Hungary

Eighth National Report

in the Framework of the Convention on Nuclear Safety

2019

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List of abbreviations

Fund – Central Nuclear Financial Fund

Act on Atomic Energy– Act CXVI of 1996 on Atomic Energy

Ákr. – Act CL of 2016 on General Public Administration Procedures

SBEOP – Symptom-based Emergency Operation Procedures

ERO – Emergency Response Organization

MoI – Ministry of Interior

MoI NDGDM – Ministry of Interior National Directorate General for Disaster Management

MoI NDGDM NEIEC – Ministry of Interior National Directorate General for Disaster Management Nuclear Emergency Information and Evaluation Centre

TSR – Targeted Safety Re-assessment

EACA – European Competent Authorities on the Transport of Radioactive Material

PSAR – Preliminary Safety Analysis Report

PSIR – Preliminary Safety Information Report

ENS – European Nuclear Society

ENSRA – European Nuclear Security Regulators Association

EPC – Engineering, Procurement, Construction Contract

EPRI – Electric Power Research Institute

ESARDA – European Safeguards Research and Development Association

EU – European Union

Euratom – European Atomic Energy Community

EAES – European Atomic Energy Society

SAETP – Sustainable Atomic Energy Technology Platform

GRP – Geological Survey Programme

HERCA – Heads of the European Radiological Protection Competent Authorities

PSR – Periodic Safety Review

PSRR – Periodic Safety Review Report

INES – International Nuclear and Radiological Event Scale

INSC – Instrument for Nuclear Safety Cooperation

IRPA – International Radiation Protection Association

IRRS Mission – Integrated Regulatory Review Mission

Ket. – Act CXL of 2004 on the General Rules of Administrative Procedures and Services

MEM – Maintenance Effectiveness Monitoring

DMCIC – Disaster Management Coordination Inter-Ministerial Committee

SFISF –Spent Fuel Interim Storage Facility

SBEOP –symptom-based emergency operating procedures

HNKMD – Hungarian Nuclear Knowledge Management Database

MDEP – OECD NEA Multinational Design Evaluation Programme

HAS CER – Hungarian Academy of Sciences Centre for Energy Research

TS – Technical Specifications

MVM Ltd. – Hungarian Electricity Private Limited Company

MVM Paks NPP Ltd. – MVM Paks Nuclear Power Plant Ltd.

MVM Paks II Ltd. – MVM Paks II Nuclear Power Plant Private Company Limited by Shares

IAEA – International Atomic Energy Agency

NEIEC – Nuclear Emergency Information and Evaluation Centre

NSC – the Appendices of the Govt. Decree 118/2011. (VII. 11.) on the nuclear safety requirements for nuclear facilities and the corresponding regulatory activity

NFCSO – National Food Chain Safety Office

NRWR – National Radioactive Waste Repository

NSD directive – Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations and its amendment, Directive 2014/87/Euratom

Convention on Nuclear Safety – Convention on Nuclear Safety signed in Vienna on 20 September 1994 under the auspices of the International Atomic Energy Authority

NUMEX – Nuclear Maintenance Experience Exchange

HAEA – Hungarian Atomic Energy Authority

OECD – Organisation for Economic Co-operation and Development

OECD NEA – OECD Nuclear Energy Agency

NRMAS – National Radiological Monitoring and Alarming System

NERMS – National Environmental Radiological Monitoring System

HNERS – Hungarian Nuclear Emergency Response System

OSART –Operational Safety Review Mission of the IAEA (Operational Safety Review Team)

Paks II Ltd. – Paks II Nuclear Power Plant Private Company Limited by Shares

PSA – Probabilistic Safety Assessment

RWTDF – Radioactive Waste Treatment and Disposal Facility

PURAM –Public Limited Company for Radioactive Waste Management

SAMGs – Severe Accident Management Guidelines

Svr. – Govt. Decree 487/2015. (XII. 30.) on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system

GSS – Guideline of Support Systems

OLC – Operational Limits and Conditions

OM – Online Maintenance

FSAR – Final Safety Analysis Report

WANO – World Association of Nuclear Operators

WENRA –Western European Nuclear Regulators' Association

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1. Declaration

On behalf of the Government of Hungary, the Director General of the Hungarian Atomic Energy Authority, based on the details of this National Report, makes the following declaration:

Hungary states that nuclear safety prevails during the application of nuclear energy and thus Hungary completely fulfils the conditions stipulated in the Convention on Nuclear Safety and it is in compliance with its spirit on the basis of the following:

- the requirements stipulated in law;
- the organizational and financial independence of the Hungarian Atomic Energy Authority and the licensing and inspection activities thereof;
- the activities carried out by the operator who is committed to the priority and continuous improvement of safety.

Budapest, 4 September, 2019

Director General of the Hungarian Atomic Energy Authority

2. Introduction[1]

National energy policy

On 14 October 2011 the Parliament adopted a resolution on the document titled as *"National Energy Strategy until 2030"*. As the most important objectives, the resolution identifies the security of energy supply, the competitiveness and sustainability, as co-realization of these long term primary objectives, the safe and economical satisfaction of the energy needs of the economy and the population taking into account the environmental protection aspects, strengthening the competition in the energy market and support of the community objectives established in the framework of the European Union (hereinafter referred to as EU).

The resolution requested the Government to take the necessary governmental steps for the implementation of the energy policy. Among the twenty-four tasks listed, there are two tasks related to the use of atomic energy. Accordingly, the Government shall:

- „commence the preparatory work for the decision on new nuclear capacities at the site of Paks NPP, paying special attention to its costs";
- „oversee the proper realization of programmes dealing with the safe management and final disposal of radioactive wastes, and the provision of the necessary conditions".

The main objective of the Energy Strategy is to guarantee the security of national energy supply. The five tools recommended for the accomplishment of this objective are energy saving and energy efficiency, the use of renewable energy in the highest possible ratio, the development of the regional infrastructure, the active role of the Government in the energy market and the long term peaceful use of atomic energy.

Consequently, the "Common effort" concept that was marked as the most realistic vision and therefore decided to be implemented is represented by the "Atom-Coal-Green" scenario of the Energy Strategy from the electric power generation point of view. One of the most essential elements of this scenario is the long term sustaining of the atomic energy in the energy mix.

The role and contribution of nuclear energy

Paks NPP, Hungary's only nuclear power plant, operates as a joint stock company under the name of MVM Paks Nuclear Power Plant Ltd. (hereinafter referred to as MVM Paks NPP Ltd.). *The contribution of atomic energy to the total generation of electric power was 50% in 2016, 50% in 2017 and 51% in 2018*. Consequently, the Paks NPP plays an essential role in the Hungarian electrical power system.

[1] *To ensure transparency, the modifications made in comparison with the Seventh National Report are indicated in italics.*

Significance of nuclear safety

Act CXVI of 1996 on Atomic Energy (hereinafter referred to as the Act on Atomic Energy) stipulates in the spirit of the Convention on Nuclear Safety signed in Vienna on 20 September 1994 under the auspices of the International Atomic Energy Agency (hereinafter referred to as Convention on Nuclear Safety) that "In the use of atomic energy, safety has priority over all other aspects", and that "The licensee is obliged to undertake continuous activities to improve safety, taking into account its operational experience and the new safety related information" in harmony with the spirit of the Convention on Nuclear Safety.

International review missions

Since its commissioning, MVM Paks NPP Ltd. has paid special attention to utilizing international experience and, at its own initiative, more than 40 international review missions have taken place since 1984. These include all kinds of important reviews organized by the International Atomic Energy Agency (hereinafter referred to as IAEA). *The latest IAEA mission reviewing operational safety (hereinafter referred to as OSART) was hosted in 2014; its follow-up mission was successfully conducted in 2016. The World Association of Nuclear Operators (hereinafter referred to as WANO) also performs regular reviews at Paks NPP. In 2016 the 4th peer review and the follow-up of the WANO corporate level peer review conducted in 2014 took place. The follow-up of the 4th corporate level peer review in 2016 was conducted in 2018.*

International relations

The Hungarian institutes maintain wide-ranging relations with various international and national nuclear organizations, professional bodies, institutes, nuclear power plants abroad, companies involved in design, construction and installation of nuclear facilities, and research institutes. These relations serve as a means of exchanging, transferring knowledge and experience. The fact that Hungarian experts are held internationally in high esteem is demonstrated by their active role in several committees, with many of them being board members of international organizations or invited as experts.

International partners of major importance are the IAEA, the OECD Nuclear Energy Agency (hereinafter referred to as OECD NEA), the OECD NEA Multinational Design Evaluation Programme (hereinafter referred to as MDEP), the EU and its organizations, the European Atomic Energy Community (hereinafter referred to as Euratom), the WANO, the VVER-440 operators' club and the VVER Forum, the International Nuclear Safety Program (the so-called Lisbon Initiative), the Nuclear Maintenance Experience Exchange (hereinafter referred to as NUMEX), the Western European Nuclear Regulators Association (hereinafter referred to as WENRA), the European Safeguards Research and Development Association (hereinafter referred to as ESARDA), the European Atomic Energy Society (hereinafter referred to as EAES) and the Electric Power Research Institute (hereinafter referred to as EPRI). Additional important partners are the European Nuclear Security Regulators Association (hereinafter referred to as ENSRA), the Heads of the European Radiological Protection

Competent Authorities (hereinafter referred to as HERCA) and European Competent Authorities on the Transport of Radioactive Material (hereinafter referred to as EACA). The Hungarian Nuclear Society is a member of the European Nuclear Society (hereinafter referred to as ENS), and the Radiation Protection Section of the Eötvös Loránd Physical Society is a member of the International Radiation Protection Association (hereinafter referred to as IRPA).

Comments on the challenges and suggestions identified in the Rapporteur's Report about the Sixth National Report

Regarding the challenges and suggestions for the Sixth National Report left open during the 7th Review Meeting, Hungary has made the following progress.

2. Implementation of the Hungarian National Action Plan

The Hungarian National Action Plan meets the necessary criteria and is in compliance with the respective recommendations of the ENSREG. In 2015, in order to keep track of the implementation of the plans, the international review was repeated. In relation to Hungary, it was concluded that the completion of the tasks duly progressed, several tasks had been completed within or well within the deadline. By the end of 2018, 40 out of the 46 tasks were completed and the Hungarian Atomic Energy Authority (hereinafter referred to as HAEA) during the Periodic Safety Review (hereinafter referred to as PSR) re-scheduled the remaining 6 tasks (see the details in Section 3.5. and Annex A7.).

6. Knowledge management

Making the organizational culture more effective and exploiting organizational knowledge are indispensable to optimize the operation of the organization and to improve internal effectiveness. Appropriate and available means for that can be provided by a knowledge management system. Development of the HAEA's knowledge management system was justified by the need to maintain easy-to-access and up-to-date knowledge for increasing the effectiveness of regulatory work that can be achieved via a well operating system. The HAEA's strategic plan for the periods 2018-2020 includes maintaining human resources and knowledge base of the nuclear authority at a high level by preserving and developing organizational knowledge and by establishing the knowledge management system of the HAEA. The knowledge management system established in 2015 for sustaining knowledge is continuously developed.

Sharing of knowledge within the HAEA is possible in several manners. The HAEA possesses a common technology background (joint network drivers, various circulars about meetings and CD data store expansions, Paks Press, library, standards, notes, official website, minutes and records of meetings, coordinations, Legal Database, governmental websites, internal shared folders) that supports knowledge sharing. The most important knowledge sharing technology is the Hungarian Nuclear Knowledge Management Database.

In summary, it can be concluded that elements of the HAEA's knowledge management system exist, integrating them into a common system is continuously ongoing.

Comments on the challenges and suggestions identified in the Rapporteur's Report about the Seventh National Report

1. Efficient review of the construction license application of new nuclear power plant units

Until the closing date of data collection for the present national report the licensee had not submitted the construction license application to the HAEA. However, the HAEA is ready to efficiently assess this license application.

The HAEA actively participates in the working groups of OECD, IAEA and other professional organizations dealing with new builds, and regularly cooperates with the Finnish, Belarusian and Russian authorities on a bilateral basis.

The HAEA has elaborated and has been implementing a systematic training plan in order to train the inspectors and further increase their level of knowledge. The HAEA established a knowledge management system to support the training system, which became part of the HAEA processes. Its development is continuous, one of its major objectives is to promote the knowledge transfer from experienced to newly recruited staff members.

2. Implementation of the revised Nuclear Safety Code at the authority and at the licensee

The Nuclear Safety Code (hereinafter referred to as NSC) volumes as the Appendices of the Govt. Decree 118/2011. (VII. 11.) on the nuclear safety requirements for nuclear facilities and the corresponding regulatory activity (hereinafter referred to as Govt. Decree 118/2011.) were amended in 2018. Section 40/E of Govt. Decree 118/2011. requires the licensee to submit a report to the nuclear safety authority within 3 months after its entering into force. In the report, they needed to declare, based on their own review, which requirements were not or not fully complied with. Based on this, the licensee evaluated the safety risk of not meeting the requirements and submitted a proposal on the deadlines for meeting the not, or not fully met requirements. According to Section 16 of Govt. Decree 118/2011., all nuclear facilities and activities related to nuclear safety shall have a license, approval or exemption. The licensees submitted applications for exemption from particular requirements until the date of implementation of the necessary actions. The authority decided about the exemption in a resolution taking into account all circumstances. The deadlines of the exemptions shall not exceed the date of the next PSR. The report was submitted by the licensees of all nuclear facilities within the deadline.

In order to comply with Principle 3 of the Vienna Declaration on Nuclear Safety (hereinafter referred to as Vienna Declaration) both the review and the implementation took place in consideration of the appropriate IAEA documents and international good practices. During the review, the HAEA

concluded that after their amendments the Hungarian regulations are still in compliance with the IAEA requirements.

3. Assessment of safety culture of the HAEA and the facilities overseen by the HAEA

After the Integrated Regulatory Review Mission (hereinafter referred to as IRRS mission) in 2015, the HAEA developed a procedure to survey and assess its own safety culture. The HAEA implemented the survey in 2017 based on this procedure. A working group consisting of representatives of all larger organizational units of the HAEA performed an assessment in 2018 based on the results of the survey. Based on the report elaborated by the assessment group for the senior management, an action plan was established to improve the safety culture of the HAEA.

In 2017, the enhancement of safety culture of MVM Paks NPP Ltd. included the following items:

- *Targeted safety culture programme (action month),*
- *Safety culture motivation programme,*
- *Questionnaire-based safety culture survey.*

The targeted safety culture programme (action month) consisted of three elements:

- *Publication of the fourth volume of the safety culture booklet series, which described the WANO strong safety culture indicators;*
- *Organization of a thematic forum for managers and production managers;*
- *Safety culture "activity" programme on the company website to communicate the information on the improvement of the safety culture to the employees.*

The management declared the safety culture motivation programme (Silver card) also for 2017 according to the framework followed in the preceding year. Individual performance in a safety area or an individual role in general improvement of safety performance of an organizational unit (e.g. supported by safety indicators) was qualified as outstanding safety performance.

In 2017, a questionnaire survey was conducted to determine the level of safety culture. 54% of MVM Paks NPP Ltd. employees and employees of 12 contractors took place in the survey. Results of the survey were communicated both to the management of the company and to the employees.

During the safety culture assessment of the licensees, the following developments took place with regard to human and organizational factors and the regulatory oversight of safety culture.

In 2016, the Human and Organizational Section was established at the HAEA and it was tasked with, among others, oversight of safety culture of the licensees. The

HAEA modified the safety indicator system with the objective to be able to collect the most relevant information related to the level of safety culture. From 2016, the annual safety performance assessment report prepared by the HAEA is supplemented with a human and organizational factors chapter containing safety culture assessment. In 2016, HAEA conducted a dedicated inspection targeted at human and organizational factors and safety culture and its improvement at Paks NPP. The assessment of results of the comprehensive inspection was extended with various aspects, such as training, safety culture, management system, problems during maintenance, supervision of contractors and qualification audits.

4. Implementation of the 3rd Periodic Safety Review of MVM Paks NPP Ltd.

In line with the Hungarian legislation, a PSR shall be conducted every 10 years at the nuclear facilities, so at Paks NPP, the results of which are to be summarized in a report by the licensee. MVM Paks NPP Ltd. submitted the report to the HAEA in the end of 2017. The HAEA was assessing if the review had taken place according to the legal requirements, and if the tasks and deadlines had been determined with due care. This regulatory assessment was concluded on 30 January 2019, which date can be regarded as a closure of the previous 10 years term of the NPP, also laying out the major tasks of the next 10 years. (See more details in Sections 3.3. and Section 14.1.2.)

In the review period the PSR performed at Paks NPP, in line with Principle 2 of the Vienna Declaration, contributed to the actions meant to continuously assess and improve the level of safety.

5. Development of regulatory requirements and instruments against fraudulent and counterfeit products

In order to prohibit and prevent the use of fraudulent and counterfeit products, the Govt. Decree 118/2011. was amended in 2018 and the HAEA issued a regulatory guideline to facilitate the interpretation of the legal requirements. The licensees commenced the implementation of the actions required by the law; the HAEA continuously follows the implementation.

6. Implementation of an effective inspector training for the large number of new employees of the HAEA

The staff of HAEA expanded by 98 members between 2015 and 2018. The staff number is 175 at the time of closure of the report, and an opportunity to hire 31 more staff is open. The HAEA elaborated a comprehensive training programme for the newcomers to teach the professional knowledge needed for the tasks with respect to nuclear safety, safeguards and security.

The new Organizational and Operational Rules (hereinafter referred to as OOR) approved in 2017 set up a new organizational structure, which annulled the former deputy director general positions and the organizational units related to regulatory work were subordinated to a single deputy director general. The supporting functions of the HAEA (Legal Department, External Relations Department and the Finance and Human Relations Department) are subordinated

directly to the director general. The HAEA is currently working on the unification of inspector training of the departments previously under different deputy directors general.

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In the present report, mainly the changes that have occurred since the closure of the previous national report are detailed, nevertheless all the basic principles that are still valid are repeated to provide the reader with a stand-alone report. Important processes that did not change in the reporting period have not been omitted from the present document, but the detailed descriptions have been placed to the Annexes. The outcomes of the review conducted after the accident of Units 1-4 of TEPCO Fukushima Dai-ichi NPP were discussed in the report submitted to the Extraordinary Review Meeting held in August 2012. The National Action Plan established based upon the Targeted Safety Reassessment (hereinafter referred to as TSR) and the review of its implementation is presented in Annex A7.

The data presented in this report reflect the situation as on 31 December 2018.[2]

[2] Despite that the report contains references to events in the first months of 2019, if the information considerably contributed to the understanding of the processes.

3. Summary

The most important changes since the submission of the previous national report have been summarized in this section.

Since the submission of the Seventh National Report there is no change in the number of existing nuclear installations in Hungary.

Throughout their work, both the HAEA and the licensee strived to benefit from the conclusions of the previous Review Meeting and special emphasis was given to evaluating the comments and general remarks addressed to the National Report of Hungary.

