the other forms of the usage of the region mean about 1% or less than that, so they are not determining from the point of view of the usage of the land and the landscape. However, we can say that these smaller spots exist in great numbers, so the region is considered proportioned, varied.

The establishment of the nuclear power station influenced both the structure of the land and the landscape considerably. However, since then it was only the overshadowing of the agricultural large terraces by the small terraces that brought considerable changes in the structure of the land after the change of the regime.

4.3. The activity of the nuclear power station in the formation of the conditions of the environment

In the Paks Nuclear Power Plant the traditional approach of industrial environmental protection is not satisfactory, namely doing the less harm possible to the natural and built environment. The concept of active environmental protection has been introduced, according to which they not only protect the environment, but also develop its quality. On the basis of this several programs could have been established with the support of the Paks Nuclear Power Plant.

More detailed information is available at local governments.
The most important holiday center of Tolna County, the **Fadd-Dombori Backwater of the Danube** is situated about 20 km far from the power station. This holiday zone, having special natural qualities, consisting of hundreds of bungalows and communal establishments was visited by hundreds of thousands of people who wanted to get relaxed every summer. The backwater that had water supply and water quality problems before, started to deteriorate in the middle of the ‘90s; its water quality became inappropriate for bathing. Beyond the natural values the relaxing opportunity of many people also seemed to be lost. With the effective help of the Paks Nuclear Power Plant a channel system was built, with the help of which the filtered cooling water of the air conditioning machines of the power station is transported to the backwater of the Danube, providing the water supply this way. This water does not take part in nuclear processes; it does not meet radioactive apparatuses. The backwater was gradually brought back to life with the fresh water supply, and today it shows one of the most stable water qualities of the country. The dying holiday and sport life also recovered. A pump system was also established to move the water to the Tolna Backwater of the Danube as well, so the development process of the quality of the environment is going to start there as well.

The channel system that provides the water supply crosses the **swamp wood of Dunaszentgyörgy** as well, the flora and fauna of which was severely damaged in the past decade because of the water shortage. In the wood, being part of the Duna-Dráva National Park the **balance of the groundwater level was restored**. Life is sparkling again; egrets, purple herons, peregrine falcons and common buzzards are nestling again. The big games (roes, deer and wild boars) have also found appropriate places of living.

In the establishment of the **fishing paradise** found beside the fence of the nuclear power station, configured exemplarily the power station took a considerable part, and it also provides the water supply of the ponds. The water surface appropriate for fishing is about 55 hectares. With its water deepness of 7 ms at certain points, the old trees surrounding its bank, its bushy and reedy bank Lake Kondor offers an ideal place of living to the flora and fauna of both the water and the waterside. That is why; the environments of the ponds are also strictly protected.

In the environment of the town of Paks the spread of ragweed causes serious health problems as well. The power station established the **foundation “Together against ragweed”** in the middle of the 90’s that started the clearing of the weed in a novel way. Their program is treated as an example for the country that develops through thought out enlightenment and actions affecting thousands of citizens, with the wide-range cooperation of the local society.
5. ESTIMATION OF PROSPECTIVE ENVIRONMENTAL CHANGES CAUSED BY THE SERVICE TIME EXTENSION

The service time of the nuclear power plant is prolongable – as it has already been presented – by applying proper age-treating processes. Most of the procedures need to be performed if only because of the already planned 30-year operating period. Except for few phases, all steps of the age-treating process are accomplishable as part of the projected maintenance and reconstruction works, so it is dispensable to take account of efficient factors and effect process different form present-day’s. The environmental effects expected in the near future are also much the same as they are nowadays. If other energy sources than the power plant do not appear in the region, significant environmental changes won’t happen in the affected zone neither till 2012 nor later on.

Activities required to provide the 30-year design life are not the subject-matters of this study, but they are taken into consideration as a ground state. That is to say that the aging process and its preventive remedies will establish the operation and its environmental effects.

5.1 Preparations for Service Time Extension

5.1.1 Radiological Effects

On the basis of the experiences gained during the maintenance and reconstruction works it is statable that:

- **airborne emission** rates are not expected to be higher in the near future. (However, it has to be taken into consideration that 40-60% of yearly airborne emission is added up by general overhauls, so the amount of airborne emission is not probable to change during the further operation.)

- **liquid emission** rates are also not expected to be higher in the near future, because in the security zone waste water is received by the collecting and treating system of the power plant. (In case of the maintenance period the liquid emission rates increase generating 30-55% of the yearly emission.)

- the amount of low and intermediate level **solid radioactive waste** produced by the four units has been averagely 100-140m$^3$ a year. The waste has been compressed and stored in special barrels. In the last few years the amount of solid waste has increased, so in the period lasting till the service time extension and later on according to conservative assessments averagely 190m$^3$ of treated radioactive waste is calculable. (The increase in the amount of solid waste is natural because of the windup of the effects of operator error occurred at Unit 2 in the fuel
Service Time Extension of Paks Nuclear Power Plant

rod cleaning system that requires special license procedure. So the increased level of solid waste indexes is just an undesirable characteristic of reconstruction works.)

- The amount of **liquid radioactive waste** is also not expected to increase greatly in the near future. (Except for the period of reconstruction work period at Unit 2 that generates extra liquid radioactive waste.)

- **Soil and ground water load** is not expected to grow as the last rates recorded were only results of technological failures, which have been already corrected. Concerning the **radiation load of the flora and fauna and people living in the environment**, the service time extension won’t probably generate extra exposure dosage that is proved by hitherto measuring results.

- The aging process of the technological apparatus and the radioactivity accumulated in it might expose the operators to extra exposure dose, but it can be treated by regular control, increasing safety or decontamination. In case of the radiation load of people living in the region it cannot cause any changes, because the accumulated radioactivity stays within the security zone.