The most important changes that have taken place since the submission of the previous National Report are addressed in the following Sections.

The following systematic assessments and reviews should be highlighted as contributors to compliance with Principle 2 of the Vienna Declaration:

- *Guaranteeing the priority of safety during licensing of operation of Units 1-4 of Paks NPP beyond design lifetime (see Section 3.1.);*
- *PSR performed at Paks NPP (see Section 3.3.);*
- *Introduction of a modern Operational Limits and Conditions document (see Section 3.2.3.);*
- *Progress in implementing safety improvement actions determined during the TSR (see Section 3.5.);*
- *The European Union's review of ageing management of nuclear facilities (see Section 3.6.);*
- *Participation in the international ConvEx-3 emergency response exercise (see Section 3.10.).*

3.1. Licensing of operation of Units 1-4 of Paks NPP beyond design lifetime

Subsequent to the end of the 30-year design lifetime of Units 1 and 2, in 2012 and in 2014, the lifetime extension allowing further operation for additional 20 years was completed.

The HAEA licensed the lifetime extension allowing further operation for additional 20 years after the expiry of original design lifetime of 30 years for Unit 3 and 4 in 2016 and 2017, respectively. This had completed the lifetime extension licensing process of Units 1-4 of the nuclear power plant. The HAEA conducted the lifetime extension licensing process with the involvement of the public; public hearings were organized in the case of each unit. The authority has required several actions for the licensee to maintain the level of nuclear safety, the implementation of which is the most important task of the upcoming years.

Section 6.1.4. contains more information about the completed process of lifetime extension.

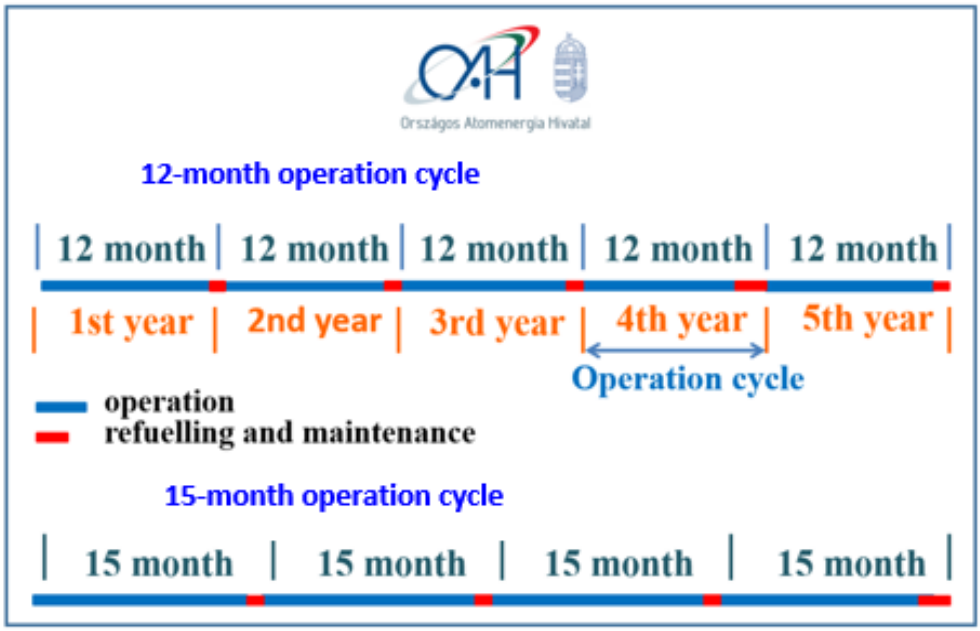
3.2. Important operational changes at Paks NPP

Several modifications of operation were introduced at Paks NPP in the review period. Based on the license application submitted in 2014, the HAEA licensed, in 2015, the introduction of a 15-month operation cycle instead of the previous 12-month cycle. The new cycle has continuously been introduced from 2016; the needed modification of the operation license is in progress currently (see Section 3.2.1.). In 2017, the nuclear power plant introduced the online maintenance (see Section 3.2.2.), and in 2018 a reviewed Operational Limits and Conditions document entered into force replacing the Technical Specifications (see Section 3.2.3.).

3.2.1. Introduction of the 15-month operation cycle at Paks NPP

The MVM Paks NPP Ltd. declared in the beginning of 2013 its intention to operate the units of the nuclear power plant, instead of the 12-month cycle period, based on a 15-month operation cycle in the future. The most visible character of the increase of the cycle period is that only 4 refuelling outages will be performed during 5 years at one unit, instead of the current 5 refuelling outages, as it is shown by the figure below.

Figure 3.2.1.: The former 12-month operation cycle and the introduced 15-month operation cycle



Increasing of the operation cycle is a complex technical modification which changes those principles and conclusions that form the basis of design and licensing of the nuclear facility. Consequently, in line with the legislation in force, a two-stage licensing is required: after licensing of the modification, it is also necessary to modify the operation license of the units, in which procedure the experience gained from the units operating with 15-month cycle needs to be examined and assessed.

As a first step, Units 1-4 of Paks NPP started the operation with 15-month operation cycle in 2016, after having obtained the modification license on 1 December 2015.

In the second step of the licensing process, on 25 July 2018, the MVM Paks NPP Ltd. submitted the license application for modification of the operation licenses of Units 1-4 necessary due to the introduction of the 15-month operation cycle. The evaluation of experience gained during the increased operation cycle, the nuclear safety and radiation protection conditions during operation and refuelling outages were introduced and the documents demonstrating long term safety of the units as specified by laws were attached. The validity of the new operation licenses was requested to be the same as licenses during lifetime extension:

- *Unit 1 - 31.12.2032.*
- *Unit 2 - 31.12.2034.*
- *Unit 3 - 31.12.2036.*
- *Unit 4 - 31.12.2037.*

According to the evaluation of the licensee, safe operability of the units operating with a 15-month operation cycle, the decrease of the dose exposure of the personnel and of spent fuel and radioactive waste generated are demonstrated by practical experience.

Regulatory review and assessment of the documentation supporting the submitted application is in progress, during which the HAEA examines and assesses among others, if:

- *the experience of the units operating with 15-month cycle confirms the conclusions of the analyses and supporting documents submitted during the modification licensing procedure, that is*
- *the increase of operation cycle has no unfavourable impact on the core damage and large release frequency;*
- *the modifications carried out in the maintenance and inspection cycle times and in the maintenance instructions and technologies are appropriate;*
- *the modifications of the operational documents are correct and complete, the emergency operating procedures, severe accident management guidelines and the emergency preparedness and response plan are adequate to achieve the goals determined in them;*
- *the amount of generated spent fuel, radioactive waste and dose exposure of the maintenance personnel decreased as expected;*
- *the conditions of long term safe operation are reached.*

3.2.2. Introduction of online maintenance at Paks NPP

Since the start of operation of Paks NPP, it was not allowed to take out of operation the SSCs of the safety systems for planned preventive maintenance at rated power operation of the twin units. (The single exception needed is taking out of operation of any of the three trains of the essential service water system belonging to joint section of the twin units that has a maximum limitation of 120 hours during a refuelling outage of one of the units).

The operator of Paks NPP started to examine the issue of online maintenance (hereinafter referred to as OM) based on international model examples, using a probabilistic safety assessment (hereinafter referred to as PSA) based Risk Monitor, the software previously not used during normal operation. The preliminary PSA calculations showed that during rated power operation of a unit, if one train of a safety system is taken out for maintenance (maximum for 30 days per year, together for the twin units) the core damage frequency increment is compensated and the early or large release frequency is decreased since during the refuelling outage, with open containment, these safety system trains and the corresponding equipment are needed to be made non-operational only for a shorter period.

The supporting documentation for the license application was developed following the draft of the Framework for an Integrated Risk Informed Decision Making Process of the IAEA. The licensee demonstrated that the introduction of OM does not cause any change to be considered in the deterministic accident analyses, among others no new initiating event needs to be taken into account and the single failure criterion is still met in all cases to be analysed. It was also demonstrated that the PSA calculations performed with the average risk model showed decrease of the annual overall risk for power operation and low power operation (including shutdown states). The authority granted its consent in two separate licenses to introduce OM for the 12-month and the 15-month operation cycles.

3.2.3. Introduction of new operational limits and conditions document at Paks NPP

The use of the Operational Limits and Conditions (hereinafter referred to as OLC) document was introduced at Paks NPP in 2018 for all 4 units. It replaced the previously used Technical Specification (hereinafter referred to as TS).

The process of introduction of OLC is described in Section 19.2. in details.

3.3. Assessment of Periodic Safety Review Report of Paks NPP

Principle 2 of the Vienna Declaration requires that comprehensive and systematic safety assessments shall be carried out periodically and regularly in operating nuclear power plants. In Hungary, this is performed via the 10-yearly implemented PSRs (it was last due in 2017-2018) and the comprehensive regulatory inspections

conducted between two PSRs. A comprehensive inspection is an overall inspection of a selected area of the PSR.

The PSR shall cover identification and assessment of changes in the condition of the nuclear facility and its systems and components, changes of the site, identification and assessment of new knowledge deriving from the results of science, international practice and technical development, and from the monitoring of parameters. The review, in addition to the technical areas, covers the administrative and human areas. The PSR does not only take a snapshot, but views 10 years back and partly forward.

The recommendations on the content of the Periodic Safety Review Report (hereinafter referred to as PSRR) is included in the Regulatory Guideline A1.39 that comprises the international requirements, relevant guidance from IAEA SSG-25 and WENRA reference levels. The HAEA published the guideline in 2016.

The report closing the 3rd PSR of Paks NPP was submitted to the authority on 14 December 2017.

Co-authorities of the HAEA contributing to its regulatory processes according to Annex 2 of the Act on Atomic Energy took part in the detailed review of the PSRR. The co-authorities granted their consent to the acceptance of the PSRR without conditions.

The MVM Paks NPP Ltd. identified several non-compliances during the review, for which an action plan was developed. The operation license of the units can be limited in light of the PSR results, but the HAEA assessment of the PSRR did not reveal any serious non-compliances with an impact on nuclear safety. The HAEA, however, identified improvement actions in both administrative and technical areas, which are to be included in the safety improvement actions of the upcoming years. The HAEA re-scheduled the TSR actions in this resolution, together with which 73 actions were identified. More than 70% of the actions are of administrative nature, while the others are associated with a technical review or modification.

Section 14.1.2. contains a detailed description of the PSR.

3.4. Development of regulations

The NSC contains the nuclear safety requirements for the entire life cycle of nuclear facilities that shall be periodically reviewed according to the Act on Atomic Energy. Frequency of the review is determined as 5 years by the Govt. Decree 118/2011. (VII.11.) The Hungarian requirement system has been continuously developing in recent years, the WENRA and IAEA requirements have been incorporated into the Hungarian regulations before 2015, taking into account the international construction experience of new units, the experience from the relevant Finnish and British regulations and national licensing.

As the results of the review commenced according to the obligation of the Act on Atomic Energy, the amendment to the Govt. Decree 118/2011. entered into force

in April 2018. One of the most important objectives of the amendment was to specify the requirements for the new builds. During the elaboration of the amendments, the IAEA recommendations, WENRA reference levels and the international good practices (e.g. the Finnish requirements) were taken into account. An important aspect was to ensure the coherence between the NSC Volumes. Recommendations and experience from the IRRS mission conducted in 2015 in Hungary were also incorporated.

Accordingly, Hungary fulfilled its obligation undertaken for harmonization with international requirements.

3.5. National Action Plan to improve safety of facilities

After the accident that occurred on Units 1-4 of the TEPCO Fukushima Daiichi Nuclear Power Plant, the Hungarian National Action Plan to implement the results of the TSR (stress-tests) was established in December 2012.

The National Action Plan contained 46 safety improvement actions for Paks NPP having a final deadline of December 2018. The actions covered technical and administrative areas; the HAEA was continuously monitoring their implementation. The actions completed until 2016 were detailed in the previous review report, progress of the next 3 years can be found in Annex 7. The summary of the status of decided actions:

- *40 tasks were completed by deadline, only some administrative deficiencies are still being managed;*
- *6 tasks were not completed by the deadline specified in the TSR resolution, so the MVM Paks NPP Ltd. re-assessed the extra risks caused by the delays in the frame of PSR and re-scheduled the tasks with the approval of the authority.*

The details of the Hungarian National Action Plan are described in Annex A7.

3.6. Review of ageing management of nuclear facilities by the European Union

According to the Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations and its amendment, Directive 2014/87/Euratom (hereinafter referred to as NSD Directive) a topical peer review shall be implemented every six years in each EU Member State operating nuclear facilities. The ENSREG designated ageing management as the topic of the review in 2017. The review had to be implemented for nuclear power plants in construction or in operation and research reactors of a power exceeding 1 megawatt. The objective was to review the Member States' provisions for ageing management, to identify good practices and areas for improvement, to identify and share operating experience of the facilities, to perform the European review and to recognize common issues. For the uniform documentation of the review a technical specification was developed for describing the scope and contents of the national reports.

In Hungary, two facilities were involved in the topical peer review process: Paks NPP and the Budapest Research Reactor. Both facilities performed the self-assessment part of the review and sent their reports to the HAEA. The HAEA reviewed the reports and, by using them together with its own assessment, developed the national report, and then published it both in Hungarian and in English on its website.[3]

The results of the review can be summarized as follows:

- *In the area of ageing management of nuclear facilities, the Hungarian regulations are in full compliance with international recommendations.*
- *The HAEA follows the principle of continuous oversight also in this area; ageing management is embedded into the regulatory licensing, inspection and assessment activities.*
- *Ageing management at both facilities is in compliance with the national regulations and consequently with international requirements and good practices.*
- *The facilities are prepared to manage the anticipated ageing effects, identify and manage unanticipated degradation mechanisms.*
- *The facilities are continuously performing the activities necessary for maintaining the safe condition of the equipment.*

Current status of ageing management is described in detail in Annex A2.

3.7. Maintaining the capacity of Paks NPP and site license for Paks II Ltd.

Related to maintaining the capacity of Paks NPP, the HAEA approved the site survey and assessment programme submitted by the MVM Paks II Nuclear Power Plant Development Ltd.[4] (hereinafter referred to as MVM Paks II Ltd.) on 14 November 2014.

After the execution of the site survey and assessment programme, the MVM Paks II Ltd. submitted the site license application on 26 October 2016, and the HAEA, after its review and assessment, granted the license on 30 March 2017.

The Russian general contractor has been conducting a comprehensive technical survey based on a pre-determined „Engineering survey" since 2016 at the planned site of the new units, first of all to collect data for detailed design of building foundation.

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3 http://www.oah.hu/web/v3/HAEAportal.nsf/E9F38CFDD458B4F2C12581FB0054954D/$FILE/Topical%20Peer%20Revie%20Report_Hungary.pdf

4 The project company was founded by the MVM Ltd. with the name MVM Paks II Nuclear Power Plant Development Ltd. in 2012. After separation from the MVM Group in 2014, from October 2017 it continued the works under the name Paks II Nuclear Power Plant Ltd. (shortly: Paks II Ltd.). The report always refers to the company name of the company responsible for sustaining the capacity of the nuclear power plant according to the time of the event being discussed.

The next larger step of the new nuclear power plant project is to obtain the construction license. The licensee shall attach a preliminary safety analysis report (hereinafter referred to as PSAR) to apply for a construction license and shall possess the technical design of the new nuclear power plant, which shall be developed by the general contractor. Before commencing any nuclear safety related activity, Paks II Ltd. shall verify by conducting a qualification audit that the contractors performing such activities are able to perform the tasks and capable of ensuring the conditions for the work performance. The nuclear qualification of all contractors involved in the design, manufacturing and construction shall be completed before commencing a nuclear safety related activity.

It is also a task of the HAEA with regard to the project to grant the license for the construction of on-site service and manufacturing buildings (e.g. offices, warehouses, concrete mixer workshops). The HAEA granted construction license for four site buildings until the closure date of this report.

Annex A5. contains a detailed description of progress in the project for maintaining the capacity of Paks NPP.

3.8. Integrated Regulatory Review Mission

In 2015, the IAEA IRRS mission reviewed the work of the organizations (inter alia the HAEA) involved in regulatory oversight of the use of atomic energy in Hungary. After the review, the HAEA and the involved co-authorities developed an action plan to manage the 32 recommendations and 10 suggestions. The IAEA IRRS follow-up mission returned to Hungary between 24 September and 1 October 2018 to review the progress of the action plan.

As the result of the review, the IRRS peer review team concluded that Hungary had made significant steps since the IRRS mission in 2015 to develop the regulatory system, and out of the altogether 42 issues 30 were closed, since Hungary had successfully resolved them.

It is to be highlighted that the IRRS mission in 2015 reviewed the regulatory system during a significant transition period because of the transference of the radiation protection regulatory competences to the HAEA. Elimination of the deficiencies defiend in the country report for this area became the task of the HAEA from 1 January 2016. These issues were mostly resolved by the end of 2015 through the new radiation protection regulations, but tasks related to recommendations and suggestions to be managed on the long term remained open.

Out of the unresolved issues altogether 5 recommendations (one shared with the co-authorities) and 1 suggestion concern the HAEA, for the (long-term) management of which an action plan was developed.

7 recommendations concern the co-authorities, and the follow-up mission also made one new recommendation and two new suggestions in the report.

Hungary plans to invite the next IRRS mission in 2025, in line with the provisions of the Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations, according to which each EU Member State shall perform a self-assessment at least every 10 years and invite an international review mission to assess the results.

3.9. Human resources of the HAEA

Based on the study made by the HAEA on the professional knowledge and staff number needed for the regulatory licensing and construction oversight tasks regarding the new units, and for taking over the new tasks and competences, the Government granted the HAEA with the possibility to recruit a significant number of new staff members in 2015. The employment of new staff members was facilitated by the amendment to the Act on Atomic Energy in 2015.

Independently of the construction of the new Hungarian nuclear power plant units, the HAEA shall flawlessly perform the oversight of the existing 4 electric power generating units, the other three nuclear facilities and the waste repositories, which implies an increasing burden due to the ageing of facility equipment and the oversight of the consequent equipment replacements, modernization projects and ageing management processes. This should also be taken into account during the trainings of the professionals.

The number of staff at the HAEA increased by 98 between 2015 and 2018, at the time of the closure of this report it is 175 and hiring of a further 31 employees is possible.

3.10. ConvEx-3 nuclear emergency response exercise

On 21 and 22 June 2017, Hungary played the role of the accident country and simulated the basic event during the ConvEx-3-2017 international nuclear emergency response exercise. The basis of the exercise was an emergency evolved from an assumed nuclear power plant accident. The exercise was special among the ConvEx exercises, since the IAEA declared it the biggest ever exercise in its history based on the number of participating Member States and international organizations (83 Member States, 11 international organizations). Another speciality of the exercise was the simulation of a multi-unit event at the nuclear power plant for 36 hours in real time and then, after a jump in time, the protective actions of the late phase could be practiced. It was also first of a kind that it included real laboratory measurement tasks, within which 121 laboratories of 41 countries implemented measurements of contaminated water samples (21 laboratories participated in Hungary).

The laboratories of the National Food Chain Safety Office (hereinafter referred to as NFCSO) also participated in the exercise. In relation to nuclear emergency response the personnel and instrumentation of the laboratories, organization of continuous work performance and the possibility of its ordering were surveyed. Based on the fall-out maps obtained via the run of dispersion models the sampling areas were determined for the contamination survey, and simulated results were

reported to the National Environmental Radiological Monitoring System (hereinafter referred to as NERMS).

In line with Principal 2 of the Vienna Declaration, the HAEA pays special attention to the survey of its own and the national nuclear emergency preparedness and the development of safety culture. The ConvEx-3 and other similar national and international exercises contribute to modelling the cooperation among several organizations under directed conditions. Evaluation of the exercises and using the experience are of outmost importance for the development of the procedures and provisions.

3.11. Integration of regulatory tasks

Provisions of Act VII of 2015 on the investment for maintaining the capacity of Paks NPP and the amendment to certain corresponding acts, related to the transformation of radiation protection scope of tasks and regulatory system entered into force on 1 January 2016. These provisions determine the scope of radiation health and radiation protection tasks.

The issues affecting radiation protection of those using radiation health and other health services first remained under the scope of competence of the Capital and County Government Offices, later on 1 April 2017 the radiation health related tasks were transferred to the Budapest Capital Government Office.

The tasks related to the radiation protection of employees and the public are performed by the HAEA from 1 January 2016. HAEA cooperates with other institutes and organizations by involvement of experts to support its decisions. The objective to transfer the competences to the HAEA was to ensure a single authority to oversee the nuclear safety, radiation protection and security of the peaceful use of atomic energy.

As a new task, from 1 January 2016, the HAEA proceeds as the general construction authority and general construction oversight authority, since certain new provisions of the Govt. Decree 112/2011. (VII. 4.) on the scope of authority of the HAEA in relation to European Union and international obligations in connection with atomic energy, on the designation of co-authorities contributing to the regulatory proceedings of the HAEA, and on the scientific council facilitating the work of the HAEA, related to the construction and construction oversight regulatory competence for existing or planned non-specific (hereinafter referred to as general) building types on real estates affected by the safety area of nuclear facilities and radioactive waste repositories entered into force on 1 January 2016.

From 1 August 2016, based on the authorization of Govt. Decree 184/2016 (VII. 13.) on the detailed rules of verification of skills and registration of civil engineering-technical experts, civil engineering designers, technical building inspectors and responsible construction supervisors of buildings and structures under the scope *of the* Act on Atomic Energy, *and on the rules for data content of the registration it is also a task of the HAEA in relation to nuclear facilities and radioactive waste repositories to verify the ability of and register those civil*

engineering professionals who have experience on civil engineering design, implementation and inspection.

A. GENERAL PROVISIONS

4. Implementing measures

Convention on Nuclear Safety, Article 4:

> *„Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention."*

Hungary was one of the first states to sign the Convention on Nuclear Safety. The Convention on Nuclear Safety was promulgated in the Act I of 1997, so the Convention entered into force on 24 October 1996 for Hungary.

5. Reporting

Convention on Nuclear Safety, Article 5:

> *„Each Contracting Party shall submit for review, prior to each meeting referred to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention."*

This *Eighth* National Report has been compiled in accordance with the requirements of the Convention and the "Guidelines Regarding National Reports under the Convention on Nuclear Safety – *INFCIRC/572/Rev.6*" together with the recommendations based on the conclusions of the Seventh Review Meeting (2017).

In line with the letter of December 2018 of the President of the 8th Review Meeting, the compliance with the principles of the Vienna Declaration in Hungary is separately indicated.

The National Report, following the order of the Articles of the Convention, includes:

- fulfilment of general provisions, and description of existing nuclear installations, mainly Paks NPP as this falls under the scope of the Convention;
- characteristics of Hungarian legislation and regulations, and the role of the Authority;
- general issues of safety (including the state of financial and human resources, quality management system, radiation protection and emergency preparedness); and
- overview of the safety status of the only Hungarian nuclear installation that falls under the scope of the Convention.

The report contains the status of the only nuclear facility, the Paks NPP that falls under the scope of the Convention, however, in Section 6 the other 3 nuclear facilities operating in Hungary are mentioned, and in Annex A5 the milestones of construction of Unit 5 and 6 planned in the frame of maintaining the capacity of the Paks NPP. With regard to maintaining the capacity, safety aspects of the planned units are presented in all relevant sections.

6. Existing nuclear installations

Convention on Nuclear Safety, Article 6

> *„Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact."*

6.1. The Paks NPP

The scope of the Convention covers the four operating units of the Paks NPP. The units were commissioned between 1983 and 1987 and are currently in good technical condition. *Their planned shutdown after their lifetime extension that took place in recent years is expected between 2032 and 2037.*

MVM Paks NPP Ltd. is a company being in indirect state ownership. As of 14 May 2015, 100% of the shares are held by the MVM Hungarian Electricity Ltd., within a competence transferred by the state to it.

6.1.1. Technical data of the Paks NPP

The main technical data of the units of the Paks NPP are summarized in Table 6.1.1

Table 6.1.1. Main technical parameters of reactor units of the Paks NPP

Reactor type	Pressurized-water, water-cooled, water-moderated power reactor, type: VVER-440/V-213
Thermal power of the reactor	1485 MW
Electric power output of a unit	*508.6 MW; 504.2 MW; 500 MW; 500 MW*
Number of primary loops per unit	6
Volume of the primary circuit	237 m^3
Pressure in the primary circuit	123 bar
Average temperature of the primary coolant	284 ± 2 °C
Height/diameter of the pressure vessel	11.8 m and 4.27 m
Average enrichment of the fuel	3.82-4.7%
Fuel quantity per unit	44 tons of uranium in 349 fuel assemblies
Number of turbo-machine groups per unit	2
Pressure of secondary circuit main steam line	43.15 bar

MVM Paks NPP Ltd. operates 4 pressurized-water nuclear units of the type VVER 440/V 213; both the moderator and the coolant of the reactors are light water. (On the basis of its safety philosophy, the Paks NPP belongs to the group of second-generation VVER-440 nuclear power plants.) The reactor has 6 cooling loops, each one is connected to a steam generator. Each power plant unit is supplied with a so-called localizing tower (operating on the bubble condensing principle) connected to airtight compartments for handling any incidents caused by pipe ruptures. In these towers, trays filled with water containing boric acid are layered one above the other, completed with air traps. This system of hermetic compartments and localizing towers makes up the containment for the reactors.

Each unit is installed with 3 active safety systems, and in case of incidents their electrical supply might be ensured by diesel generators. These systems are supplemented by passive systems. Two saturated (wet) steam turbines operate in each unit. The original nominal thermal power of each unit was 1375 MW, and the nominal electric power outputs of each unit were 440 MW. As a result of the power uprating programme realized between 2006 and 2009, the thermal power of each unit has increased to 1485 MW and the electric power to 500 MW. *Within the reporting period modernization of high pressure housing of the turbines took place in Unit 1 and 2 that resulted in further increase in the electric power output of the units.*

The designers of Paks NPP chose the so-called twin-unit version. The turbine hall is common for the four units and the reactor halls each shared by 2 units enable common use of high value maintenance equipment. At the same time, the main components and safety systems of the units are independent of each other. The only exception is the safety cooling water system, where the pressure line

at the water intake station from the pumps to the pressure-equalizing tank is shared by two units.

Taking advantage of a common site and adjacent location of units, the supply systems were designed to be shared by the whole power plant.

6.1.2. Safety reviews

The Hungarian regulatory body, namely the HAEA assesses the safety reports of the facilities from the licensing of construction, during the entire life cycle of the facilities.

The construction of a nuclear facility ends with the completion of the Final Safety Analysis Report (hereinafter referred to as FSAR), which describes the realization of the design basis and provides a basis for operation. This report shall be updated annually in the case of technical and organizational modifications.

Hungary, in line with Principle 2 of the Vienna Declaration, performs regular safety reviews, of which the PSR emerges together with the comprehensive regulatory inspections that tightly belong to it in thematics, and the international reviews of the licensee.

Periodic Safety Review

In Hungary, the *Act on Atomic Energy* provides for the conduct of PSRs, in the framework of which, in line with the recommendation of the IAEA, the technical status and safety level of the facility shall be reviewed every 10 years, in comparison with the technical solutions and safety requirements corresponding to the actual international requirements. During the review those conditions have to be identified based on the risk given from any non-compliance with the requirements which have to be fulfilled by the facility in the next 10 years. As an outcome of the review, in order to decrease the risk, the licensee has to implement safety improvement measures in the next cycle. *The authority publishes a guideline on the implementation of the PSR that incorporates both the national and international recommendations with the objective to guide the licensee on interpretation and the way of compliance concerning the PSR requirements.*

In the first part of the PSR the licensee evaluates the status of the facility and then prepares the PSR Report, which is evaluated by the HAEA in the second part of the review. The PSR is closed by a resolution, in which the HAEA orders the implementation of the necessary safety improvement measures.

In 2015, Subsection 14 (3) of the Act on Atomic Energy incorporated the competence that the HAEA as the nuclear safety authority may revoke or limit the scope of the operation license of the facility based on the PSR of the licensee and the findings of the regulatory evaluation of the PSR Report and the construction license of the spent fuel interim storage facility if it identified the change of conditions that had provided the basis related to *nuclear safety,*

security, safeguards and protection against ionizing radiation for the issuance of the license or the increase of the risk in its resolution. The nuclear safety authority may establish new conditions, other than the previous ones for the further operation of the facility, or in the case of the spent fuel interim storage facility for the extension, and may require obligations to the licensee, including the implementation of safety improvement measures.

The Paks NPP completed the 10-yearly due PSR between 2017 and 2018. The results are described in detail under Section 14.1.2.

Comprehensive inspections of the authority

The HAEA oversight system contains comprehensive inspections to be conducted by the HAEA every year based on the topics of the IAEA Safety Guide No. SSG-25 "Periodic Safety Review for Nuclear Power Plants". Based on the internal procedures of the HAEA, the comprehensive inspections should go through each PSR safety factor at least once every ten years between two PSRs.

In 2016, the HAEA, in accordance with its annual regulatory oversight programme, inspected the technical condition and operation of the Paks NPP. During the inspection the authority focused on survey of the technical condition of the facility, e.g. equipment qualification, maintenance of qualified state, implementation of in-service inspections, ageing management and maintenance issues.

The HAEA reviewed the status of technical modifications meant to maintain and improve the level of safety, attributes of safe operation and use of operating experience. The latter included the use of operational experience from other facilities and R&D.

Radiation protection inspection at the Paks NPP covered the topics of internal exposure, qualification and maintenance of radiation protection instrumentation, supervision of protective equipment and activities posed to radiation and dose planning.

The authority identified 19 non-compliances during the inspection, for which the the Paks NPP provided an action plan and an implementation schedule. The HAEA finally identified 21 actions in its resolution which were meant to be completed before the next comprehensive inspection, at latest within 2 years.

The comprehensive inspection of 2017 addressed the following topics: organizational change, ageing management of civil structures, maintenance effectiveness monitoring (hereinafter referred to as MEM) and the use of PSA-based risk monitor in the Paks NPP. MEM, as a pillar of lifetime extension, has been under continuous development to achieve a better compliance with the national and international requirements. Ageing management programme of the main building and the auxiliary building and its documentation was in compliance with the legal requirements, the status of the buildings and structures are continuously inspected, the necessary repairs are performed under regulatory oversight. During the comprehensive inspection, the organizational change of the Safety Directorate

of Paks NPP was also reviewed. The change was identified as a good practice, the efficiency of the organization, especially in the area of using operating experience, is extraordinary.

The comprehensive inspection of 2018 focused on radioactive waste management and safety analyses. During the inspection the authority identified some administrative non-compliances. Out of the non-compliances revealed, the HAEA ordered for the review of legal background of the procedures and modernization of the waste registration.

International reviews

The Paks NPP pays special attention to international reviews since the start of the operation. A list of international safety reviews is included in Section 19.7.

6.1.3. Targeted safety improvement actions

After the Fukushima accident, the MVM Paks NPP Ltd. conducted the TSR in 2011 in line with the EU requirements. Based on the evaluation made as an outcome of the TSR, at the end of 2012, the HAEA ordered the implementation of the developed safety improvement measures.

Until the end of 2015, 24 of the 46 TSR actions, while between 2016 and 2018 further 16 TSR actions were completed and closed by the HAEA. In the resolution closing the 2017 PSR process 6 actions remaining from the TSR were re-scheduled. Progress of the TSR and the National Action Plan together with the particular actions are described in Annex A7.

The 16 TSR actions closed between 2016 and 2018 are as follows:

- *Modification of electric supply of machine racks and travelling band screens (2016);*
- *In the case of earthquake, ensuring the necessary amount of demineralised water for cooling down of Units 3 and 4 and maintaining the cold state (2016);*
- *Flooding protection of the turbine hall and cable tunnels (2016);*
- *Evaluation of underground pipelines and cables endangered by settlement of the main building (2016);*
- *The arrangement for setting the boron concentration of water inventories from external alternative source (2018);*
- *Construction of alternative water supply of the spent fuel pool (2018);*
- *Ensuring emergency electric power supply for bank filtered well station (2016);*
- *Ensuring the usability of joint Unit 3 and 4 fire water pumps in accident situation to obtain water supply from the discharge canal (2018);*
- *Severe accident management guideline for simultaneous severe accident of the reactor and the spent fuel pool (2018);*
- *Seismic reinforcement of the shelters and their equipment (2018);*
- *Elaboration of use of external coolant supply opportunities (2016);*

- *Modification of the Protected Command Centre and its preparation for multi-unit emergency (2016);*
- *Software based severe accident simulator (2018);*
- *Radioactive waste management procedures for severe accident situations, including release routes and monitoring (2016);*
- *Ensuring resistance of equipment endangered by electromagnetic effects (2016);*
- *Analyse of building settlement and soil liquefaction, determination of safety margins (2016).*

The actions and modifications in response to the non-compliances of higher safety risk identified during the TSR were completed by the end of 2018. Consequently, the core damage frequency extent from internal initiating events decreased by more than one magnitude compared to the assessment in 2011.

It was known that the resolution requiring the TSR actions would lose its validity on 15 December 2018, so an agreement was made between the MVM Paks NPP and the HAEA during the regulatory inspection in 2018. According to the agreement the new deadlines of the tasks not accomplished until that date will be included in the resolution closing the PSR process of Units 1-4. If it can be justified by analysis that the higher safety risk state due to delay of the tasks means an acceptable risk, the authority would approve the new, modified deadlines.

The following remaining TSR actions were re-scheduled in the resolution closing the PSR:

- *Seismic reinforcement of the fire brigade barrack (2021);*
- *Installation of severe accident diesel generators (2021);*
- *Construction of protection against containment over-pressurization (2021);*
- *Construction of a Backup Command Centre equivalent with the Protected Command Centre (2022);*
- *Development of wireless communication that can be used in each operational state (2021);*
- *Installation of informatics mirror storage computers at the Backup Command Centre (2022).*

6.1.4. Lifetime extension of the Paks NPP

The owner of the Paks NPP declared, as a strategic goal in 2001, to extend the original design lifetime of 30 years of the Units 1-4 by an additional 20 years, following a study of lifetime extension and its economic feasibility. This strategic goal, after the specification of necessary tasks and preparatory works, was confirmed by an assembly resolution of the owner, based on which the MVM Paks NPP Ltd. launched the project aimed at founding and licensing lifetime extension.

In the framework of the lifetime extension project, the MVM Paks NPP Ltd. performed the two major tasks for licensing: it prepared and founded the

environmental license application for lifetime extension and elaborated and founded the programme with the intention of creating the conditions for the planned lifetime extension.

The HAEA has verified the programme and its attached documentation and has not identified any deficiency which would have excluded the possibility of lifetime extension.

From 2010, the lifetime extension implementation programme was conducted to establish the conditions required in the lifetime extension programme and its regulatory assessment. The tasks were related to modification of technical practices of the Paks NPP. The time span of the implementation project was between 2010 and the end of 2018 when the new operation license of Unit 4 was granted.

Licensing of lifetime extension for the units was performed by the HAEA based on the license applications submitted for each unit separately. The license application had to demonstrate that the lifetime extension programme described in the lifetime extension documents assessed and supplemented with requirements by the HAEA was successfully completed, so the given unit is prepared to operate during the extended lifetime.

In the licensing processes the HAEA stated that:

- *Basic principles of lifetime extension are met: safe operability shall be continuously maintained, safety margins shall not be used during the lifetime, maintenance of the technical conditions shall commence during the design lifetime and performed continuously;*
- *The technical condition of the safety class components (including the building structures) makes lifetime extension possible;*
- *Revalidation of safety analyses with a view of 30 years of operation to 50+10 years of extended lifetime was completed and the calculated core damage frequency (CDF) increase is acceptable or, wherever it was not possible to demonstrate the extendibility of the analysis, the licensee planned appropriate actions;*
- *Activities meant to maintain the required state of the safety class components (e.g. ageing management, maintenance, availability of spare parts, use of operating experience, maintenance of qualified state, reconstructions) are adequately performed by the licensee;*
- *Decided safety improvement actions (including measures to prevent their consequences and mitigate accident situations) are performed in proportion to the length of time, and as a result the management of events within the design basis and the design extension conditions are ensured;*
- *Operational limits and conditions, if met, ensure safe operation;*
- *Financial and human resources are ensured for the safe long term operation;*
- *Disposal of spent fuel and radioactive waste expected to be generated during the extended lifetime is ensured;*
- *Document modifications necessary due to lifetime extension were completed, the in-service inspection, management, emergency operating*

procedures, severe accident management guidelines and the emergency preparedness and response plan are adequate to achieve the goals included.

The HAEA granted the operation license on 17 December 2012 for Unit 1 of the Paks NPP, the operation license for Unit 2 on 24 November 2014, the operation license of Unit 3 on 19 December 2016 and the operation license of Unit 4 in 19 December 2017. The lifetime extension project achieved the set objective, so it was closed on 31 December 2018.

6.2. Spent Fuel Interim Storage Facility

In order to store the spent fuel assemblies removed from reactors of the Paks NPP for an interim period of 50 years, a modular type dry storage facility operates on a site adjacent to the site of the plant.

The holder of the operating license of the Interim Spent Fuel Storage Facility (hereinafter referred to as ISFSF) is the Public Limited Company for Radioactive Waste Management (hereinafter referred to as PURAM).