It was necessary to expand the interim liquid waste storage capacity. The expended storage capacity together with the introduction of volume concentrating technologies is expected to be enough for the extended service time. The present possibilities of solid waste storage are limited, so they are satisfactory only for few years. It is essential to reconstruct power plant buildings used for keeping solid waste storage barrels, extend storage capacity or build an interim storage building that requires special licensing procedure. The need of extension of interim storage buildings might get relevant before the service time extension of the power plant that is dependent on the possibility of building permanent waste stores.

**5.1.2. General environmental influence**

Activities, interventions, age-treating processes are probably accompanied with other similar environmental influences usual in case of maintenance and reconstruction works.

Id est:

- air pollution (for example because of restoration or overhaul),
- effects on surface waters (for example extra diversion or water pollution),
- geological and hydrogeological formation load,
- waste producing and treatment (it will be one of the most essential environmental processes in this phase),
- noise and vibration load,
- indirect effects on the flora and fauna, the population and the environment of settlement.

Considering the influences mentioned above general air pollution, noise load and waste producing are expected to have effects in the present case. Prospectively the latter will be determinant, because the area of the depot and its distance from surrounding settlements guarantee that the population won’t exposed to considerable effects of air pollution and noise load.

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Plain Summary 2006.02.06
Service Time Extension of Paks Nuclear Power Plant

In the case of reconstruction works radioactive waste might be generated that is unusual at traditional building sights. (Phenomena like this are controlled by a special environmental department.) Some parts of the radioactive waste will be decontaminated and eliminated or recycled as industrial waste. Regarding technological apparatuses the situation is very similar. Their facultative replacement hardly can have general environmental effects, while the amount of radioactive waste might negligibly increase. In summary the following things are expected in the period between 2006 and 2012:

- neither interventions planned at Paks NPP nor influences independent of the power plant will significantly change the quality of air. Maintenance and reconstruction works having effects on the quality of the air will be carried out consistently according to the hitherto restoration routine. Overhauls are desirable in shorter phases, which won’t exert an influence on the conditions of the air pollution close by the roads.
- preparation works won’t require any extra water diversion or additional water pollution, so apart from other chance damages it is unnecessary to take the change of quantity and/or quality of surface and underground waters in the near future.
- the load of geological formations will change in only two cases: firstly in the event of indispensable soil stabilization where the main task is to keep the consistency of the artificial elements, secondly in that of damages when common or radioactive polluting agents get into the materials. But the activities projected do not increase the danger of extra damages, so considering geological formations it is needless to calculate upon changes of present conditions in service time extension period.
- in this phase the most important environmental effect is waste production and waste treatment. It appears in every type of interventions. It is not requisite to reckon on a significant, unexpected increase in the amount of waste, but it has to be taken note of that modernization and renovation works are accompanied by extra waste production. The waste generated has to be eliminated according to its type. Paks NPP is perfectly prepared for the proper treatment of every waste type. The power plant applies the method of careful classification that is followed by decontaminating processes and the proper storage of industrial waste in outer storage buildings.
- as the planned renovation, maintenance and reconstruction works do not includes noisy phases, they won’t change the environmental noise conditions.
- as it is seen in the case of environmental effects it is not necessary to calculate upon considerable changes of environmental components that also means that the influences of the interventions won’t spread to the flora and fauna, the ecosystem, the population, the settlement environment and the power plant region. In the case of environmental systems no undesirable effects are expected.

In summary it is statable that preparations for the planned service time extension won’t be accompanied with any significant extra environmental load.

More detailed information is available at local governments.
5.2 Operation of the service time extended power plant

The probable environmental effects and changes are summarized below:

5.2.1. Radiological effects

The amount of radioactive emission does not change during the period between the present operation and the service time extension and later on. It means that in comparison with the present conditions the amount and way of radioactive liquid emissions won’t significantly change in the future. Because of the low level of emissions and the dynamic balance set in the environmental elements, the 20 years of the power plant operation did not cause any perceptible accumulation of radioactive materials in the environment. On the basis of external measurements, artificial radioactive isotopes are only rarely detectable in strongly accumulating environmental elements such as sludge in fishponds or the Danube.

The yearly amount of radioactive waste does not change. Naturally, the total amount of waste will have increased by the end of the 50-year period as compared to the 30-year operation period.

The amount of emissions applied to final effect receivers does not grow. It is expected to stay under the official ultimate value later on, either, so its prospective value is not estimated in comparison to the present indexes.

5.2.2. General environmental effects

- Air Quality
  The present good quality of air will stay the same if other air polluting source does not move into the area. It is because the emissions (diesel engines, paint room) of the power plant do not basically change. The effects of the emission of the power plant did not exceed the air pollution limit values at the boundary of the power plant area. The traffic emission might grow as a result of increase in traffic intensity. The traffic of the power plant is not expected to change, because neither the number of employees nor the volume of transportation will be modified. As according to recent measurements the concentration of the emission does not exceed the limit values at the road embankment either, the eventual extra traffic load will be detectable only hard by the road.

- Climatic impacts
  As compared to present conditions, the features of the mesoclimate are expected to stay the same, because there won’t probably be any changes in the building density in the near future.

- Surface and subsurface waters: the effects of diversion
  The amount of water diversion, its methods and environmental effects are not expected to change significantly in the near future in comparison with the present conditions. The amount of water-consumption does not reach the official ultimate value, so the emergency capacity is available. The continuous change (natural and artificial) of the Danube bed definitely has an influence on the surface water diversion. Concerning the driving water supply, the cyclic ascent and descent of the river bed, the building and wearing of bottom banks have to be

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noted as a fact. The degeneracy and obliteration of the cold water channel should be prevented by continuous maintenance, so it will be negligible to calculate upon operational errors or environmental load.

- **Quality of surface waters: effects of spent water immission**
  According to the results of year-long water chemistry and hydrobiological measurements the cooling water heated up by the power plant and the sewage do not significantly change the water quality of the Danube. Changes in the combination of the flora and fauna are detectable in mainly the area of discharge culvert. As the amount of the spent cooling water won’t change after the service time extension of the power plant, changes caused by the immission of the spent cooling water of the power plant into the Danube are not expected after 2013, either.

Because of the longer service time, the accumulation of impurities is not preposterous. According to hitherto measurements the level of bed silt pollution, which was due to the general pollution generated by Paks NPP, was only marginally higher than the Danubian average. The rate of contamination accumulation in the bed silt is not expected to be harmful to living beings.

In summary on the basis of the water quality, rate of flow and water temperature of the Danube the planned service time extension is realizable without so much as encountering limitations towards the protection of the quality of receiving water or going against the aspects determined by the Environmental Protection Authorities and Water Frame Policy. The load of water stations located near the Danube is not expected to change. The detailed study of this load was made within the power plant area characterization program.

According the reports on thermal load and its conditions, significant changes are not in view in comparison to present conditions, so it is statable that in the Paks NPP region it is unnecessary to reckon upon the changes of the aquatics or the structural modification of the population caused by the power plant. The present richness of species and high fish density and biomass will probably stay the same near the discharge culvert.

- **Geological and hydrogeological formations**
  The load of geological and hydrogeological formations is generated by different establishments and operational pollution caused by eventual breakdowns.

Neither during the service time extension period nor later on such building of new establishments, enlargement or reconstruction of present buildings, which would have important geological effects, is not in the offering. It means that the load a geological formations won’t change in the following 20-year period.

In the area of the power plant soil pollution is naturally taken into consideration during the operation of Paks NPP. In many cases the hitherto pollutions pointed out technological defects. The power plant has already eliminated the environmental damages causing environmental risk and blocked the source of the pollution according to the methods determined by the environmental protection authorities. In cases when the damage prevention was unnecessary, on the basis of the evaluation of the environmental risk the source of the
pollution was blocked, either, and taken under regular control. These experiences are taken into consideration during present and further renovation, modernization works. Because of these experiences the monitoring system of the power plant has broadened, too. Owing to the condition control program, reconstructions carried out and planned and the operating of the environment monitoring system, the number and seriousness of such errors won’t increase in the future.

- **Maintenance and Value Safety of Terrestrial Flora and Fauna and Population**
  Considering the neighboring populations of the power plant it is statable that if Paks NPP operates with unaltered conditions, **the service time extension won’t have any effects of high account on the surrounding flora and fauna.** Most parts of the power plant area are regarded as disturbed/strongly disturbed biotopes whose populations “got used to” such disturbance.

- **Production and Treatment of Customary Waste**
  During the extended service time the amount of different types of waste will be much the same as it is nowadays. The system of waste collecting and its storage building within the power plant area have been made and they are suitable for waste management techniques designed according to present measures and do not need any modifications in the near future. More than 90% of the industrial waste gets recycled.

  **The goals of Paks NPP whose service time has been extended considering aspects of profitability and environmental protection include the reduction of the amount of waste produced, the raise of the rate of waste utilization and the development of selective waste collecting system.**

  All things considered waste producing is the only one effect that causes **accumulating quantities** in the case of service time extension. Although the power plant can reduce the yearly emission, it is natural that during a 50-year operation period more waste is generated than during a 30-year one. Regarding these facts disenergization needs more attention and preparation.

  The proper operation of the apparatus of the sewage-treatment plant can be provided by regular maintenance and consistent renewal. The aerator needs updating (or renewal) in every fifth year. In the case of the new measures made after the introduction of the Water Frame Policy the complement of the present sewage-treatment plant or the building of a new, up-to-date sewage-treatment plant will probably be necessary, because the technology of the present sewage-treatment plant is not suitable for the elimination of nitrogen and phosphor.

- **Noise and vibration load**
  **Changes projected are not expected to have any influences on the present noise load conditions.** The renovation and renewal of the establishment and technical apparatus of the power plant is continuous until the service time extension period and later on. The activities planned do not require building of new establishments. Demolition of certain buildings or construction of new ones is not planned. Only the normal operational renewal is requisite. Inside of the power plant buildings there is no need of a great volume of construction works. Updating and renovation works take place inside the establishments so the increase of noise emission is not in view. It is unnecessary to reckon upon the change of the noise load.

More detailed information is available at local governments.
Service Time Extension of Paks Nuclear Power Plant

- **Land utilization and use zoning**
  In the case of Paks NPP the service time extension won’t require changes in the land utilization and use zoning, but in its region smaller changes in the land utilization are in the offing. Structural changes are concentrated in the area between the city and the power plant. Substantive changes will be generated by only the start of the decommissioning.

5.2.3. **Social, economical and environmental health effects**

Apart from the estimation of calculable changes in environmental elements and systems, environmental effect-studies have to include two urged subjects, either, which have not been detailed in the introduction. One of these subjects is the environmental health effect applied to people living in the affected zone. The other is the social and economic effects. Considering the topics mentioned above the comparison between the case of the service life extension end that of the disassembly (the close-down of the power plant).

The service life extension can be characterized by features similar to present environmental conditions, while the close-down of the power plant might have doubtful effects, mainly in the case of that these effects interrupt the community development, which hardly can be avoided. A significant economic loss causes direct environmental problems if the disappearing economic actors did not mean environmental load for the settlement, but they financed its efficient operation as the way it is in the case of Paks, too.

Without service time extension the disassembly phase at the units of the Paks NPP would start in 2013 that would mean the gradual decrease and ceasing of the profit of the establishment and the taxes paid from the profit. The disassembly would provide jobs for the half or two third of the present employees but it would only lessen the negative effects instead unmaking them.