The modules that are capable of storing fuel assemblies can be extended in a modular system. The positioning of modules in a row allows *the use of* a common reception building and loading equipment. Spent fuel assemblies are stored individually in vertical tubes in the storage building. In order to prevent corrosion during long-term storage, the storage tubes are filled with nitrogen gas and are placed in vaults surrounded by concrete walls. The removal of residual heat generated by irradiated fuel takes place by natural flow of air through the vaults and the connected stack system. This cooling process is self-regulating. The cooling air does not come into direct contact with the fuel assemblies as they are in a hermetically sealed environment.

A comprehensive, regular review of safety of the facility according to a determined programme is the PSR to be performed every 10 years. Decision is made upon the PSR about the conditions for further operation of the ISFSF. In 2017, the PURAM performed the due PSR of the ISFSF, which basically served the demonstration that the technical condition of the facility, the nuclear safety related criteria, also taking into account the ageing mechanisms, environmental conditions and operating experience, are in compliance with the design basis, legal requirements and international good practice. The licensee submitted the PSR report to the HAEA, which contained the results of the review, non-compliances influencing the safety of the facility and the programme of safety improvement actions. Based on the report, in 2018, the authority finalized the review by a resolution and ordered the implementation of the actions. The obligations (with deadline of March 2022, the latest) were aimed at preparation or revision of supporting analyses and taking administrative measures. One of the actions is the review of design basis of the ISFSF based on evaluation of impact of climate change on the meteorological conditions and extremes.

During the reporting period, the latest extension of the ISFSF with the vaults No. 21-24. had been completed. After commissioning of these vaults in 2018 as licensed

by the HAEA, the licensing of operation of the extended No. 1-24. vault ISFSF took place. In harmony with the future storage needs, construction of a module containing further 4 vaults is in preparation. The storage facility contained 9307 spent fuel assemblies at the end of 2018.

6.3. Budapest Research Reactor and Training Reactor of the Budapest University of Technology and Economics

Although these reactors do not belong to the scope of the Convention, they are considered worth mentioning here.

6.3.1. Budapest Research Reactor

The Budapest Research Reactor operated by the Energy Research Centre of the Hungarian Academy of Sciences (hereinafter referred to as HAS CER) was built in 1959 and its full reconstruction was carried out between 1986 and 1993. After its reconstruction, the PSR of the Budapest Research Reactor was first completed in 2003 and then in 2013. Based on the results of nuclear safety reviews, the HAEA issued a license for further operation and for performing activities described in the Final Safety Analysis Report. The operating license is valid until 15 December 2023.

Main technical data of the reactor:

- tank-type reactor, the tank is made of aluminium alloy;
- coolant and moderator: light water;
- nominal thermal power: 10 MW;
- fuel: VVR-M2 LEU, 19.75% enrichment.

The conversion from high enriched (HEU) to low enriched (LEU) fuel assemblies was completed between 2009 and 2013. After the test campaign closing the conversion in 2013, the Budapest Research Reactor has been operating with LEU fuel. The spent and unused fuel assemblies and other high enriched nuclear materials were repatriated in several stages to the Russian Federation between 2008 and 2013 in the framework of the Global Threat Reduction Initiative financed by the United States of America.

6.3.2. Training Reactor of the Budapest University of Technology and Economics

The reactor operated by the Institute of Nuclear Techniques at the Budapest University of Technology and Economics was built in 1971 for training and research purposes. The current operating license of the Training Reactor *that was granted by the HAEA in 2017 based on the results of the PSR, is valid until 30 June 2027.*

Main technical data of the reactor:

— pool-type reactor;
— coolant and moderator: light water;
— nominal thermal power: 100 kW;
— fuel: EK-10, 10% enrichment.

B. LEGISLATION AND REGULATIONS

7. Legislative and regulatory system

Convention on Nuclear Safety, Article 7:

> *„1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*
> *2. The legislative and regulatory framework shall provide for:*
> *(i) the establishment of applicable national safety requirements and regulations;*
> *(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a license;*
> *(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licenses;*
> *(iv) the enforcement of applicable regulations and of the terms of licenses, including suspension, modification or revocation."*

7.1. The Act on Atomic Energy

The Hungarian Parliament approved the Act on Atomic Energy in December 1996 which entered into force on 1 July 1997. The Act on Atomic Energy as amended several times considers all regulatory-related and operational experience gained during the construction and operation of the Paks NPP, the technological development, all international obligations, and obviously integrates the requirements of the Convention on Nuclear Safety. The main criterion and key point of this is reflected in the quoted provision: "In the use of nuclear energy, safety has priority over all other aspects". The Act on Atomic Energy complies with the European Union legislation and the recommendations of the IAEA and the OECD NEA. The main characteristics of the Act on Atomic Energy are as follows:

- declaration of the overriding priority of safety;
- definition and allocation of tasks of ministries, authorities and public administration organizations in licensing and inspection procedures;
- delegates the facility-level licensing tasks of nuclear facilities to the HAEA;
- declaration of the organizational and financial independence of the HAEA;
- declaration of the need for utilizing human resources, education and training, research and development;
- definition of the responsibility of the licensee for all damage caused by the use of nuclear energy, and fixing the sum of indemnity in accordance with the Revised Vienna Convention;
- giving the right to the authority to impose fines, should rules be violated.

7.2. Legislative and regulatory system

7.2.1. Implementation of the Act on Atomic Energy

Implementing decrees including government decrees and ministerial decrees contain the detailed provisions to implement the requirements of the Act on Atomic Energy (see details in Annex A5).

During the period of 2016-2018 the following relevant laws (and law amendments) entered into force:

Acts and amendment acts

- *Act CV of 2016 on the promulgation of the modifications in 2015 and 2016 of the Convention concerning International Carriage by Rail (COTIF) and its annexes in unified structure;*
- *Act LXXXI of 2016 on the amendment of certain energy related acts;*
- *Act CXLIII of 2016 on the amendment of energy related acts;*
- *Act CL of 2016 on general public administration procedure;*
- *Act I of 2017 on public administration judicial procedure;*
- *Act L of 2017 on the amendment of certain acts associated with the entering into force of the acts on general public administration procedure and on the public administration judicial procedure;*
- *Act LXXV of 2017 on the amendment of energy related acts;*
- *Act CCVIII of 2017 on the amendment of certain energy related acts and certain associated acts;*
- *Act XLV of 2018 on the amendment the Act CXVI of 1996 on Atomic Energy;*

Government decrees and their amendments

- *Govt. Decree 184/2016. (VII. 13.) on the detailed rules of verification of skills and registration of civil engineering-technical experts, civil engineering designers, technical building inspectors and responsible construction supervisors of buildings and structures under the scope of the Act on Atomic Energy, and on the rules for data content of the registration;*
- *Govt. Decree 379/2016. (XII. 2.) on the amendment of certain government decrees associated with the review of central offices and reinforcement of settlement (capital district) offices;*
- *Govt. Decree 382/2016. (XII. 2.) on designation of organizations fulfilling regulatory tasks associated with traffic administration tasks*
- *Govt. Decree 385/2016. (XII. 2.) on fulfilment of public health tasks of the capital and county government offices and settlement (capital district) offices, and on the designation of health state administration body;*
- *Govt. Decree 225/2017. (VIII. 11.) on the amendment of Govt. Decree 112/2011. (VII. 4.) on the scope of activities of the HAEA in connection with its international obligations including the European Union, the assignments of its co-authorities, penalizing rights, and on the Scientific Committee assisting the HAEA's activity and Govt. Decree 118/2011. (VII.*

11.) on the nuclear safety requirements for nuclear facilities and the corresponding HAEA regulatory activities;

- *Govt. Decree 179/2017. (VII. 5.) on the promulgation of the Annex of Appendix C of the Vilnius Protocol of 3 June 1999 amending the Convention concerning International Carriage by Rail (COTIF), and on certain issues related to its application within Hungary;*
- *Govt. Decree 489/2017. (XII. 29.) on the general and specific rules of fire protection authority procedures;*
- *Govt. Decree 532/2017. (XII. 29.) on supplementary procedural rules of the aviation authority;*
- *Govt. Decree 457/2017. (XII. 28.) on the amendment of certain government decrees related to the entering into force of the act on general public administration procedure;*
- *Govt. Decree 27/2018. (II. 28.) on the amendment of certain government decrees associated with atomic energy;*
- *Govt. Decree 70/2018. (IV.9.) on the amendment of certain government decrees associated with atomic energy;*
- *Govt. Decree 94/2018. (V. 22.) on tasks and competences of members of the Government.*

Ministerial decrees and amendment ministerial decrees

- *Decree 4/2016. (III. 5.) of the minister of national development on the fees to be paid for certain public administration procedures and administration services of the Hungarian Atomic Energy Authority;*
- *Decree 2/2016. (I. 15.) of the minister of human resources on the amendment of certain ministerial decrees related to the entering into force of the government decree on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system;*
- *Decree 89/2016. (XII. 29.) of the minister of agriculture on the amendment of ministerial decrees on certain environmental protection and nature conservation, forestry, fishery and hunting related to the review of central offices and background organizations of ministries operating as a budget organization;*
- *Decree 49/2017. (XII. 21.) of the minister of national development on designation of the entity exercising the owner rights and assuming the responsibilities over Paks II Nuclear Power Plant Private Company Limited by Shares;*
- *Decree 52/2017. (XII. 22.) of the minister of national development on the promulgation, amendment and annuling certain ministerial decrees associated with energy related to the entering into force of the act on general public administration procedure and for other purpose;*
- *Decree 4/2018. (VII. 5.) of the minister of innovation and technology on the amendment of certain ministerial decrees related to atomic energy;*
- *Decree 6/2018. (VII. 19.) of the minister of innovation and technology on the amendment of the Decree 55/2012. (IX. 17.) of the minister of national development on special professional and training of employees of nuclear*

installations, and on the scope of professionals authorized to perform activities related to the use of atomic energy.

Nuclear Safety Code (NSC)

The Act on Atomic Energy requires the regular revision and update of the nuclear safety requirements for the application of atomic energy taking into account scientific results and international experience. The relevant governmental decree stipulates the frequency as 5 years.

The Nuclear Safety Code contains the safety requirements for the use of atomic energy in reactor facilities in line with the NSD Directive, the Convention on the physical protection of nuclear materials, signed in Vienna on 17 June 1980, that was further developed based on the safety recommendations published by the IAEA in the last five years as well as the WENRA reference levels. The NSC is issued as annexes of the Govt. decree 118/2011. (VII. 11.), as follows:

- 1. Nuclear safety regulatory procedures of nuclear facilities;
- 2. Management systems of nuclear facilities,
- 3. Design requirements for operating nuclear power plants;
- 3a. Design requirements for new nuclear power plants;
- 4. Operation of nuclear power plants;
- 5. Design and operation of research reactors;
- 6. Interim storage of spent nuclear fuel;
- 7. Site survey and assessment of nuclear facilities;
- 8. Decommissioning of nuclear facilities;
- 9. Requirements for the design and construction period of a new nuclear facility
- 10. Nuclear Safety Code definitions

In addition to the continuous development of IAEA recommendations and WENRA reference levels the modification of the national regulations was performed more often than the required five year frequency. As a result of the review the amendments to the Govt. decree 118/2011. (VII. 11.) were issued in several steps.

The planned construction of new nuclear power plant units required the development of the Nuclear Safety Code Volume 3a on advanced technical requirements to be applied during the design of new units. Additionally, the HAEA reviewed and further developed the requirements for the design and construction periods.

During the periodic review and revision of the NSC the text of the following pieces of legislation in force had to be also taken into account:

- Act on Atomic Energy;

- Act CXL of 2004 on the general rules of administrative procedures and services (hereinafter referred to as Ket.), and *Act CL of 2016 on general public administration procedure (hereinafter referred to as Ákr.)*[5]*;*
- Govt. decree 118/2011. (VII. 11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities;
- Govt. decree 112/2011. (VII. 4.) on the scope of authority of the HAEA in relation to European Union and international obligations in connection with atomic energy, on the designation of co-authorities contributing to the regulatory proceedings of the HAEA, and on the scientific council facilitating the work of the HAEA;
- Govt. Decree 246/2011. (XI. 24.) on safety area of nuclear facilities and radioactive waste repositories;
- Govt. Decree 247/2011. (XI. 25.) on the independent technical expert proceeding in the scope of the application of atomic energy;
- Govt. decree 190/2011. (IX. 19.) on the physical protection requirements for various applications of atomic energy and the corresponding system of licensing, reporting and inspection;
- Ministerial decree 55/2012. (IX. 17.) of the minister of national development on special professional education and training of workers employed at a nuclear facility, and the scope of those authorized to perform activities associated with the use of atomic energy;
- Ministerial decree 5/2015. (II. 27.) of the minister of interior on specific fire protection requirements related to the use of atomic energy and the method of their enforcement during the activities of authorities.
- *Govt. Decree 487/2015. (XII. 30.) on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system (hereinafter referred to as Svr.).*

As an effort to comply with principle 3 of the Vienna Declaration, during the revision of the NSC started in the second half of 2015, the HAEA overviewed the IAEA requirement and guide level publications revised after the Fukushima accident including those finalized but not yet published.

The following publications were considered:

- *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards / Series No. GSR Part 3;*
- *Safety of Nuclear Fuel Cycle Facilities / NS-R-5 (Rev. 1);*
- *Decommissioning of Facilities / GSR Part 6;*
- *Leadership and Management for Safety / GSR Part 2;*
- *Commissioning for Nuclear Power Plants / Series No. SSG-28;*
- *Criticality Safety in the Handling of Fissile Material / Series No. SSG-27;*
- *Safety Classification of Structures, Systems and Components in Nuclear Power Plants / Series No. SSG-30;*
- *Periodic Safety Review for Nuclear Power Plants / Series No. SSG-25;*
- *Use of External Experts by the Regulatory Body / Series No. GSG-4.*

[5] Ket. ceased to be in force on 31 December 2017, from 1 January 2018 provisions of the Ákr. shall be applied.

The following documents were revised by the IAEA to reflect the experience from the Fukushima accident:

- *Governmental, Legal and Regulatory Framework for Safety / Series No. GSR Part 1;*
- *Site Evaluation for Nuclear Installations / Series No. NS-R-3;*
- *Safety of Nuclear Power Plants: Design / Series No. SSR-2/1;*
- *Safety of Nuclear Power Plants: Commissioning and Operation / Series No. SSR-2/2;*
- *Safety Assessment for Facilities and Activities / Series No. GSR Part 4.*

Additional modifications were proposed based on the recommendations of the IRRS mission carried out in the first half of 2015 regarding further development of the regulations.

Several requirements have been modified during the revision in line with the IAEA requirements. Hungary introduced e.g. the concepts of fraudulent and counterfeit products. A requirement was also developed concerning these in NSC Volume 2: „2.6.5.0210. Targeted preventive, monitoring and corrective processes shall be developed and used to identify counterfeit and fraudulent products as special non-conformances in the management system".

The following important changes were implemented in the NSC:

- *Contents of the PSAR was more specified;*
- *Chapters related to the licensing of structures, buildings and elevators were revised;*
- *A new chapter on certification of capability of contractors was included;*
- *Requirements on development and operation of management systems were further specified;*
- *Requirements for design extension conditions were further specified;*
- *Content of the FSAR became more specified;*
- *Radiation protection related requirements were supplemented (decontamination, radiation protection programme, waste storage, Significant Radiation Hazardous Work, discharge control) in line with the amendment of the Svr.;*
- *Requirements for safety classification were further specified;*
- *Provisions for employees and maintenance were further specified;*
- *Requirements for the Final Decommissioning Plan were further specified;*
- *Requirements for the Decommissioning Safety Analysis Report were supplemented;*
- *Definitions were revised for harmony with IAEA recommendations;*
- *New definitions were also introduced: non complying product, counterfeit product, fraudulent product, hazard factor.*

During the revision it was concluded that the Hungarian requirements are in compliance with the IAEA safety standards.

7.2.2. Licensing procedure of facilities

The basic licensing principles of nuclear facilities and radioactive waste repositories, and the concerned authorities taking part in licensing processes are regulated by Chapter III of the Act on Atomic Energy.

Regarding a new nuclear power plant or a new radioactive waste repository the preliminary decision-in-principle of the Parliament is required for starting the preparatory work, whereas the acquisition of ownership of a nuclear power plant that is in operation or to transfer the right of operation the decision-in-principle of the Government is required.

In accordance with regulations in force, licenses shall be obtained from the authorities for all phases of the life-cycle (site survey and evaluation, site suitability, construction, expansion, commissioning, operation, shutdown, decommissioning) of a nuclear facility. Moreover, a separate license shall be obtained for all plant-level or safety-related equipment-level modifications. Within the licensing processes, technical aspects are enforced by the legally designated co-authorities, the statements of which shall be taken into account by the HAEA.

When the construction of a new nuclear facility is being considered, the precondition for issuing the construction license is the existence of an environmental protection license. According to the relevant European Union and international regulations the construction of a nuclear power plant shall be subject to an environment impact assessment.

Taking into account the environmental impact assessment submitted as an annex to the license application, the statements of the involved co-authorities and foreign authorities of participating states, as well as the public comments gained in Hungary and abroad, the environmental protection authority issues a resolution. In the case of a positive decision, the environmental protection authority grants the environmental protection license, which is a condition of the actual use of the environment (i.e. the start of construction and future operation).

During the nuclear safety licensing procedure of the facilities, including the modification of operation license of a facility, the HAEA, pursuant to the stipulation of the Act on Atomic Energy, conducts a public hearing, and makes its decision taking account of the public remarks and opinions. The license is effective for limited or unlimited time and might be granted with certain conditions. The license granted for limited period can be extended, if requested. The Act on Atomic Energy and the Ket. or the Ákr. allow appealing against the resolutions and decisions of the HAEA only in front of court.

7.2.3. Inspection and assessment

The Act on Atomic Energy stipulates that nuclear energy can be used only in the way defined by law, and the nuclear facility and the radioactive waste repository are under continuous regulatory oversight. An important tool of regulatory

oversight is inspection. The HAEA is obliged to check compliance with all regulations contained in laws and licenses, and the safety of the application of nuclear energy.

The HAEA is entitled to perform inspections either with or without an advance notice, should it be justified*, and to conduct a comprehensive inspection every year in the predefined topics*. The HAEA prepares an annual inspection plan*, in which it lists the planned inspections quarterly*. The HAEA operates a multilevel inspection system to continuously assess the safety performance of facilities falling under the scope of the Act on Atomic Energy. *The main elements of the inspection system are the 10-yearly PSR as specified in principle 2 of the Vienna Declaration, the annual comprehensive inspection and the inspections pertaining to licensing processes and modifications during the refuelling outages.*

In addition to the HAEA's inspection activities, the co-authorities taking part in the licensing procedures also perform separate regulatory inspections. Through cooperation agreements in cases that concern different competences, the authorities may perform joint inspections.