In the case of service time extension the following effects are in the offing:
- Paks will have a population of about 20-21,000 as it does nowadays if no significant economic draw (for example a commercial establishment) appears in the city;
- Regarding the settlements of the region, the decadence of age-class characteristics is detectable. In some years time most of the population will consist of old people in Paks;
- The increase in the level of education of the population will probably continue;
- The reconstruction of the employment structure will continue and the number of people employed in tertiary branches (commerce and services) will increase while it will decrease in the case of agricultural and industrial branches;
- The technical infrastructure is well-developed in the region, but there is still a lot to do, for example canalization in the villages of the region.
- Agriculture, which a dominant branch beside the energetic industry, can keep or strengthen its position in the economy of the region in the event of accommodating itself to the strict international market conditions.

The service time extension stabilizes the energetic industrial and energetic industrial related, producer-service featured employment in the region. A consistent development is in view in

More detailed information is available at local governments.
Service Time Extension of Paks Nuclear Power Plant

commercial and service branches. Public incomes, which are higher than the national civic average, provide prosperity for Paks.

Regarding the process from the population’s point of view, the disassembly of the power plant would mean relief to those people who are afraid of some serious accident accompanied by significantly increased emission and environment pollution, while others living in Paks and the settlements of Tolna County would be exposed to the stress of snakes and ladders if the power plant closed down, because most of them would lose their jobs, so the service time extension would be regarded as good news by many ones.

The satisfactory relationship between the settlement environment and the power plant won’t change during the service time extension period if the environmental effects stay the same. In order to keep these conditions up the aging process needs to be compensated by proper and continuous updating and modernization. The service time extension provides Paks with time to prepare for the disassembly of the power plant.

The environmental health studies did not show detectable increase of the risk factors and what is more regarding sanitary aspects, Paks was proved to be a better place to live than other cities similar to Paks. (The fact that Paks has rather young population was taken into consideration in the study.) The infrastructure of the settlement is also more developed than that of similar Hungarian cities. As it is in the interest of Paks NPP to maintain the satisfactory quality of the settlement environmental, it will probably make further progress. After the realization of the service time extension, the habitability of Paks is expected to be better than that of similar Hungarian cities in the next 20 years, that is very advantageous for the people living there.

The quality of everyday life and lifestyle of the population concerned won’t probably change in the near future. After 2012, one of the most important effects of the service time extension will be that the population of Paks will be able to live in its usual way for another 20 years. The present beneficial effects of the power plant will be perceivable till 2032. According to the social-economic study these positive effects are the following:

- prominently good employment conditions,
- satisfactory, continuously developing infrastructural conditions,
- significant local tax income,
- significant supportive activity,
- continuous training of the scientific potential.

In addition the service time extension has national effects, too, because it makes the role of Paks NPP 20 years longer in the Hungarian power economy. In the case of the disassembly of the power plant, the substitution for the loss of nuclear energy would have unfavorable effects on the environmental and economic conditions after 2012. The price of electric power would greatly go up, while the compliance with the Kyoto Protocol would mean extreme efforts to the country.

In summary it is statable that in the case of the service time extension of the power plant, neither volume, intensity nor load type changes are calculable in comparison with the present conditions.

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Plain Summary 2006.02.06
5.3. The Effects of Operator Errors

The judgment of operation breakdowns and accidents differ in the nuclear and environmental regulations, moreover, the definitions of operation breakdowns and accidents are not the same, either. In the everyday use of the ideas the confusion is even greater. According to the regulations of environmental protection every event that is different from the normal operation is an “accident”, irrespectively of the probability of the occurrence and the seriousness of the consequences. The nuclear regulations are more specific, they differentiate between normal operation, probable factory events and operation breakdowns, accidents and serious accidents belonging to the contingency planning, and these are linked with incidence rates. The nuclear regulations link the security requirements to these rates. It is obvious that it requires the determination of the probability of dangers and failures, and the quantitative evaluation of risks at the same time. The demonstration of the different interpretations of the environmental and nuclear regulations is summarized in Figure 14.

<table>
<thead>
<tr>
<th>Normál üzemi állapotok</th>
<th>Várható üzemi események</th>
<th>Tervezési üzemzavarok, tervezési alapok tarló események</th>
<th>Balesetek</th>
<th>Súlyos balesetek</th>
<th>Meteor becsapódás</th>
<th>Nagy-súlyú balesetek</th>
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Van határlétekből (környezetvédelmi, sugáregészésegügyi)

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<th>NBSZ előírások</th>
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<td>- következmény csökkentő beavatkozások</td>
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<td>- nincs határlétekből (környezetvédelmi, sugáregészésegügyi)</td>
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<td>- nem erőenergiás terjedelm</td>
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<th>Környezetvédelmi fogalmak szerint:</th>
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<td>Normál üzem</td>
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<td>Idő, amely egy esemény nagy vallószínűséggel történő bekövetkezéséhez szükséges</td>
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Szószedet

Nukleáris fogalmak szerint = On the basis of nuclear notions
Normál üzemi állapotok = Normal operation conditions

More detailed information is available at local governments.
Várható üzem események = Probable operation events
Tervezési üzemzavarok, tervezési alapba tartozó események = Planned operator error, events based on plan
Balesetek = accidents
Súlyos balesetek = bad accidents
Meteor becsapódás = Meteor impact
Esemény gyakoriság = Frequency of events
Van határérték (környezetvédelmi, sugáregészségügyi) = There is limit value (environmental protection, radiological sanitary)
NBSZ előírások = Directions of NSSS(National Security Special Service)
Baleseti intézkedések = Steps in the case of accidents
Következmény csökkentő beavatkozások = Encroachment to decrease the repercussion
Nincs határérték (környezetvédelmi, sugáregészségügyi) = There is no limit value (environmental protection, radiological sanitary)
Nem engedélyezési terjedelem = There is no authorized range
Körnezetvédelmi fogalmak szerint = On the basis of environmental notions
Normál üzem = Normal operation
Baleset = Accidents
Idő, amely esemény nagy valószínűséggel történő bekövetkezéséhez szükséges = The necessary time that an event happens with high probability
A legutóbbi jégkorszak = Last Ice Age
Földtörténeti NEGYEDIDŐSZAK = Neogene period
Földtörténeti HARMADIDŐSZAK = Paleogene period
A Himalaya kialakulása = Formation of Himalja
A Vörös-tenger kinyilása = Formation of Red Sea
Ausztrália és az Anktartktisz különválása = Segregation of Australia and Antarctica
A virágos növények megjelenése = Appearance of flowerers

Képaláírás:

Figure 14. The yearly incidence of the probable events.