In order to ensure the overseen use of nuclear energy and to evaluate the activity of the licensee, the HAEA operates a reporting system. The reports are detailed so as to enable independent assessment, review and evaluation of operating activities and events that have taken place. The inspection of events affecting safety that have occurred during operation and the identification of causes and the implementation of measures in order to prevent their repeated occurrence is primarily the duty of the licensee. Any event affecting nuclear safety is required to be reported by the licensee to the HAEA in accordance with the regulations in force. On the basis of this notification and of the report prepared pertaining to the investigation carried out by the licensee (or based on the significance of the event independently of the licensee) the HAEA analyses and evaluates the event and initiates further actions if necessary.

The HAEA makes use of the evaluation results originating from various sources for assessment of the safety performance of the licensees.

In the case of the most important nuclear facility, namely the Paks NPP the HAEA, in addition to traditional evaluation techniques, applies the system of safety indicators developed on the basis of the IAEA methodology from 2001. The term "safety indicators" means such measurable parameters, which measure the safety performance of the organization and the human factor.

Based on the nuclear power plant experience gained, the HAEA established the safety indicator system for other nuclear facilities overseen by the HAEA. In order to extend its oversight capabilities, the HAEA has been applying the system to the SFISF, the Budapest Research Reactor and the Training Reactor of the Budapest University of Technology and Economics since 2005.

The safety indicators can be categorized into three major groups:

— attributes of smooth operation,

— safety characteristics of operation, and
— attributes of commitment to safety.

The accumulated statistical set of indicators provides the possibility both for comprehensive assessment and highlighting various issues. The HAEA annually assesses the safety performance of the licensees. The lessons learned from completed assessments are benefited during the organization of regulatory proceedings, e.g. during the elaboration of the annual inspection plan.

Consequently, the assessment takes into account the results of the safety indicator system in each facility. In addition to allow detecting potential safety issues in a timely manner, monitoring and analysing the safety characteristics of operation provide data for the oversight activity of the HAEA and may form the basis for regulatory actions.

7.2.4. Enforcement of legal mandates of the HAEA

Legal basis

The HAEA regularly inspects the compliance with the licenses, laws, provisions of the NSC and the safety code for radioactive waste repositories and the overall safety of the use of atomic energy. The HAEA promptly takes action or initiates action to eliminate any non-compliance that is observed.

In accordance with Subsection (2) of Section 9 of the Act on Atomic Energy, the continuous regulatory oversight of the HAEA shall be performed through:

— *licensing and approval decisions made in the frame of specific regulatory proceedings;*
— *regular assessment and evaluation of the operation of the licensees, and safety, security and exclusively peaceful use of atomic energy;*
— *continuous oversight and inspections conducted in the frame of specific proceedings, the implementation of inspection programmes related to modifications;*
— *conduct of enforcement proceedings ensuring the practical realisation of legal requirements and their implementing regulatory provisions.*

The Act on Atomic Energy requires that the HAEA shall regularly perform inspections, analyses and on-site examinations, and take or initiate measures to eliminate the observed non-compliances. The goal of the enforcement process and the implementing enforcement proceeding is to insist and support the timely detection, voluntary revealing and correction of non-compliances with provisions assuring the realization of safety, security and nuclear safeguards and from relevant requirements by the affected persons through enforcement measures. In order to continuously maintain the high level of safety, security and exclusively peaceful use, the HAEA intends, and if necessary forces that the clients (licensees) and all contributors under its responsibility (employee, contracted partner) take corrective measures, as soon as possible, in the case of non-compliances with legal requirements or regulatory provisions.

The HAEA can take the following enforcement actions in line with the above obligations in cases falling under its scope of competences to enforce the safe use of atomic energy and compliance with the requirements and provisions of laws, regulatory resolutions and other documents of mandatory effect:

- *a) warning (recorded verbal, written),*
- *b) requirement of supplementary conditions,*
- *c) imposing of public administrative fine,*
- *d) limitation of the licensed activity,*
- *e) suspension of the licensed activity,*
- *f) limitation of the time validity of the license,*
- *g) withdrawal of the license.*

In the case of non-compliance with the legal and regulatory provisions, the HAEA assesses the risk imposed by the non-compliance in order to determine whether an immediate action is required. The graded approach is applied for the determination of the corrective measures, taking into account that the safety importance of certain provisions is greater than of others, thus the impact of non-compliances entails different risks.

The enforcement process shall be based on the objective revealing of facts and risk assessment. The HAEA treats every case individually. The HAEA reviews the specific characteristics of the given case, in order to characterise the severity of the violation on the level corresponding to the importance of the given violation/non-compliance, and to direct the decision essentially towards eliminating the non-compliance.

The HAEA conducts the enforcement proceeding in accordance with the relevant provisions of the Ákr., the Act CXXV of 2017 on the sanctions for breaching public rules[6] and the Act on Atomic Energy.

The graded approach shall be applied in each phase of the proceeding, including the determination of the enforcement measure to be applied and the amount of potential fine to be imposed.

In the case of systems, processes and methods, the basis of the graded approach is that such measures and conditions are applied which are proportional to the risk of an unmanaged situation, the likelihood and potential consequences. In harmony with the provision of the act, the HAEA operates a system, which guarantees the realisation of this principle.

In addition to the above described legal consequences or separately, the HAEA may impose a public administration fine. All the circumstances of the violation shall be taken into account by the HAEA when imposing public administration fine and

[6] The Act CXXV of 2017 will enter into force on 1 January 2020. In the transition period, the provisions of the Act CLXXIX of 2017 on the interim rules for breaching public administration rules, and on amendment of certain acts and annulling of certain laws corresponding to the reform of public administration procedure.

determining its amount; especially the aspects during the breach of the rules and omission listed as follows:

- *Whether an extraordinary event, a nuclear emergency or a nuclear damage occurred;*
- *Whether an unauthorised removal or a successful sabotage occurred;*
- *How severe is the violation of requirements, provisions;*
- *Whether repeated violation occurred;*
- *Whether a behaviour inducing the violation or omission is attributable;*
- *Whether the violator or omitter showed a behaviour facilitating the measures aiming at eliminating the occurred condition or mitigating the consequences;*
- *The disadvantage caused by the violation, including the costs of the prevention, mitigation and recovery, and the extent of advantages reached by the violation;*
- *The reversibility of the disadvantages caused by the violation;*
- *The scope of those affected by the violation;*
- *The duration of the violating condition;*
- *The repetitiveness and frequency of the violating behaviour;*
- *The behaviour assisting and cooperating during the proceeding after the violation; and*
- *The economic influence of the violator.*

After careful consideration of all the circumstances, the amount of the public administration fine can be fifty-thousand HUF as minimum and three-million HUF as maximum.

The amount of the fine, imposed against the licensee of the nuclear power plant in a nuclear safety related regulatory proceeding, can be fifty-thousand HUF as minimum and fifty-million HUF as maximum.

The amount of the fine, imposed against the licensee of other nuclear facility in a nuclear safety related regulatory proceeding, can be fifty-thousand HUF as minimum and five-million HUF as maximum.

The amount of the fine, imposed against the licensee of a nuclear facility in the case of a regulatory proceeding initiated due to the violation of an obligation established in the laws on the application of nuclear safeguards according to the treaty on the non-proliferation of nuclear weapons decided by the XXII General Assembly of the United Nations on 12 June 1968, can be fifty-thousand HUF as minimum and five-million HUF as maximum.

Commitment of crime

Based on the Act XIX of 1998 on Criminal Procedure, the HAEA shall not have a right for deliberation and shall report to the police if a crime defined in the Penal Code is committed. Accusation and the measures to apply if necessary after an accusation shall be decided by the investigation authority or the court.

Regulatory experience on enforcement

The HAEA did not impose a fine between 2016 and 2018 to nuclear facilities falling under the scope of the Convention on Nuclear Safety, but imposed fines several times related to the use of radioactive materials.

8. Authority

Convention on Nuclear Safety, Article 8:

> *„1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
> *2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.*

8.1. HAEA

In the case of nuclear installations as defined by Article 2 of the Convention, according to the Act on Atomic Energy, the competent authority in Hungary is the HAEA. The HAEA is an organizationally and financially independent, central public administration body having its own competences and administrative acts, operating in the field of peaceful use of nuclear energy, under the supervision of the Government[7]. As of the closing of this report the minister responsible for innovation and technology supervises the HAEA as the minister designated by the Prime Minister.

The HAEA's scope of competence comprises nuclear safety licensing, evaluation and oversight of nuclear facilities falling under the scope of the Act on Atomic Energy, the regulatory oversight of radioactive waste repositories, the registration and control of radioactive materials, the licensing of transportation and packaging thereof, the licensing of nuclear exports and imports, the evaluation and co-ordination of research and development, the performance of tasks related to nuclear emergency preparedness on the site, the approval of the emergency response plans of nuclear installations, and international relations. Licensing, reporting and oversight activities related to physical protection relevant to the use of atomic energy also fall within the competence of the HAEA.

A new task from 1 January 2016 for the HAEA is the regulatory tasks related to radiation protection and, also from 1 January 2016, the HAEA proceeds as a

[7] The HAEA is a central a public administration body as a government office until 31 December 2018 according to Act XLIII of 2010 on central state administrative organs and on the legal status of government members and state secretaries, then from 1 January 2019 it is a central public administration body as a governmental main authority.

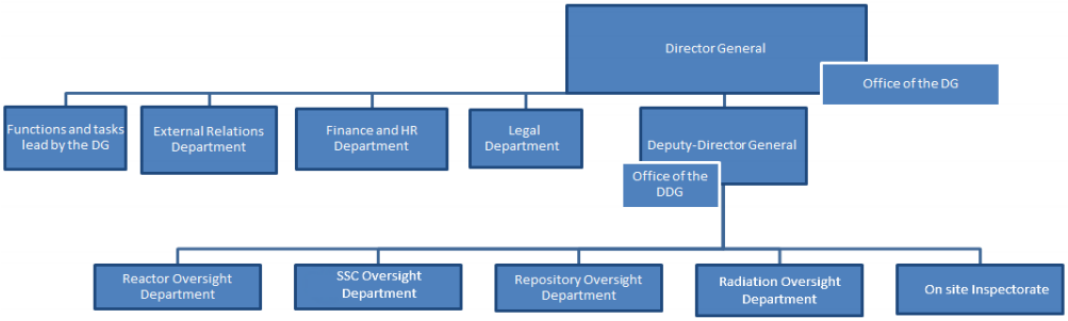
general building authority and general building oversight authority. From 1 August 2016 it is also a new task within the civil structure authority role to verify the skills and registration of civil engineering-technical experts.

It is also the duty of the HAEA to perform the tasks generated by the Agreement with the IAEA corresponding to the Treaty on the non-proliferation of nuclear weapons decided by the XXII General Assembly of the United Nations on 12 June 1968, including the accountancy for and control of nuclear materials.

In 2017 the HAEA developed a new OOR to prepare for licensing of new units and more effectively perform the new tasks. The departments fulfilling regulatory tasks were subordinated to the deputy director general in a thematic distribution of tasks, while the organizational units fulfilling operational tasks of the HAEA were subordinated to the director general.

The tasks of departments subordinated to the director general are maintaining the operation and information technology security of the HAEA computer hardware and software systems (Office of the DG), coordination of international relations and communication towards public (External Relations Department), the financial and human policy tasks of the HAEA (Finance and HR Department), the legal and administration support to fulfil the regulatory tasks, and the coordination of European Union matters (Legal Department).

Figure 8.1. HAEA organizational scheme from 2017



Departments subordinated to the deputy director general are as follows:

- *Reactor Oversight Department is tasked with facility level regulatory oversight of nuclear power plants and research reactors.*
- *SSC Oversight Department is tasked with regulatory oversight of systems, structures and components of nuclear power plants, research reactors, facilities for spent fuel interim storage and radioactive waste repositories.*
- *Repository Oversight Department is tasked with facility level regulatory licensing, inspection and assessment of nuclear safety and technical aspects of radiation protection of radioactive waste repositories.*
- *Radiation Oversight Department is tasked with the regulatory oversight of nuclear materials, radioactive materials, use and transport of equipment generating ionising radiation but not containing radioactive materials, and with general radiation protection regulatory oversight tasks.*

— *On-site Inspectorate is tasked with the operative regulatory oversight activities on the site.*

In the licensing procedures of the HAEA related to nuclear safety, the other competent administrative bodies take part as co-authorities and the regulations allow the involvement of professional experts (both institutions and individuals).

In accordance with the Act on Atomic Energy, the work of the HAEA is supported by a Scientific Council made up of nationally recognized individual experts.

8.1.1. Financial resources of the HAEA

Undisturbed operation of the HAEA is ensured from the budget support according to the actual act on the budget and from the regulatory oversight fee collected according to the Act on Atomic Energy.

- A specific sum shall be provided annually from the state budget:
  - to cover the costs of technical support activities assisting the regulatory work of the HAEA;
  - to cover the development costs related to the emergency preparedness and response activities; and
  - to cover the costs of the HAEA as a consequence of its international obligations.
- Licensees of nuclear installations and radioactive waste repositories are obliged to pay an oversight fee to the HAEA in the manner and to the extent defined in the Act on Atomic Energy.

Accordingly, the HAEA is currently financially independent of nuclear installations and its funding is sufficient for carrying out its duties efficiently. The income of HAEA from oversight fees shall be used exclusively for covering its operation, it shall not be used for any other purpose. The financial resources are used by observing the effective laws.

8.1.2. Human resources of the HAEA

94% of the employees of the HAEA have a higher education degree, 40% of which have two or three diplomas and 10% of which have a PhD or a university doctor title. 84% of the whole staff have state language exam from one or more languages.

The following table summarizes the change of staff at the HAEA and the number of employees acting in nuclear professional field within that between 2016 and 2018:

Year	*2016*	*2017*	*2018*
Total number of HAEA employees	*164*	*168*	*176*
Number of employees acting in nuclear professional field	*112*	*122*	*128*

Those employed by the HAEA may perform regulatory activities on their own, i.e. licensing, inspection and assessment according to the general rules of public administration, only if they pass an inspector's examination. The inspector's examination authorizes the employee of the HAEA to perform individual work. The exam terminates the whole introductory training process.

To acquaint the staff of the HAEA with the practices of the facilities, their training is done in the facilities mostly at the nuclear power plant or in the form which conforms to the training system of the facility. International courses are also integrated into the training along with "on-the-job training", which forms an integral part of the above-mentioned training system.

A plan using a systematic approach to training has been prepared by the HAEA for introductoryory and refreshing training of inspectors. The plan is based on individual training profiles and consists of three basic training types: introductory training, re-training, and advanced courses.

The basic principles governing the training system of the HAEA are as follows:

— learning is a continuous task to maintain the level of expertise and to acquire new knowledge;
— the most important value of the HAEA are the highly qualified humans; therefore it expects and urges the acquisition and maintenance of the work-related knowledge.

A knowledge management system was established to support the training system of the HAEA, which also appeared in the processes of the HAEA. Its development is continuous, one of its objectives is to facilitate the transfer of knowledge from the experienced colleagues to the new ones.

The HAEA prepared a study on the professional and staff demand for the regulatory licensing and construction oversight tasks required for the planned new units. The HAEA delivered the study to the concerned government organizations.

Based on this study, in 2015, the HAEA was provided with the opportunity to hire a significant number of new staffs with respect to the new units and the other new tasks (oversight of radioactive waste repositories and radiation protection). The staff of the HAEA was practically doubled by hiring 80 new employees. The opportunity to find new staff members was facilitated by an amendment of the Act on Atomic Energy in 2015 act that improved the salary conditions of the employees of the HAEA.

Today the staff number of the departments of the HAEA dealing with regulatory oversight of facilities is 130.

While a new nuclear power plant unit is constructed, the HAEA still shall perform the regulatory oversight of the existing four units along with the other three nuclear facilities and the waste repositories, which means an increasing work load required by the regulatory oversight of the ageing of nuclear equipment, equipment replacement, modernization projects and ageing

management procedures. All these shall be taken into account during the training of the professionals.

8.1.3. International relations of the HAEA

In accordance with the Act on Atomic Energy the HAEA is responsible for the coordination of international cooperation in the field of peaceful use of nuclear energy and for the fulfilment of tasks originating from the cooperation with international and intergovernmental organizations.

Among the international organizations being in contact with the HAEA the most important ones are the EU, the IAEA and the OECD NEA. The HAEA is a member of the Network of Regulators of Countries with Small Nuclear Programmes that was initiated by Switzerland, and the so-called Multinational Design Evaluation Programme of the OECD NEA. The HAEA actively participates in the work of the WENRA, the ENSRA, and the cooperation forum of the countries operating VVER type reactors (i.e. VVER Regulators Forum). The HAEA is a member of the ESARDA; additional important partners are the HERCA and the EACA.

The HAEA represents Hungary in the European Union Instrument for Nuclear Safety Co-operation programme and in the Euratom 7th Research Framework Programme for Research and Development.

Wide scope cooperation has been developed with the competent authorities and nuclear facilities of neighbouring countries. The HAEA maintains close professional links with the competent authorities of countries operating VVER reactors (Czech Republic, Finland, Russian Federation, Slovakia). In the framework of mutual information exchange agreements, the HAEA cooperates with the competent authorities of the Czech Republic, Slovakia, the United States of America, the Russian Federation, Ukraine, Slovenia, Austria, Croatia, Romania *and Serbia*. A direct link has been established with the Ministry of Environmental Protection of the Federal Republic of Germany in the framework of a scientific-technological cooperation, while close cooperation exists with Austria in the field of verification of software tools and methods used for dispersion calculations.

Currently, the HAEA has 12 MoU's with the nuclear authorities of other states (Russian Federation, Finland, USA, Slovakia, Romania, Czech Republic, Turkey, Republic of Belarus, Bulgaria, Morocco, Poland, Ukraine). Most recently, in 2016 the HAEA concluded MoU's with the Belarusian and Ukrainian authorities for the first time, in 2017 with the Moroccan and Polish authorities for the first time, and with the US authority for the second time, while in 2018 with the Bulgarian authority for the first time.

Additional bilateral relations are the bilateral international agreements concluded in the field of the safe use of atomic energy, where the HAEA also participates in the implementation.[8]

[8] The list of bilateral international agreements can be found on the website of the HAEA: https://www.haea.gov.hu/web/v3/OAHPortal.nsf/web?openagent&menu=04&submenu=4_8

In order to make the bilateral meetings more effective, the nuclear authorities of the Czech Republic, Hungary, Slovenia and Slovakia discuss the actual issues on mutual interest in quadrilateral meetings, while the series of annual bilateral meetings was continuing with Austria: *the twenty-fourth bilateral meeting was held on 15-16 October 2018.*

8.1.4. Communication policy of the HAEA

An important part of communication activity of the HAEA is the report on the safe use of atomic energy to be submitted to the Parliament annually, the preparation of which is the task of the HAEA. The HAEA informs the public on the most important information and relevant facts regarding the safe use of atomic energy in Hungary through its continuously updated Hungarian and English website (www.oah.hu), by organizing press conferences and publishing press releases.