The environmental effects of the operation breakdowns are rather complex; they strongly depend on the environmental spreading conditions. The evaluation of this is contained in the Definite Security Report, where we can find the probable emissions in the case of operation breakdowns belonging to the contingency planning, their incidence rates and the estimated doses that can occur in the factory buildings and in the environment. In the case of operation breakdowns a certain amount of the radioactivity of the primary circle spreads to the rooms of the main building of the factory, and maybe to the air as well. In the Definite Security Report we can find the calculations of the isotope-constitution, radioactivity of radioactive materials potentially spreading into the environment of the power station, as well as the calculations of the radiation load coming from these. It has been proved that we do not have to reckon with negative effects on the environment, even in the most serious case, either within normal, or unfavorable weather conditions. The effects considered to be bearable stay within a range of 20-24 km, even under extremely unfavorable circumstances, as far as the attenuation is concerned. As a result of a

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security enhancing alteration, which is going to take effect during the preparations for the extension of the operating time, the emission rates of the operation breakdowns are going to be reduced by an order of magnitude, so the area affected by the operation breakdowns belonging to the contingency planning is going to be covered by a circle with a radius of 6.3 kms.

By keeping up and developing a proper maintenance and safety practice, during the 20 year-old service time extension period no change in the frequency, seriousness and order of magnitude of operator errors is expected in the near future.

5.4. Areas of Affection

After the careful analysis of the effects, the establishments of the experts and different calculations the areas involved in the service time extension were stated precisely in the effect-study. The areas determined are the following:

- During normal operation the nuclear power station does not affect the neutral conditions, according to the criteria of gas and liquid emissions and the dose criteria of human health care depending on them.
- In the case of events belonging to the contingency planning the area of affection can be characterized by a maximum range of 6.3 km.
- Air: the area of affection is the environment of the slip roads of the route 6 within 25 kms, as far as traffic is concerned; in point of industrial sources it is the company seat, and in the case of testing the diesel generators it is a circle of 590ms, surrounding the machines.
- In the case of surface waters the area of affection can spread to the firth of the river Sió, primarily considering the thermal load. All in all, coming from the water quality, the outflow and the temperature conditions of the Danube, the planned extension of the operating time can be carried out without coming up against barriers that serve the protection of the water quality of the river, and without opposing the criteria determined by The Water Frame Policy.
- Considering the soil and the ground waters, the effects of the probable special pollutions stay within the company seat.
- Noise: the company seat, the slip roads and their immediate environment could be considered areas of affection; the effects stay within the company seat.
- Settlement environment – the area of affection is primarily the township of Paks. However, the positive effects considering the establishment of workplaces among others expand to the neighboring settlements of Paks and the Fadd-Dombori backwater of the Danube as well.
- Terrestrial flora and fauna – our investigations recovered no direct area of affection.
- Aquatic flora and fauna - the cold water channel and the few kilometer-long part of the river below the point where the warm water channel pours in has to be evaluated as areas of affection.
• **Usage of the land** – the 3 km long security zone of the power station is considered the area of affection. From the point of view of the landscape the area of affection is larger than that; from certain directions, an area of 8-10 km can be marked.

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According to the calculations, the range of radiological effects of operator errors related to contingency planning consists of the sectors corresponding to the timely windward within a circle with a radius of 6.3 kms and a reactor unit in its center.

The range of non-nuclear operator errors due to the breakdown of technologies applied in the power plant, hazardous materials and hazardous waste generated covers only the security zone of the power plant. In the case of the Danube it means an area of 10-20kms down-stream.
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Service Time Extension of Paks Nuclear Power Plant

Szószedet

A tervezési üzemzavar hatásterülete a szélirány változás esetén a pillanatnyi irányban a burkológörbén belül marad = The area of effects of the planned operator error will remain in the curves if the direction of the wind changes.

a tervezési üzemzavar hatásterülete = The area of effects of the planned operator error
hatásterület a táj szempontjából = the area of effects considering of landscape
hatásterület a víz szempontjából = the area of effects considering of water
hatásterület a települési környezetnél = the area of effects considering of settlement environment
ellenőrzött zóna = protected area

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Plain Summary 2006.02.06
Képaláírás

The estimable area of effects in the wide environment of the power plant (normal operational and conventional operator error effects considering of radiology, air, soil, trash and noise emissions)

Regarding the introduction of the ground status, the fact that the range of the activity covers different areas of certain environmental elements/systems was taken into consideration. Detailed examinations were carried out hard by the power plant area called the security zone, while survey evaluations and introduction of prominent values and risk factors were taken place in the broader environment of the power power plant.

5.5 The disassembly

The effect-studies are to explore the environmental effects of the disassembly. According to the 314/2005. (XII. 25.) decree applied to the environmental effect-studies and uniform environment utilization licensing procedure, the disassembly of the power plant requires special environmental effect-study, so only essential considerations are described in the effect-study.

The process of disassembly is realizable in several various ways including the immediate and delayed disassembly of the establishments. Considering length of time, schedule and cost these methods are very different from one another. The present conception of disassembly (“The Preliminary Disassembly Plan of Paks Nuclear Power Plant” DECOM Slovakia Ltd., TS ENERCON Kft., 2003.) was made by the Public Company for Radioactive Waste Management. Three possibilities are analyzed in the study:

1. Immediate disassembly,
2. Delayed disassembly and keeping the reactors for 50 years,
3. Delayed disassembly and keeping all the primary loops for 50 years.

Taking economic and technical aspects into consideration, the third method was chosen.