The HAEA continuously strives for providing more and more comprehensive information to professionals and the general public, who show interest in questions associated with nuclear safety. As a part of this process, the HAEA periodically provides information on its resolutions by publishing their concise comprehensible summary. The list of resolutions is accessible on the website of the HAEA. An essential task of the HAEA is to inform the public about the nuclear safety related events that are worth public interest. Accordingly, the HAEA publishes on its website the events categorized as Level 1 or higher on the International Nuclear Event Scale (hereinafter referred to as INES), and the outcomes of regulatory investigations of other reportable events that are worth media interest. The HAEA keeps regular contact with the representatives of the media. Usually about fifty journalists participate in the annual press conferences of the HAEA.

In the end of 2013, based on the proposal of the HAEA, the Act on Atomic Energy was amended to facilitate transparency. Accordingly, the act regulates the procedures, when the HAEA shall hold public hearings. The public hearing provides the opportunity for the public and various organizations to be aware of the details of the given procedure and to present their opinions. *Altogether, 11 public hearings were organized between 1 January 2016 and the end of December 2018.*

The HAEA continued the several-year-long tradition that it organizes, together with the TIT Studio Association, "To everybody about atomic energy" conferences twice a year. The format of the event was completely renewed by 2017. The topics were better tailored to the demands of the audience, the interactive exhibition organized together with the event was modified and modernized involving new exhibitors, putting in focus the method of drawing attention via entertaining experiences, since it is by far more efficient and effective.

The HAEA strives for providing more information about its activity. The HAEA publishes every six months a Hungarian and an English summary (Bulletin) of its own activities and the actual professional news, which are also accessible on its website. In addition, the HAEA informs the public on the most important facts

associated with the safe use of atomic energy by organizing press conferences and publishing press releases.

The continuously developed internet-based information service is a part of the communication policy of the HAEA both via its own website and its Facebook page. In addition to other information materials National Reports are also accessible in both Hungarian and English.

8.1.5. Scientific technical background

Technical support organisations

During the regular technical support programmes of the recent years, the network of organisations supporting the regulatory work of the HAEA has been established.

The actual number of institutions in the network is almost 40, which the HAEA strives to expand with new organizations depending on the amount of regulatory tasks.

With the most significant institutions of the network (HAS CER, Institute of Nuclear Techniques at the Budapest University of Technology and Economics, NUBIKI Nuclear Safety Research Institute Ltd.) the HAEA concluded agreements for a more effective cooperation. In order to support the general building authority tasks that became part of the HAEA competence in 2016, the technical support network was extended with the institutions of the relevant area. In 2018, the HAEA concluded an agreement with the ÉMI Non-Profit Limited Liability Company for Quality Control and Innovation in Building (ÉMI Non-profit Llc.).

It can be concluded that the HAEA has appropriate technical background in each important professional area. The independence of the technical support organisations and experts is continuously checked via the opportunities provided by law, procedures and quality management systems.

According to the OOR of the HAEA approved in 2017, the administrative coordination of the contracts with the technical support organizations is subordinated to the DG Office. A new procedure was introduced that takes special account of excluding conflict of interests concerning internal and external players during contracting (e.g.: multi-level commenting and approval process, sub-contractors can be involved only with the preliminary consent of the HAEA and employment of further sub-contractors is forbidden).

The IRRS Follow-up mission in 2018 concluded that the HAEA had reinforced its control during the use of technical support organizations and external experts to exclude conflict of interest.

Technical support activity

The HAEA is responsible for the harmonization of the research and development activities in connection with the safety of peaceful applications of

nuclear energy, as well as for the financing of the technical activities providing basis for the regulatory oversight.

The strategic directions of technical support activities serving for the facilitation of the regulatory oversight of the safe use of atomic energy are established in the policy of the HAEA related to technical support activities, while the actual tasks are identified in the four-year programme. The priorities of technical support activities for the period of 2017-2020 were identified by the HAEA as follows:

- *direct support to the regulatory activity;*
- *technical-scientific support of regulatory work;*
- *support to the tasks connecting to the new units;*
- *management of expertise.*

Besides the priorities, it is important that the areas determined for the 4-year cycles are in harmony with the short-term needs of the HAEA, and that they contribute to supporting the regulatory work on the longer term, too.

The Hungarian-Russian Intergovernmental Agreement signed in 2014 on maintaining the capacity of Paks NPP has significantly influenced the directions of technical support activities for the period between 2017 and 2020. While in the previous cycle the analyses of experience gained from the Fukushima accident to use in the regulatory practice received a higher emphasis, in the new research cycle the analyses, research projects supporting the preparation for licensing the new units play a more important role.

Besides, the results of analyses and research developed in the given year, the HAEA organizes a seminar of a couple of days for the experts of technical support organizations, industrial and professional players, where they can obtain a picture about the research tasks of the HAEA and have an opportunity to discuss their professional views.

The HAEA, in addition to the technical support activities meant to support regulatory oversight, is a member of several other national and international research programmes, for example the Sustainable Atomic Energy Technology Platform (hereinafter referred to as SAETP) established following the example of a European initiative. It aims at coordinating the Hungarian research in the nuclear field. Since the SAETP research areas are in harmony also with the HAEA objectives, the HAEA supports several research activities in the framework of the SAETP, such as programmes related to the development of the tools of safety analyses, fuel research and modelling of certain thermo-hydraulics processes.

According to the decision of the Ministry for National Development (legal successor: Ministry for Innovation and Technology) in 2017 Hungary joined the European Joint Programme on Radioactive Waste Management initiated by the European Commission. The HAEA did not join the programme as an official participant, but in order to coordinate the research topics it keeps track of progress of the programme.

Hungarian Nuclear Knowledge Management Database

An important element of HAEA technical support activities is facilitate the maintenance of professional knowledge both within the HAEA and in the national industry. The HAEA therefore makes the research results available for the national technical community through the Hungarian Nuclear Knowledge Management Database (hereinafter referred to as HNKMD).

In 2010, on the initiative of the HAEA director general, the representatives of the leading organizations in the Hungarian nuclear field established the HNKMD by signing a cooperation agreement. The HNKMD takes it as main objective to collect and retain the documents of professional knowledge accumulated first of all in Hungary for the future generations, to promote information sharing within the nuclear community and to create an updated, common knowledge base. Operation of the HNKMD is the task of the HAEA. During the IRRS mission in 2015, the international experts performing the review recognized the establishment and operation of the HNKMD as a good practice on international level. The HNKMD already contains more than 10,000 documents.

8.2. Independence of the HAEA

The HAEA is a government office established by law, a central state administration organization working under the supervision of the Government[9]. It is overseen by the minister designated by the Prime Minister (*currently the minister responsible for innovation and technology*). The HAEA operates and deals with its budget independently; it is a state budget organization having chapter rights and individual title within the budget chapter of the ministry led by the minister overseeing the HAEA. The HAEA shall not be directed in the scope of its tasks established in an act, its decisions shall not be amended or annuled based on oversight right. The act determines that the HAEA overseeing the use of atomic energy shall be independent of any other organ or organization that has interest in the field of use or promotion of atomic energy. The above mentioned two, clearly and unambiguously formulated rules in the act guarantee its independent and uninfluenced decision making.

The financial resources of the HAEA are own revenues supplemented with state contribution as determined annually in the state budget. *The compilation of the resources did not change in the last three years. During the annual operation, if unplanned expenditure related to the regulatory tasks emerges, further resources can be requested during the planning phase of the budget.*

[9] The HAEA is a central a public administration body as a government office until 31 December 2018 according to Act XLIII of 2010 on central state administrative organs and on the legal status of government members and state secretaries, then from 1 January 2019 it is a central public administration body as a governmental main authority.

9. Responsibilities of the nuclear power plant as a licensee

Convention on Nuclear Safety, Article 9

> *„Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant license and shall take the appropriate steps to ensure that each such license holder meets its responsibility."*

The Act on Atomic Energy primarily makes the licensee responsible for the safe use of atomic energy and the fulfilment of safety related requirements. The basic responsibilities of the licensee are as follows:

- to ensure technical, technological, financial and personal conditions for the safe use of atomic energy, for maintaining and improving safety;
- to prevent the occurrence of an inadvertent and uncontrolled nuclear chain reaction;
- to prevent ionizing radiation or any other factor from causing any unacceptable damage to human life, health and living conditions of current and future generations, environment and material assets;
- to maintain the radiation exposure of employees and population to the level as low as reasonably achievable;
- to continuously monitor radiation conditions in accordance with the latest scientific results, international requirements and experience and to provide the population with regular, at least monthly, relevant information thereof;
- to keep the production of radioactive waste as low as reasonably achievable in terms of activity and quantity via appropriate design measures, operational and decommissioning procedures, especially via the reuse and reutilization of nuclear and other radioactive materials;
- to continuously carry out activities to improve safety, and to finance costs of the related research and development activities;
- to regularly revise and update internal regulations serving to fulfil the safety related requirements;
- to take into account the potential and limits of human performance from the aspect of safety throughout the entire lifetime of the nuclear facilities;
- to fulfil the obligations of Hungary arising from international agreements in the fields of peaceful use of atomic energy;
- to ensure that the qualifications, professional training and health conditions of employees meet the legal requirements;
- to hire only those subcontractors and suppliers that have an appropriate quality management system regulated by nuclear safety regulations;
- to ensure the financial coverage of civil liability (insurance) for nuclear damage;
- to appropriately manage extraordinary events, to ensure that the risk of occurrence thereof decreases, their occurrence can be prevented, their consequences can be managed as planned, the harmful effect of

potentially released radioactive material and ionizing radiation can be decreased to as low as reasonably achievable;
— to compensate within a limited time and under a certain amount for nuclear damage caused due to the application of atomic energy;
— to ensure the physical protection of the facility by armed guards, and to operate an effective physical protection system;
— to make regular payments into the Central Nuclear Financial Fund (hereinafter referred to as Fund) to cover costs related to the final disposal of radioactive waste, the interim storage of spent fuel, and the closure of the fuel cycle and in the case of nuclear power plant the decommissioning.

C. GENERAL SAFETY ISSUES

10. Priority to safety

Convention on Nuclear Safety, Article 10

> *„Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety."*

10.1. Safety policy of the HAEA

The various documents issued by the IAEA set the basic principles of safety. These are the principles which the HAEA follows and applies taking into account the fact that each country has to follow its own practice during the actual implementation. The "Safety Policy and the Operational Principles of the HAEA" is the basic document of safety policy and it is supplemented by the Enforcement Policy.

10.1.1. Objectives

The key objective of the HAEA's activities is to guarantee that the local population, the environment, and the operating personnel do not suffer any damage due to effects originating from ionizing radiation. The HAEA exercises its oversight activities in order to achieve these objectives; these oversight activities comprise licensing, inspection, assessment and the enforcement of regulations.

It is also an objective of the HAEA to constantly raise the standard of safety culture both for its own operation and for the organizations under its oversight.

10.1.2. Responsibility

The HAEA is responsible for licensing, inspection and evaluation of nuclear facilities, systems and components in order to enforce the full compliance of the licensee with the official requirements.

In order to achieve these goals, the HAEA shall be independent, competent and duly prepared; it shall clearly understand all processes under its oversight; and it shall be open towards the co-authorities and to the society as a whole. Every reasonable effort must be made to gain and retain the confidence of the public and it shall make itself and its objectives fully transparent to the public. The HAEA meets all the above requirements.

10.1.3. Basic principles

The functioning of the HAEA is regulated by the Government in accordance with the Act on Atomic Energy. The regulations governing the work and activities of the HAEA are all aimed at keeping risks to a minimum, but the principle of reasonably low risk should be kept in mind at all times.

It is the responsibility of the licensee to keep risks as low as reasonable. In the field of safety improvement measures, however, the HAEA should also set a priority list.

The HAEA in order to permanently sustain nuclear safety follows the principles below in its work:

- the primary task is to minimize the frequency of technical problems and human errors that are initiators of accidents.
- mitigation of any serious consequences originating from multiple failures is of second importance. To accomplish mitigation tasks, the importance and function of the various components in the process of accident evolution and the availability of systems suitable for mitigating interventions must be known.
- deterministic approach complemented with probabilistic approach shall be used to reveal technical problems and incorrect practice.

10.1.4. Practical side of the HAEA's work

The HAEA, when performing regulatory tasks:

- makes every effort to handle issues in a rapid and precise manner, but speed must never be allowed to jeopardize precision. If, for any reason, any uncertainty arises, the HAEA always decides in favour of greater safety;
- endeavours to weigh every issue according to its importance. importance is determined in relation to safety;
- takes the licensee's viewpoints into consideration as reasonable besides exquisite enforcement of the safety requirements;
- assesses the severity of incidents that may occur by processing them in a precise manner and utilizes the feed-back of experience gained in the operation process.

10.2. Safety policy of the MVM Paks NPP Ltd. as a licensee

Govt. Decree 118/2011. (VII. 11.) concerning the implementation of the Act on Atomic Energy obliges the licensee to elaborate a safety policy that lists the licensee's concepts and objectives related to safety and demonstrates in a convincing manner that the fulfilment of the principle of nuclear safety has priority over all other aspects.

The Safety Policy of the MVM Paks NPP Ltd. summarizes the main requirements in relation to the safety of the nuclear power plant and proclaims the principle of the priority of safety. It deals with particular methods of practical implementation only indirectly, since these are enforced through internal regulations, procedures, and instructions.

The Safety Policy has uniform and thorough validity over each organizational unit and employee of the nuclear power plant, and also over subcontractors. It stresses the importance of the general responsibility of the NPP's Chief Executive Officer and the particular responsibility of the Safety Director for ensuring the safety. The Safety Policy emphasizes the importance of the commitment to safety, the necessity of maintaining positive approaches to safety, the need to reveal those factors weakening safety, and to prioritize endeavours to improve safety culture. It also stresses the importance of training, information and feedback mechanism for enhancing safety.

MVM Paks NPP Ltd. reviews its Safety Policy on a regular basis to ensure its up-to-date status and correctness.

The management of the MVM Paks NPP Ltd. supports the delivery and comprehension of the defined requirements to the executors with a conscious communication. The requirements established in the Safety Policy are regular items on the agenda of the internal and external fora and communication forms (e.g. suppliers' day) with the suppliers and contractors. The MVM Paks NPP Ltd. has the necessary management, supervision and operational items and instruments to ensure compliance with the requirements formulated by the Safety Policy on the designated operational areas and functions.

10.2.1. Responsibility of the managers

The NPP's Chief Executive Officer is responsible for the proper and safe operation of the power plant as well as for quality. He is assisted by the Director of Safety who holds a transferred portion of rights of the competences.

The managers are responsible, within their respective organizations for the fulfilment and enforcement of safety requirements in addition to enforcement of the Safety Policy.

In order to define various tasks, responsibilities and competences together with rights, the NPP's Chief Executive Officer set up the regulation hierarchy defined in the Management System Manual. Job descriptions also outline the rights and competences.

10.2.2. Role of personnel in maintaining operational safety

All members of the operating staff hold qualifications and have had the necessary training for carrying out their particular function. Qualifying examinations are either performed within the plant in normal or advanced level plant exams or in front of representatives of the HAEA, depending on the

potential effect on safety of the particular position. Qualifying examinations should be repeated at regular intervals.

The training and qualification requirements for operating staff working in shifts and employed by the operating organizations are outlined in the Ministerial decree 55/2012 (IX.17.) of the minister of national development on special professional education and training of employees of nuclear installations, and on the scope of professionals authorized to perform activities related to the use of atomic energy and in the procedural orders describing the training activity.

Personnel doing shift work may transfer their responsibility to other individuals in a regulated manner only and under regulated circumstances, be it during normal operation or in the case of an incident.

As a part of the FSAR, in line with the nuclear safety requirements, the Paks NPP determined the so-called safety-related job positions, for which the requirements, training and qualifications requirements are specified.

The unit control room activities of non-shift personnel are also regulated. Direct intervention in the operation process can only be executed by those holding appropriate qualifications, and they can do so only if this is set out in their job descriptions and they are on shift according to the appropriate schedule. Other personnel are forbidden to intervene directly.

It is the task and responsibility of the maintenance staff to keep all power plant equipment in a reliable and operable condition. Maintenance of the nuclear power plant is an on-going process and follows a detailed, structured format with work instructions. An administrative instruction guarantees that only those works are carried out that are planned and well prepared and have received the appropriate licenses. Inspection and assessment functions are integrated into the work process in a way laid down in a procedural order.

The maintenance personnel is prepared in the same training system as the operating staff. The well-equipped Maintenance Training Centre of the nuclear power plant largely contributes to the preparedness of the staff.

It is the task of maintenance departments to maintain and, where necessary, reconstruct any given installation, to handle equipment failures and to prepare them for official inspections, to execute all welding and technological assembly work, and to carry out repairs and assist in production tasks at the NPP, together with the planning and providing of all safety-, human resource-, and material-related conditions necessary for such work.

The tasks of the technical support organization are as follows:

- development of safety analyses;
- preparation of reactor physics calculations;
- *preparation and coordination of the nuclear fuel cycle;*
- definition of the scope, time schedules and cycle times of technological tests;

- preparation, conciliation, review and modification of operating instructions, operating schemes, programming and scheduling of tests;
- *keeping records of technology tests and operation programs performed in a manner sufficiently detailed to prepare reliability and trend analyses on the basis of which conclusions can be drawn concerning the adequacy of components and systems;*
- preparation of and commenting on production regulations and the upgrading thereof within the required time intervals, along with keeping records of these;
- planning and preparation of refuelling outages, weekend maintenance and weekly operative works, together with the control and co-ordination of the accomplishment thereof;
- *development of maintenance, repair and failure response technology;*
- planning of in-service works and the definition of methods and conditions of implementation thereof;
- *development of lifetime management, ageing management programmes, maintenance of environmental qualification of equipment;*
- collection, arranging, recording and evaluation of data concerning refuelling outages;
- composition and time scheduling of service walk-down activities;
- ensuring the availability of appropriate documentation necessary for work performance, of appropriate documentation and archiving of work performed.

Activities performed by auxiliary personnel have no direct influence on safety.

10.2.3. Responsibility and safety related issues concerning the employment of external suppliers

On the premises of the NPP, on safety class systems, structures and components work may be performed only by external suppliers holding a valid qualification approved by MVM Paks NPP Ltd. External contractors are required to undergo re-qualification on a regular basis. Such qualifications are implemented following the requirements of the NSC and the internal procedures of the plant, under regular inspection by the HAEA. MVM Paks NPP Ltd. is responsible as auditor for lawfully carrying out the auditing and evaluating procedure and further to ensure that the conditions for qualification remain fulfilled.

The fulfilment of requirements of the Management System Manual – and of the more detailed internal regulations – is mandatory for all external organizations and suppliers performing work on the site of the nuclear power plant. The hiring organization inspects all work performed by a supplier by appointing a technical inspector for all work.

In the area of engineering services, analyses, calculations and assessments requiring professional knowledge are performed by research institutes, universities, or engineering offices. Co-ordination and inspection of outside work are carried out by the hiring organization.