The disassembly of the power plant is not avoidable by the service time extension, but only postponed. Aims related to the disassembly of the power plant are the final disassembly of the units and clearance of the power plant to make it suitable for further utilization. In the case of further utilization, local and regional aspects are had to be considered.

The disassembly can be regarded as reverse construction works, so it is statable that the effects of the process are very similar to those of the traditional construction works. (See for example dust load, air pollution related to transport, noise and vibration load.)

The main difference is the significantly larger amount of waste produced and the increased need for decontamination of radioactive waste derived from the disassembly process. After the decontamination radioactive waste generated by the disassembly will probably be either released, recycled or taken its final form and placed in the permanent waste storage building planned.
5.6. The question of effects over the borders

According to the regulation of environmental pre-test analysis it has to be notated if an operation probably will have anticipated environmental effects over borders. The possibility of the effects spreading over the borders which comes from the service time extension of the power plant can be declared based on the location, the type of operations, the expectable effects, the possibility of spreading effects and the importance of effects. So the following affections can be conjectured:

- **Radioactive emissions into air:**
  There are some $10^{14}$ Bq/day radioactive noble gas and $1.5 \times 10^{10}$ H (tritium) emissions into air per day coming from normal operation of the power plant. The gas concentration attenuates one millionth considering of the most conservative estimation while it gets at the border so the anticipated concentration of noble gas is 1 Bq/m$^3$ and tritium is much smaller. This calculated activity can be detected by measurer but the increase coming from the operation of the PPN cannot be differentiated from the natural background concentration. The radiance sanitary effects to citizens and nature are decreased under detectable and ratable level in 10-12 km distance from PPN. So these concentrations are valid only for noble gas and tritium and they are neutral to the environment. The emissions of longer-half-decay-period isotopes, that can be accumulated in the environment, is typically $10^4$-$10^7$ Bq/day whose shape concentration at border is probably tenth of mBq/m$^3$ so it is under the detectable limit.
  
  The spread of calculated emissions occurred by planned operator error result $10^4$-$10^7$ Bq/m$^3$ noble gas concentration but its sanitary effect decreases to neutral level inside the country. **On the basis of previous data, the radioactive emissions into air cannot be classified to important over the country border.**

- **The radioactive emissions into surface water:**
  Less than 1.5 Gbq/year fission corrosion materials get into surface water during normal operation of the power plant. This results 50-60 mBq/m$^3$ concentration calculated from minimal observed stream flow in Danube which cannot be measured directly but it could be detected by radio analytic methods. The accumulation of longer lifetime components in heterodyne or traction load is observed but it is going with outwash so its effect to human or nature is already evanescent next to PPN.
  
  The emission of $^3$H coming from power plant is approximately 20 TBq which is moved into Danube. This can be measured at the border during low-water period, approximately 300-600 Bq/m$^3$, but this increase is not detectable at the natural background load so it has not sanitary effect.
  
  It is probable that 170-200 mBq/m$^3$ fission and corrosion ware activity concentration appears in low-watered Danube at the border during the reclamation of the operator error caused by the burst in the big-diameter water pipe. This is very close to the emission of normal operation. **On the basis of previous data, there is no significant radiological water environment effect spread over borders.**

- **Heat emission into Danube:**
  The estimations of earlier heat emissions supposed that the heat tail sensibly modifies the temperature of the water from 10-80 km from the point of inflow so its effect could be detected at border being 94 km far. The measures of surface water temperature and the thermovisional aerial photos being taken in the last few years have pointed out that heat tail can be detected about 30 km far from inflow but it is minimal. On the basis of our measures,

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Plain Summary 2006.02.06
this minimal heat surplus evanishes into natural background bellow the outfall of Sió because of admixture and changes of the flow-ways. The effects to the effect receivers, e.g. the aquatics, stay in normal level, **it can be detected only in a few kilometers distance from the inflow of heat canal so it has is no significant effect spread over borders.**

- **The emissions of conventional contaminating substances:**
  The conventional contaminating substances can be leaked into Danube by regular operation or damages. The evaluations of long-term-water-quality measures show that appraisable changes caused by PPN don’t occur in the components of water quality, except heat pollution. It is not necessary to keep count of considerable spread of conventional water and air pollution over borders even if an operator error happens. The previous submittal is sustained by that the southern neighbor country has never denoted any problem about quality of water during regular operation to Hungary. So it can be declared that **the unchangeable state of water-quality can not be considered as a significant environment effects** and it is also not mentioned that not all pollution that can be measured by instruments is inserted into the items of the categories of environmental effects.

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6. INFORMATION GATHERING AND CONTROLLING POSSIBILITIES OF THE POPULATION OF THE REGION

In order to develop an efficient dialogue between the nuclear power station and the population of the environment the establishment of a social organization became unavoidable, which is a registered legal entity and which is able to efficiently act for the realistic demands and interests of the population of the region with a separate, unified program, order of operation and budget. So in the middle of 1992 the Social Controlling and Informational Association (Társadalmi Ellenőrző és Információs Társulás, TEIT) was formed which consists of the representatives of the local governments of 13 settlements.

In the deed of foundation of the organization the local governments of 7 settlements from Bács-Kiskun County and 5 settlements from Tolna County expressed their intention of cooperation. Later the town of Paks also joined the organization. The population of the settlements within the 12 km wide range of the power station is more than 60 000 people.

The TEIT operates according to a fully worked-out order of operation; its center is the Office of the Local Government of the Town of Kalocsa. Usually they have meetings every two months, but in well-founded cases extra meetings are also held. The representative of the power station with deliberation right is the regular guest and participant of every meeting. The chief executive of the power station also meets the mayors of the TEIT regularly. They inform their citizens with the usual methods of the settlements and with newsletters put in the mailboxes.