10.3. Safety policy of Paks II Ltd. as a licensee

In line with the legal requirements the licensee shall prepare a safety policy, in which it shall declare the priority of safety over every other aspect during all activities related to the nuclear facility. The safety objectives need to be satisfied throughout the lifecycle of the nuclear facility (including the design, site selection, manufacturing, construction, commissioning, operation, final shutdown, decommissioning and closure, furthermore in relation to radioactive materials also the transportation and radioactive waste management). In line with that, Paks II Ltd., after obtaining the site survey and assessment license (14 November 2014) developed its safety policy.

For the continuous implementation of the measures needed to achieve the objectives declared in the safety policy, Paks II Ltd. established, operates and develops an effective management system. The fundamental safety objective of the management system is to achieve and maintain safety and to ensure the priority of safety over every other competing aspect.

10.3.1. Responsibility of the managers

The management identified those key factors and attributes that support a strong safety culture and takes care of sharing it with the employees and making the employees understand it. They provide regular training for the employees and created the opportunity for the employees to submit any safety related proposals, worries.

The management developed such management principles and supports such behaviours (also by setting an example) that promote the maintenance and continuous development of the safety culture.

Grounding and development of safety culture for Paks II Ltd. is a long term task (safety culture model based on interpretation of 2013 WANO safety culture principles for construction phase of new nuclear power plant units was approved in July 2017). The management is committed to the implementation of safety culture and its safety-conscious improvement and encourages the staff to express their safety related opinion and raise safety related questions.

10.3.2. Role of the employees

The management system creates a working atmosphere in which the employees could raise matters of safety concern without being apprehensive of persecution, punishment, intimidation, or discrimination.

The management of the Paks II Ltd. requires from the employees to show a responsible behaviour towards safety and with their acts, activities and decisions to maintain and reinforce safety, and to be prepared to question the prevailing practice if it endangers safety.

The employees get to learn and comprehend the safety effect and significance of their work. They perform all their activities and make all their decisions by keeping safety in mind.

10.3.3. Safety issues of employing external suppliers

In order to maintain the capacity of Paks NPP, Paks II Ltd. involves only contractor partners to the implementation of construction of the new units at the Paks site who are prepared, have high skills and professional experience and are acknowledged within the industry, whose professional applicability must be proven and audited according to the standards. In addition, during the selection of the partners, the preliminary examination of their capacity and assessment of their performance during their activities must take place via a qualification and evaluation process in light of safety requirements. Paks II Ltd. strives for constructive and proactive cooperation with the partners and institutes involved in the implementation.

11. Financial and human resources

Convention on Nuclear Safety, Article 11

> *„1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*
> *2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life."*

11.1. Financial resources

11.1.1. Financial resources of the MVM Paks NPP Ltd

The MVM Paks NPP Ltd. and the MVM Partner Power Trading Ltd. has concluded an electric power trading agreement. *The agreement provides the basis for the sale of the energy produced by the Producer to the Trader until 2022.*

The Act on Atomic Energy called for a Fund that was created in 1998 for financing the tasks related to final disposal of radioactive wastes and storage of spent fuel, closure of the nuclear fuel cycle, decommissioning of nuclear installations and to support the associations of municipalities established for monitoring and public information. Those users of atomic energy that generate radioactive waste or spent fuel during their activities are obliged to bear the costs of the waste management. The financial instruments of the Fund shall be used exclusively to finance these activities. The income side of the Fund consists

of the annual payments by Paks NPP Ltd., support from the central budget and other occasional incomes.

The manager of the Fund from 1 January 2014 is the ministry led by the minister assigned to oversee the activities of the HAEA (*currently the Ministry for Innovation and Technology*).

The tasks related to the management of wastes and spent fuel generated by Paks NPP and the decommissioning of the facility are summarized by an annually updated medium and long term plan as approved by the competent minister. This plan contains the costs arising with respect to the implementation of the above tasks. Paks NPP shall cover the costs through annual payments to the Fund evenly distributed over the entire service lifetime. The determination of the sum to be paid is performed by the method of net present value calculation, the point of which is that the present value of the future costs shall be equal to the present value composed of the sum from the Fund and the further payments of the MVM Paks NPP Ltd.

The payments performed by MVM Paks NPP Ltd. are meant to meet the demands raised by the tasks with respect to waste management, decommissioning and spent fuel management until 2084. The objective of the Fund is to provide coverage for financing these activities, thereby avoiding any unjustified financial burden on the future generations.

According to Law-Decree 24 of 1990 (II. 7.) on the ratification of the 1963 Vienna Convention on civil liability for nuclear damages signed May 21, 1963, pursuant to Subsection 52 (1) of the Act on Atomic Energy the absolute liability of the licensee of a nuclear power plant, nuclear district heating plant and a facility producing or processing nuclear fuel shall not exceed SDR (Special Drawing Rights) 100 million on each occasion of a nuclear accident arising in the facility, and SDR 5 million on the occasion of each nuclear accident arising in other nuclear facilities and in nuclear accidents arising during the transport or storage of nuclear fuel.

The nuclear damage in excess of the amount defined above shall be compensated by the State of Hungary; however, the total amount devoted to the compensation shall not be greater than SDR 300 million even in this case.

11.1.2. Financial resources of Paks II Ltd

Paks II Ltd. is the property of the State of Hungary in 100%. The owners' rights are exercised by the minister responsible for the design, construction and commissioning of the two new units of Paks NPP. The resources for the operation of the company and the construction of new units will be provided by the State of Hungary for Paks II Ltd.

11.2. Human resources

The Hungarian system of higher education offers a wide range of professional knowledge through the education of mechanical engineers, electrical engineers, chemical engineers, physicists and engineering-physicists. At the Faculty of Mechanical Engineering and Faculty of Natural Sciences of the Budapest University of Technology and Economics, the syllabus covers power plants and nuclear power plants within the framework of subjects related to energetics; in addition, there is a postgraduate course on nuclear engineering.

11.2.1. Human resources of MVM Paks NPP Ltd

On 31 December 2018 the number of individuals employed by MVM Paks NPP Ltd. was 2,533 of whom 89 were in manager positions. The number of those engaged in operations was 819; the number of maintenance staff was 658, and the number of others ensuring support (safety, technical, economic and human) activities was 1,056. 40% of the employees have a higher education degree. Of the operating personnel, 450 have a valid regulatory or advanced plant exam.

A system of expert training with the necessary financial, material and personal conditions exists within the nuclear power plant. The expert training system established at MVM Paks NPP Ltd. meets the international requirements and the Hungarian legal requirements. The training, in accordance with the Systematic Approach to Training (SAT) methodology preferred by the IAEA is job oriented and consists of a series of modules based on job-specific programmes. Theoretical training is always followed by practical training that consists of practical training on the simulator, in the Maintenance Training Centre or in the plant. The training is completed by practical sessions under supervision in a real work environment. Each training phase is ended by an exam; at the end of a training programme the candidate obtains the right to work individually based on company, advanced company or regulatory exams. However, training does not come to an end on obtaining the qualification or the right to perform duties: training courses and evaluations aimed at increasing knowledge continue together with periodic adequacy tests. Periodic exams must be passed every five years by workers employed in job positions requiring regulatory or advanced company license, while it is every three years by workers employed in job positions requiring a company license. Annual medical and psychological fitness tests are also a prerequisite.

The general rule of the development and implementation of training programmes, the list of job positions and activities having an obligation to obtain special nuclear expertise, the content elements of training programmes are regulated in the NSC, in the related ministerial decree [Ministerial decree 55/2012. (IX. 17.) NFM on special professional and further education of employees of nuclear installations, and on the scope of professionals authorized to perform activities related to the use of atomic energy], and in internal procedures.

The radiation protection training involves the greatest numbers of employees. The education of those professionally engaged in radiation protection, of the operative staff, of the maintenance staff and of those performing technical assistance activities takes place separately. Workers employed from outside on a contractual basis also have to meet the qualification and examination requirements.

MVM Paks NPP Ltd. trains its experts at its own cost and in its own training centres. The training infrastructure is suitably developed; facilities of the training centres are well equipped. Teachers and instructors are well qualified and well prepared.

A full-scope simulator has been in operation in the Simulation Centre since 1989, serving all four units. The simulator has been continuously developed so as to follow the various modifications performed on the units. In addition to training of operators, the simulator plays an important role in technological development projects.

The Maintenance Training Centre, which started its operation with the support of the IAEA in 1997, is unique in the world with its genuine primary components and mechanical equipment for training workshops. A special feature is that training and education make use of full-scale primary main components (reactor vessel, steam generator, main circulating pump, etc.) under inactive conditions, equipment identical with the components built in technology systems as well as training mock-ups.

Company level knowledge management toolkit supplements the training system that was developed in alignment with the IAEA requirements and guides. It contributes to the continuous maintenance of knowledge required for the operation of the units, so it is focused on sustaining and sharing knowledge and decreasing risk of loss of knowledge. The most typical fluctuation cause at the company is retirement, so several 'IAEA compatible' tools are used to support mapping and transferring the implicit and tacit knowledge of the colleagues of several decades of experience before the retirement. Besides, a company knowledge portal surface was developed, and the main organizations delegate contributors to a working group tasked to organize knowledge management events, facilitate knowledge management communication and to support periodic professional organizational tasks. This arrangement was acknowledged as an international good practice. The unit responsible for knowledge management maintains an intensive relation with the relevant national and international organizations to learn and adapt the most recent knowledge of the profession.

Appropriate number of human resources with adequate education is indispensable for the operation of MVM Paks NPP Ltd. and Paks II Ltd. A closer cooperation between the two companies is required to ensure the adequate staff both on the short and long term for the operation of the currently operating units and to construct and operate the new units. A working group shall be set up to reveal the problems with determining the needs and ensuring the human resources and to elaborate the solutions for work force flow between the two companies.

11.2.2. Human resources of Paks II Ltd.

The staff number of Paks II Ltd. on 31 December 2018 was 371, while the average staff number participating in the company activities during 2018 was 339.54.

Steps of the company to ensure recruitment and preparation of professionals for nuclear safety:

- *The structure and staff number of Paks II Ltd. assumes different human resources needs in each phase of the construction. Therefore the issue of survey and planning the needs for each phase is handled by the company as a critical one. All these influence the recruitment activity, especially the selection of operating, maintenance, technical support and training staff.*
- *Paks II Ltd. operates a computer based knowledge management system from the fourth quarter of 2018, the primary goal of which is to share and sustain the relevant professional knowledge, and to describe the professional attributes and operating environment of the particular organizational units within the organization.*
- *Considering the tasks determined for the human resources units of Paks II Ltd., development of the training-development system, and so the development of internal systems to supply new professionals, is continuous.*

12. Human factor

Convention on Nuclear Safety, Article 12

> *„Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation."*

12.1. Consideration of human factors

Both the HAEA and the licensee take into account the role of the human factor throughout all life cycle phases of the nuclear facilities. During the regulatory oversight activities, the HAEA puts emphasis on the human and organizational factors in the licensing, inspection and review and assessment area. *In 2016, the HAEA established the section for oversight of human and organizational factors, which is first of all was tasked with the regulatory oversight of human and organizational factors, including licensing and inspection of organizational structure of the licensees, management system, modification of internal technical and administrative regulations including radiation protection aspects, and the oversight of activities related to contractors.*

The annually updated and repeated probabilistic safety analyses are always carried out taking the human factor into consideration and assessing numerical values of probabilities of human error during various activities. When

evaluating simulator training and potential incidents, further data can be derived concerning the probabilities of the occurrence of events originating from human error. In accordance with the requirements of the HAEA, the licensee shall put emphasis on the identification of human and management errors during event investigations. *During the assessment of the events, also the HAEA puts emphasis on the human and management errors and the actions taken to prevent recurrence of them. The HAEA, during its annual regulatory assessment for considering human and organizational factors, evaluates the operation of the facilities in a complex manner through the assessment of the safety indicators of this area, reveals the non-compliances with the purpose of prevention, points out the safety impact and the potential causes and initiates effective actions to eliminate the non-compliances.*

As in the past, the Hungarian Electricity Group, that incorporates the MVM Paks NPP Ltd., wishes to take into account the opinions and comments of employees regarding their employer, work conditions and personal carrier opportunities in the future.

Paks II Ltd., related to its operation, puts emphasis on the human factor in the design phase of the new nuclear facilities, with special attention to those job positions, to which certain control obligations are assigned according to law.

12.2. Selection of work force

MVM Paks NPP Ltd. constantly enforces the requirement that only such individuals may carry out work in the nuclear power plant, who have the necessary qualifications, skills and examinations set out for the given job and in addition meet the appropriate medical, psychological and public security requirements.

The recruitment and *the multi-level* employee selection process require close cooperation between the professional organizations and the human division. The manager of the requesting organization defines the professional requirements for the position to be filled, while the human division performs preparation, screening and evaluation, *while the evaluation of the applicants' skills takes place jointly.*

The selection system applied by MVM Paks NPP Ltd. consists of psychology aptitude test and measurement of competencies required for a given job or position. The psychologist provides the manager with a detailed evaluation on the results of aptitude tests and competence measurements, and then prepares the priority list of candidates. *A job interview conducted by the professional and human recourses section is part of the selection process, which is attended exclusively by the applicants (at least in a three-times number to be provided) meeting the application criteria. The most appropriate candidate is selected by the relevant leader assuming the employer rights.*

If the recruitment takes place in a position that needs nuclear power plant specific professional and/or practical experience, which cannot or cannot fully be obtained via school education, and the replacements cannot be solved from

internal resources (internal transfer), the manager assuming the employer rights can initiate at the human organization to launch an introductory training programme. The implementation of the introductory training is realized through the ATOMIX Ltd. owned by Paks NPP Ltd. in 100%., which has its Training Centre. The Training Centre organizes the modules of the introductory training, ensures the participation of the trainee in the training and the conditions needed for fulfilling the given job position.

During the introductory training the trainees are not authorized to work individually. The introductory training programmes shall be implemented according to the relevant internal regulations of the Paks NPP. The claimer professional organizational unit can initiate the employment of the applicant into the MVM Paks NPP staff after the successful completion of the introductory training.

MVM Paks NPP Ltd. is operating a programme for adapting and professional tutoring of newcomers or employees reassigned to another job position. The objective is to facilitate the adaptation of the newcomers, describe the organizational culture and, for the internally reassigned employees, to practice the working techniques, to transmit the organizational values and requirements, notwithstanding the as effective as possible transfer of professional knowledge and experience of the highly qualified workers of special significant professional experience to the next generation.

One of the mid-term possible resources of ensuring recruitments is represented by those youngsters interested in nuclear industry and participating higher education, whom the Paks NPP receives during practical sessions of the their education, ensuring such professional and local knowledge that will facilitate the option for them to be employed in the nuclear power plant.

Paks II Ltd. shall determine the list of job positions important to safety and of those determining from the aspect of safety taking into account the attributes of the nuclear facility under design and the design related tasks. The list shall appear in the Preliminary Safety Report and the respective design documentation to be developed by the company and submitted to the HAEA according to the formal requirements determined by law. The development of the organization shall follow the life cycle phases of the construction, *taking into account the requirements described in Section 11.2.2. Employment and preliminary training of simulator instructors to contribute the* introductory *training of the technical staff of the new units has been commenced.*

The objective of the recruitment and selection process of Paks II Ltd. is to ensure the human resources in an optimal number and education for the effective operation. The selection process is multi-level. The curriculum vitae of the most suitable applicants from the company level applicant curriculum vitae database and occasionally from job mediators are examined to organize the job interviews. After the second level interviews an offer is prepared for the selected applicants with the involvement of the manager of the concerned organizational unit, which is to be approved by the Chief Executive Officer. Employment can start if the applicant accepts the offer.

12.3. Improvement of working conditions

The Collective Contract of the MVM Paks NPP Ltd. limits overtime work to 300 hours a year for an employee. The rules in force at the plant are in accordance with the related stipulations of the Act I of 2012 on the Labour Code. The Human Affairs Directorate keeps comprehensive records of the workload of employees.

In order to ensure undisturbed work, the NPP established and has ever since been operating a social system whose scope in several areas reaches beyond the services usually available in Hungary.

The nuclear power plant was awarded by a "Family Friendly Work Place" title in 2018 for the third time.

Paks NPP developed such a salary system based on job position analysis that exceeds the general level of salaries in Hungary, and ensures a high-level package of allowances for employees.

Paks II Ltd. pays special attention to the operational processes, work environment, equality of opportunity and employee satisfaction survey. The survey focusing on these aspects was partially completed in quarters III and IV of 2018, its final results will be available during quarter II of 2019 that will determine the steps of the employer. To overcome and maintain fluctuation at an acceptable level, retention of work force is an important task of human resources unit. Paks II Ltd. has been continuously working on the practical steps and taking the further necessary actions (e.g. ensuring permanent professional challenges and transparent carrier, application of acknowledgement and awarding forms going beyond the currently applied allowances, supporting training) to facilitate that aligning to the HAEA requirements.

12.4. Future aspects of the characteristics of human resources

In order to ensure a supply of adequately trained workers, the human resources units constantly measures the optimum manpower demands and handles the manpower shortage or redundancy on the basis of the probable lifetime of the nuclear power plant.

One of the strategic goals of the company is to operate all four units of the NPP by 20 years more beyond the design lifetime. With the lifetime extension, the possibility of the perspective of life-long careers opens up.

The performance and competence assessment system operates fruitfully on a continuous basis. The system covering each of the employees makes regular and real feedback possible, as well as facilitates the differentiated motivation based on personal performance. The motivating financial budget separated in the salary agreement contributes to the effective operation of the system.

Paks II Ltd. shall possess in each phase of the realization the appropriate competences and resources for ensuring the safe implementation of the given

phase. Paks II Ltd. prepares a plan for the entire length of the implementation of the programme that is based on the evaluation of needs of expected tasks which also takes into account of the future operation. Determination of the annual staff number plan takes place by considering the actual progress of construction. The development of competences and identification of new competences shall take place based on annual evaluation of the employees, during which they get feedback on their performance, and based on the effective fulfilment of regulatory and legal requirements of the particular professional areas. Leadership skills, development and maintenance of a strong safety culture, professional skills for design, construction, commissioning, operation and decommissioning are among the organisational competences.

12.5. Feedback of experience in order to enhance safety

It is laid down in the safety policy of Paks NPP that commitment to safety should manifest itself, among other ways, in open detection of factors compromising safety and in an endeavour to enhance safety and safety culture. The objective of event investigations is to draw conclusions rather than to call personnel into account.

Investigation and analysis of non-planned events in the Paks NPP are regulated in a separate procedure. Any human error found during an investigation should be analysed in detail. Specialists help to identify initiating causes, take part in the psychological analysis work as well as in defining the direction of necessary changes and modifications. The results of the investigations with definitions of the related concrete tasks and measures needed are strictly recorded.

Paks II Ltd. pays attention to survey and manage the risks related to the construction, and to the evaluation and utilization of external and internal experience.