As it can be seen from the name of the association, its work is characterized by two major factors. On the one hand it carries out a controlling activity, and on the other hand it is in a close cooperation with the power station in forwarding information. Its goal is not to confront the power station, but to protect the interests of the population, maintain the honest dialogue and cooperation and build the mutual trust. As a result of their activity that is successful and exemplary on an international level as well, the association was awarded an important environmental prize for its activity to help the elimination of the conscious, psychological environmental pollution. The TEIT issues sporadic publications, and in order to do a controlling activity it established a social committee as well. The committee can enter the named establishments and get an insight into the relevant documents; in the cases of programs, new establishments and actions that can arouse the interest of the population it can carry out social control on the spot. Fitting into the process of the extension of the operating time of the units the TEIT has been operating a controlling committee since 2004, the members of which come from the neighboring settlements.

The Paks Nuclear Power Plant runs a Visitor’s Center beside the power station. Anyone can come here without previous arrangements and all of their questions can be answered. The exhibition, covering an area of almost 1000 m², set up on the basis of European standards situates the peaceful usage of nuclear energy in the everyday lives of people. The gaining of knowledge is supported by active mock-ups and demonstrating computer programs. The “nuclear playhouse” is visited by about 30 000 people every year; the visitors can even take a walk in the power station accompanied by trained guides until they reach the reactor hall. The Visitor’s Center is one of the most important places of the meetings of the population and the

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power station; it provides daily, personal possibilities of getting information for every Hungarian citizen, including the people living in the environment.

It is the interest of the Paks Nuclear Power Plant to share the information to be published with the widest range of people living in the region, either in the form of simple news or an interview, or in the form of a background conversation. The power station is in a close relationship with the representatives of the local and regional press, and it provides them with information regularly, or depending on the situation. The “Fortuna Rádió” of Paks, the local television called “TelePaks”, the “Paksí Hírnök”, the “Tolna Népujság”, the “Korona Rádió” of Kalocsa, the local television, the “Kalocsai Néplap” and the “Petőfi Népe” are objective, helpful partners of the Paks Nuclear Power Plant, and through them most of the population of the region can be reached.

The power station has got a house paper on its own, the monthly paper called “ATOMERÖMŰ”. This paper provides proper information about the events that happened is the power station, the plans and the development efforts, as well as about the symbiosis with the environment. Beyond these the current, exemplary events of the settlements are also presented in it. The paper is posted to every mailbox of the settlements within the 12 km wide range of the power station (TEIT), so it is one of the most important, direct carriers of the news and the informational relationships of the power station. The paper deals with the questions of the extension of the operating time of the units of Paks regularly.

The representatives of the nuclear power station visit the mayors of the neighboring settlements regularly; if needed, they provide information in the meetings of the local governments, in the forums of the settlements and in public enquiries. Sporadically, either together with the TEIT, or on their own they also provide the population and the local governments with written information.

In the website of the power station (www.atomeromu.hu) we can get acquainted with the history of nuclear research, the operation of the nuclear power station, its environmental effects and the latest news in a large compass. The biggest nuclear websites of the world (NRC, IAEA) deal with the plans of the extension of the operating time of Paks as well.

Between the Paks Nuclear Power Plant and the population of the region possibilities of communication going back to decades do exist and work, which also cover control on the level of the local governments. The wide range possibilities of getting information and expressing opinions form the basis for trust building, relaxed cooperation and consensus reaching.

7. SUGGESTIONS ON THE EXAMINATIONS OF THE ENVIRONMENTAL EFFECTS OF THE EXTENDED OPERATING TIME OF THE NUCLEAR POWER STATION

In the case of present activities the uncertainties are much smaller than in the case of new activities. Usually the uncertainties arise from the uncertainties of the preliminary estimations (eg. from the possible differences between the plans and the execution or the imprecise
knowledge of background loadings) and the fact that usually the present conditions are not documented with measurements. Practically, after the extension of the operating time the power station is going to be run with the present technical characteristics and technological resolutions. Moreover, the present conditions are documented with a lot of measurements – especially from the point of view of radiology. So the expected changes of the environmental conditions can be forecast more precisely than in the cases of many other activities, investments.

In summary we can say: the environmental effect-study was finished with the result that the examined radiological and non-radiological environmental effect-processes did not show any environmental loading that would exclude the extension of the operating time in the given company seat.

During the extended operating time of the nuclear power station the environmental appropriateness can be reached primarily with the guaranteeing of the security of the nuclear power station. For this the continuous control of the conditions of the industrial establishments and apparatuses and the regular examination of their endurance is necessary. The operation of the plant has to be carried out according to the current security report and the regulations determining the certain activities.

Keeping the operation of the nuclear power station within normal industrial frames can guarantee that both the radiological and the non-radiological environmental loadings are going to stay within the frames of the changes written down in the environmental effect-study. The activity of environment control has to be carried on with during the time period of the extension of the operating time as well, or changing some of its typical examinations would be practical, as well as examining new characteristics.

7.1. Radiological emission and environment control systems

The control system of radiological emissions was updated between 2002 and 2005. Taking this into consideration, during the extended operating time it will not be necessary to change the system; at the most, with the development of technologies its update can become practical.

The Government Decree 15/2001. (VI. 6.) issued by the minister of environment prescribes in connection with the application of nuclear energy that the nuclear power station has to control the radioactive loading arising from its activity and prepare the Regulations of Emission and Environment Control that regulates the controlling activity. These regulations contain the order, the methods and the means of control and the characteristics of their capacity and efficiency. During the extended operating time the emission and environment control has to be carried out according to the regulations accepted by the authorities as well.

The activity of the authorities carrying out the control of the environment of the nuclear power station from the point of view of radiation protection, namely the Ministry of Health, the Ministry of Agriculture and Rural Development, the Ministry of Environment and Water and their cooperation with each other and the industrial environmental control system of the nuclear power station is carried out within the frames of the Official Environmental Radiation Protection Control System that was established with the command of the Hungarian Atomic Energy Agency. The collection of the measurement results and the processing of the data are

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carried out in the Data Collecting, Processing and Evaluating Center established in the “Frédéric Joliot-Curie” National Research Institute for Radiobiology and Radiohygiene.

So the control of the radioactive loading of the environment has to be carried on with according to the followed practice of the power station during the extended operating time as well, in accordance with the possible changes of the relevant legislative regulations.

7.2. Common environment control systems

Out of the common characteristics of the environment conditions the geological and hydro geological conditions were examined and monitored the most extensively in the environment of the nuclear power station during the previous operation. These can be considered finished examinations, and since the changes of the conditions of the environment can only come off in a natural way and in a long period of time, supposedly there is no need to carry out further investigations during the twenty years of the extended operation. Out of these examinations the microseismic investigations are exceptions. Here the power station has been running the microseismic monitoring system for ten years, according to the order of the HAEA NSD, and according to the prescriptions of the order it makes the yearly reports on the operation prepared. The further operation of the system is going to be decided by the HAEA NSD, taking the results and the international practice into consideration. A separate report has to be prepared on the development in 2008 within the frames of the Periodic Security Check.

Several other parameters were measured by the power station, which are important from technical and security points of view, but they also play a role in the characterization of the conditions of the environment. See for example water circulation, non-nuclear contamination and temperature of emitted used waters, conditions of groundwater. The measurements of these are necessary during the extended operating time as well. The ways of carrying out these investigations (eg. measurement frequency, pollutants to be measured) are determined by the previous environmental orders, so it is practical to carry on with them similarly to the examinations carried out at present.

However, there were common environmental elements/systems that were not measured regularly until 1999, until the start of the company seat characterization program. Usually, the company seat characterization program concerned to the measurement and monitoring of environmental characteristics that were not necessary to be monitored continuously, since the changes of their conditions take a long time. On the basis of the results of the environmental effect-investigation and the company seat monitoring program we suggested the below controlling activities:

- **Conditions of surface waters:** investigation of common water quality and biological characteristics every three years in the sections of the Danube above and below the power station according to the previous methods, and every season in the warmed up cooling water, taking the expectations of The Water Framework Directive into consideration as well.
- **Conditions of surface waters:** water temperature control with the help of a two dimensional hydrodynamic heat transport model calibrated with the help of preventing experiments.
- **Subsurface waters:** carrying on with the control of the effects on them in 2006-2007; determining the necessity of the further operation of the monitoring system considering the results.

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The bed of the Danube and the conditions of the river wall: keeping tabs on the reef and ford formations, and forecasting these in ten-year periods of time. (Measurement of the speed and direction of the flow, measurements of temperature distribution and investigation of suspended silt and bed material samples in the 8 sections determined in the preceding period of research, registering water levels in the periods of low water levels.)

8. CONSEQUENCES OF THE CANCELLATION OF THE EXTENSION OF THE OPERATING TIME

In the present economic environment the cancellation of the extension of the operating time of the nuclear power station requires the compensation of the missing electric energy production on the domestic level, which can be carried out with the help of new units, coal- or gas-fired smaller units, using reviving energy sources in greater amounts, and/or energy import. This can be carried out, but with considerable investment and import costs. The relevant costs have to be included in the price of electric energy.

The technology of producing electric energy in the nuclear power station is free of the common emissions, like dust, scale, sulfur-dioxide, nitrogen-oxides and carbon-dioxide. Considering the present yearly average output of 14 000 GWh of the nuclear power station and the average (weighted) specific carbon-dioxide emission (~0.4 kg/kWh) of the domestic, more modern power stations, the emission of 10 million tons of carbon-dioxide is spared. This is a considerable amount, since the domestic power stations emitted 12,037 million tons of carbon-dioxide altogether in 2001. If we wanted to replace the Paks Nuclear Power Plant with the present power station structure, the emission of sulfur-dioxide, carbon-monoxide, nitrogen-oxides, solid air pollutants and carbon-dioxide would increase according to the output proportion of the power station, namely with almost 40% in the electric energy industry. When compensating the missing capacity it has to be investigated whether the emission of carbon-dioxide fixed in the Kyoto Agreement can be kept or not, because of the emissions of the expectedly fossil based firing material using power stations applied in the compensation process. At present the emission in Hungary is below our determined proportion (quota). If the missing capacity of the nuclear power station was compensated by gas-fired power stations, the emission of carbon-dioxide would increase with almost 6 million tons, so we would almost reach the Hungarian quota of 80 million tons. The replacement of the capacity with coal-fired power stations would mean a further increase of 4 million tons, compared to the gas-fired power stations. The long-term import of energy would be an expensive solution, and it would increase the dependency of the country on import. In theory the usage of reviving energy sources would be a favorable alternative from the point of view of the environment, but their realistic amount that could be produced within a short period of time would be much less than the missing amount of energy; moreover, their production costs are also high.

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Plain Summary 2006.02.06
On a local level, stopping the operation of the nuclear power station and its stripping would mean a continuous activity of at least 20-30 years in the present company seat, but the termination of electric energy production would be followed by the gradual decrease of employment and the supports of the region. The area used at present can only be used for industrial or agricultural purposes after the stripping. As opposed to this, the Paks Nuclear Power Plant is the biggest employer of Tolna County and the South Transdanubian region at present and during the time period of the planned extension of the operating time. Our workers and the employees of the ventures working for the power station mean about 3600 people. In an indirect way the work of further thousands of people is connected to the operation of the power station, primarily in the field of services. On both sides of the Danube the Paks Nuclear Power Plant offers considerable support in the fields of healthcare, education, culture, folk tradition keeping, and sports, considering the domestic conditions. Among the supported there are civil organizations, different associations and churches as well. The micro-regional associations for regional development also get considerable support for different tenders every year, supporting the investments of the settlements this way.

In summary we can state that without the execution of the extension of the operating time we can expect the deterioration of the security of the electric energy supply, the decrease of employment in the region and the termination of most of the supports. However, the planned extension of the operating time of the units of the power station can support the development of the settlements, the region and the economy for further decades.

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