Observations/notices related to violation of safety can be reported by anybody. These are promptly assessed and investigated according to their significance at organizational level, and the company appropriately informs the workers of the project of the corrective and preventive actions.

12.6. Safe working conditions

Healthy working conditions in accordance with standard values are created in the nuclear power plant. If there is doubt that any of these conditions in a particular workplace does not meet the requirements, accurate measurements are performed on the basis of which supplementary measures are taken. The proper use of personal protective equipment is enforced by regular check-ups and the possibility of imposing sanctions.

It is a usual practice to modify or change the external conditions, the ergonomic environment or the man-machine interface so that the probability of repeating errors and mistakes is reduced. All tools, measuring instruments, maintenance

and all other special equipment, meet the requirements both for quality and quantity.

The management of Paks II Ltd. is continuously ensuring the appropriate conditions, environment friendly and ergonomic working circumstances, appropriate materials, equipment, computer systems and users' softwares to effectively fulfil the tasks for satisfying the requirements

The management regularly, but at least during the annually due management review, re-evaluates the infrastructure and working conditions for safe work performance and compliance with the requirements. The safe working conditions relate to the provision of such circumstances, under which the work can be performed without endangering the health of the worker. Such factors can be physical, environmental and other factors, like noise, temperature, humidity, illumination and weather. The hazard factors appearing from beginning of the construction period, the construction, assembly, industrial environmental factors, like electric shock, moving-rotating parts, stumbling, slipping, falling down, falling objects, equipment under pressure, gases, steam, aerosols, chemical agents, working in closed room, etc.

13. Quality management

Convention on Nuclear Safety, Article 13

> *"Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation."*

13.1. Basic principles

In operating and developing management systems, nuclear safety is always the key objective. The design, manufacture, installation, assembly, commissioning, in-service inspections, testing, etc. of the components are performed on the basis of requirements of the NSC and of associated guidelines. During the regulation of the activities, in addition to the domestic regulatory requirements, the HAEA follows the standards and guidelines of the international organizations (e.g. IAEA) and other countries having advanced nuclear industry (e.g. USA). It is important that the suppliers of the nuclear power plant have to be in possession of a valid qualification for the relevant activity.

13.2. Description of the management system

The Act on Atomic Energy requires that "Only those institutions, organizations, companies which possess appropriate quality management systems regulated as a part of the nuclear safety requirements can take part in activities related to nuclear facilities, their nuclear systems and components, a radioactive waste

repositories and their systems and components". Moreover, the Act on Atomic Energy also requires that in the field of application of nuclear energy only such individuals can be employed who meet all the necessary requirements, such as qualifications, and the necessary personal and health condition, integrity etc. The adequacy of the management system shall be examined and certified.

The principles of the quality management system are included in Volume 2 of the NSC, and these requirements were elaborated according to Principle 3 of the Vienna Declaration, based on Safety Standard No. GSR Part 2 of the IAEA and the WENRA reference levels, by taking into account the ISO 9001:2015 standard. The NSC defines the management system requirements not only towards the operator but also towards its suppliers. Recommendations on the methods of fulfilment of these requirements can be found in the guidelines issued by HAEA.

13.3. Management system of the HAEA

The HAEA was among the first of the governmental administrative bodies, which introduced and then certified a management system according to the standard ISO 9001.

Pursuant to the standard, the certification shall be renewed every three years and a supervisory audit shall be conducted every year. As a result of the certification renewing audit that was conducted in 2018, the certification has been validated for another 3 years, until March 2021.

13.4. Management system of the MVM Paks NPP Ltd.

13.4.1. Management

MVM Paks NPP Ltd., as the operator and licensee of the nuclear power plant, established, operates and develops its management system in line with the requirements of Volume 2 of the NSC. The fundamental principles of the integrated management system are described in the Management System Manual, while the full compliance of the system with the requirements is verified in Chapter 17 of the FSAR that is submitted annually to the HAEA. The plant has an integrated system, thus the environmental protection, physical protection, labour safety, radiation protection, fire protection and information security requirements for the personnel are all considered beyond the quality requirements during the operation thereof. The integrated approach assures that these requirements are complied with besides the overriding priority of safety. The integrated management system is a complete system, it covers the full scope of the basic activity; consequently, it covers each process as well as defines the related requirements. The quality policy definitely describes the general quality related intention and direction of the higher management.

An indicator system is used to assess the correct functioning of the integrated management system of MVM Paks NPP Ltd. The indicators indirectly reflect the

adequacy of the functioning of the quality assurance system, and necessary measures can be determined upon the evaluation of these indicators.

Based on annual programme, the quality management organization regularly reviews the operation of the system. The auditors reviewing the system are trained in special training; well experienced experts contribute to their work during audit of certain special areas.

Any non-compliance detected during the operation of the nuclear power plant is in all cases followed by evaluation. Depending on the severity of the non-compliance, evaluation is performed either by the HAEA, the quality assurance experts of the power plant, or by experts of the given professional areas.

One of the most effective elements for developing quality assurance systems is the investigation of events at different levels and the feedback of experience. Accordingly, the nuclear power plant investigates events according to their severity and in a way regulated by procedural orders. When performing such investigations, the initiating causes and necessary measures are identified. *The lessons learned from investigations are fed back to the concerned suppliers as well.*

The preparation and change management of the documents required for the operation of Paks NPP is controlled.

For evaluating the efficiency of the management system and to determine the necessary corrective actions the plant management holds a management review every year.

13.4.2. Execution

Design work necessary for the operation of the nuclear power plant is performed by or on behalf of the various technical support organizations.

The process of procurement is fully regulated from ordering, through import to delivery, and to inspection of the delivered product.

Operating activities are accomplished in a way regulated in procedures and execution instructions, and in the *document regulating the operation, namely the TS until 24 October 2018, then the Operational Limits and Conditions*. Operations are performed on the basis of handling and operating instructions. Special attention is paid to the clear identification of equipment at all times and the continuous monitoring of the condition of the given equipment. When shift changes take place, they are performed in a documented way in all cases, with a clear indication of the status of equipment valid at the moment of hand over. All necessary temporary modifications are performed according to procedural orders. Regulated fuel management procedures covering the entire cycle also form an important element of quality management of operation.

The procedures and execution orders ensure the proper control of the management of maintenance process. The maintenance activities are performed based upon plans, maintenance technologies and work programmes.

Control over technical background activities is also performed according to procedures. Requirements concerning reactor physics, diagnostic analyses, and the process for waste treatment have also been defined.

The audits and performance evaluation of the manufacturing and service provider organisations/suppliers according to the ABOS (safety class) graded requirements are performed regularly, in a controlled manner.

In order to improve operational effectiveness, the processes of the production subsystem are under review on the basis of the nuclear industry standard model. The management of changes is performed in line with the relevant rules. The changes will be introduced after the realization of the conditions, expectedly in 2019-2021.

13.4.3. Audits

The safety and quality assurance organizations of MVM Paks NPP Ltd. exercise internal control over the executing organizations.

Control manifests itself with regard to approval of documents describing execution conditions for daily activities and during on-site supervision of real execution. Additionally, control appears in the form of audits that assess the system level and practical compliance with requirements as defined for a given operational area.

Organizations and process-owners monitor the operational efficiency of their organisations and processes run by them through self-assessment process.

The suppliers of MVM Paks NPP Ltd. are assessed and qualified according to the safety relevance of their work. The qualification or assessment process audits the adequacy of the quality management systems of suppliers in a planned and documented way, particularly the efficiency of their operation.

13.5. Management system of Paks II Ltd.

13.5.1. Structure of the integrated management system

Paks II Ltd., as an organisation holding a nuclear facility license, shall establish, operate and continuously develop an integrated management system. The relevant requirements are included in the manual, internal regulations, procedures and work instructions.

Paks II Ltd. is responsible also for those processes and the services generated by the processes, which it partially or fully purchases from external suppliers or contractors. The differentiation of processes, respective products and services are managed according to their significance from safety aspects.

The management developed the policies as follows:

— Safety policy,
— Quality policy,
— Training policy,
— Computer security policy,
— *Risk management policy.*

The operation model of Paks II Ltd. has been determined on the basis of the competencies and determination of professional areas required to effectively perform the tasks related to the construction of the new nuclear power plant units also taking into account the relevant legal requirements. An attribute of the operation model is the project-based structure, which is implemented as a coordinated programme within the framework of the functional organizational units.

13.5.2. Audit programmes

The method of internal audits is used to monitor/review the processes. The objective of the internal audits is to monitor and develop the operation and the integrated management system on a continuous basis, to provide effective and quality work, to comply with the laws, standards and regulatory requirements.

The management monitors the performance of the main objectives on a continuous basis. In addition to the management reports prepared during the operation and the checkpoints built in the processes, the management evaluates the performance of the objectives in the framework of annual management reviews.

13.5.3. Audit of suppliers

Paks II Ltd. developed an audit system and started its operation concerning the selection and capability audit of the suppliers, and the continuous supervision of their performance.

The nuclear qualification procedures related to nuclear safety important activities, with a graded approach, are performed via:

— review of requested documents and with an on-site audit, or
— review of requested documents without an on-site audit.

Following the qualification of the suppliers, the continuous supervision of their performance is made in a manner regulated in corresponding procedures.

13.6. Role of the HAEA in verifying the quality management system

The HAEA performs a comprehensive inspection either as a system audit or a process audit. Audits are carried out on previously designated areas by internal

auditors; any attempt to eliminate remarks recorded in the audit-minutes must be reported.

Pre-planned inspections are performed according to the annual schedule of the HAEA. Non-scheduled single inspections are performed relating to events adversely affecting quality, or upon the individual decision of the HAEA.

The areas of the licensee's quality management system regularly inspected by the HAEA are as follows:

— structure of the organization,
— training and qualification of staff,
— documentation,
— management of non-compliances,
— normal operation,
— maintenance and repair work,
— nuclear fuel management,
— selection of contractors,
— design,
— acceptance inspection at manufacturers,
— modifications,
— *safety culture.*

Inspection of audits includes both independent reviews and those performed by the management. Official inspections are carried out according to written and approved procedural orders.

The HAEA requires the licensee to decide upon improvement measures related to findings identified during the inspections. If this is neglected or not performed adequately, the HAEA in a special resolution will itself order for the improvement measures.

13.6.1. MVM Paks NPP Ltd.

The oversight of the safety culture, training, suppliers, safety policy and external experience feedback at Paks NPP is a significant part of the inspection and assessment activity of the HAEA. During the regulatory activities related to the assessment of organisational factors, the HAEA has not identified any problem significantly jeopardising safety, and immediate regulatory intervention has not been justified.

13.6.2. Paks II Ltd.

The HAEA performed the comprehensive inspection of the management system of the licensee during the reporting period. The inspection resulted in an Action Plan, the execution of which was ordered by the HAEA in a regulatory resolution. The execution of the actions is partially completed, partially in progress.

The HAEA inspected the licensee's supplier qualification process and the operation of its training system. During the inspections, the HAEA did not identify any non-compliance requiring immediate regulatory intervention.

In the frame of the oversight activity of the suppliers' nuclear qualification of the licensee, the representatives of the HAEA participated in several on-site supplier qualification and/or supervisory audits conducted by the licensee.

14. Assessment and demonstration of safety

Convention on Nuclear Safety, Article 14

> *"Each Contracting Party shall take the appropriate steps to ensure that:*
> *(i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the HAEA of the regulatory body;*
> *(ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions."*

14.1. Assessment of safety

14.1.1. Preliminary and final safety analysis report

The method of preparation and implementation of safety analysis reports is set out in acts and Government Decrees. The official procedure related to a nuclear construction is based on the PSAR necessary for the commencement of commissioning that is followed by the FSAR necessary for the commencement of operation of a given nuclear installation.

The requirements regarding the contents of safety reports are based on the requirements of Reg. Guide 1.70 of the US NRC (United States Nuclear Regulatory Commission) taking into account the national characteristics.

The FSAR demonstrates the safe operation and the compliance with the safety requirements, which is updated annually by the licensee in agreement with the regulatory provisions. It is such a living document, which follows and assesses the safety impact of actions and modifications and the safety, in harmony with the international good practice.

The MVM Paks NPP Ltd. revised the FSAR in 2004. The revision aimed at the preparation of such a state of the art fundamental document, which could serve as basis for the service life extension proceeding. The extension of the time limited safety analyses, as needed for the justification of the service life extension were completed, the implementation of the renewed ageing management programmes began.

The HAEA performs a PSR within ten years of the first day of the validity of the operation license issued for the initial commencement of operation, and it repeats this review every ten years following the first one. The HAEA issues a decision based on its own safety assessment and the PSRR of the licensee, in which it lays down the conditions for future operation.

The reviews are legal obligations and the review is a condition of the operation license that ensures, in line with Principle 2 of the Vienna Declaration that comprehensive and systematic safety analyses are regularly performed during the lifetime of the facility.

14.1.2. Periodic Safety Review

Principle 2 of the Vienna Declaration requires the system of regular and comprehensive reviews for nuclear facilities. An element of this regular review process is the PSR, which was incorporated into the IAEA practice and which was due in 2017-2018. The IAEA recommendation on periodic safety reviews (Periodic Safety Review of Operational Nuclear Power Plants, Safety Series No. SSG-25) schedules regular reviews every ten years thereby providing a comprehensive view of safety of nuclear power plant units and, by virtue of their systematic approach, they are suitable for defining necessary safety improvement measures and priorities.

Licensees are liable to perform their own internal assessment one year before the deadline set for the performance of the assessment and to submit a PSRR on the results of this assessment to the HAEA. In the review the HAEA performs the analysis and evaluation of the technological and safety level of the operated nuclear installation on the base of the report of the licensee, and compares it with the known, most recently developed international technology and safety levels. The HAEA appraises whether or not the risk, from any non-compliance revealed, can be tolerated during the next 10 year operating cycle and the operation of the installation complies with internationally accepted good practice. The HAEA terminates the review with a resolution, in which it may limit the validity of the license if the risk justifies it or may order the implementation of safety improvement measures to reduce any unacceptable risk. The safety improvement is conducted under regulated conditions; the HAEA inspects the improvement actions decided upon and grants permission for the relevant necessary modifications.

In Hungary, the HAEA issues a guideline to each specific PSR, which sets the objectives, principles of implementation, legal regulation, and technical background of the review and its related documents.

The first Periodic Safety Review of Units 1&2 of Paks NPP took place in 1995-1996. The Periodic Safety Review of Units 3&4 was performed in 1998-1999 by the operator in accordance with the new Act on Atomic Energy, entered into force in 1997, and the related regulations.

The PSR in 2008 was completed for the four units together; the HAEA ordered the implementation of 169 corrective measures. The PSR was completed again in 2017-2018 for the four units, where the implementation of 73 safety improvement measures were required in the approving resolution.

70 % of the required measures are of administrative nature, such as reviewing safety analyses, introducing new procedures into the management system and updating quality management documentation. Measures requiring technical modifications were made necessary by the lack of environmental resistance conformance of electric and control equipment, and the ageing management of civil engineering structures and technical engineering systems. Additionally; measures were required in relation to renewal of access control gates from physical protection point of view and reconstruction of radiation protection monitoring systems due to their ageing technical condition.

The PSA and DSA should keep up with the development of science and technology. If a new result or operating experience comes up, then the existing analyses should be reviewed or if needed repeated taking account of it. Majority of the analyses should be adjusted in order to get a picture of the risk meant by the units and to improve the quality of various PSA based applications.

The implementation of the PSR improvement measures is continuously followed and verified by the HAEA.

The review due every ten years, in line with the effective regulation, was completed in 2017. The review was performed in the frame of an individual project and it covered 14 sub-areas, including administrative and human areas in addition to the technical ones. The review had not only provided the picture of today, but covered aspects of the previous as well as the next ten years.

In addition to the targeted assessments completed in the frame of the project, the PSR intensively used the updated FSAR, the relevant materials of the available recent and on-going projects (lifetime extension, Targeted Safety Assessment, licensing of operation with C15 cycle, Severe Accident Management), as well as the outcomes and documents of various national and international assessments (HAEA, IAEA OSART, SALTO, WANO, etc.). The PSR document summarising the outcome of the review was submitted to the HAEA on 11 December 2017.

14.1.3. Further safety assessments

Safety assessments are performed also for those modifications, failures or ageing-related equipment and device replacements that do not require an amendment to the Final Safety Analysis Report.

Safety assessments are also performed if technical problems, events or accidents take place. Those safety assessments have to be also mentioned which include lessons learned from events abroad, when the potential occurrence of a similar event in a domestic facility has to be considered. External hazard factors, risks from natural phenomena belong to this scope, but there was also such a case when a notification was provided by a relevant organization having a technical problem with a product commonly used in various countries. In this case it has to be examined whether the revealed technical problem of the product might cause any failure under the operating conditions of another facility.

14.2. Verification of safety at the MVM Paks NPP Ltd.

14.2.1. In-service inspections and tests, material testing

The proper technical condition of nuclear power plant systems and components fulfilling safety functions shall be maintained. The proper technical condition and functionality is demonstrated by in-service inspections *and online maintenance introduced in 2017*, inspections and tests performed in connection with refuelling outages, as well as by periodic material testing of pressure retaining equipment and valves. A detailed description of the in-service inspections, tests and examinations is given in Annex A1.

14.2.2. Ageing management of equipment

The NSC dedicates separate sub-sections to the topics of ageing and lifetime management. Ageing management of equipment at Paks NPP is being performed according to the decree; its detailed description can be found in Annex A2.

14.2.3. Seismic safety

Between 1996 and 2002, the total seismic safety review and the implementation of the required reinforcements took place. The value of the free surface PGA acceleration, for seismic hazard value of 10^{-4}/year frequency was determined as 0.24g.

In addition to free-surface measurements, several triaxial acceleration gauges are located within each twin unit: three of them are fixed onto the base plate and three additional pieces are installed at different locations of the reactor building important from both structural and mechanical points of view. The earthquake monitoring system provides sufficient measurement data for the evaluation procedure. *In 2018, 32 permanent seismographs operated in Hungary, including 5 hole seismographs (seismic meter at the bottom of a 150 m deep bored hole equipped with an inner tube) and 27 surface stations (15 wide range and 12 short periodicity stations).*

The safety and control rods drop down in their full length into the reactor within 10 seconds, thus, it is not justifiable to initiate automatic reactor protection operation for earthquakes of any free surface acceleration or duration. In order to prevent unit shutdowns triggered by false signals, the earthquake alarm and protection system currently operates off-line, so it does not shut down automatically the reactor. In earthquake alarm the personnel takes a decision on the shutdown. In accordance with international recommendations and with modern practice, the criterion for unit shutdown is the transgression of limit values set for the cumulative absolute velocity and for the response spectrum. Actions to be taken in case of an earthquake are laid down in OLC and in Emergency Operating Procedures.

14.2.4. Improvement of technical conditions for severe accident management

The following modifications were completed at Paks NPP between 2011 and 2014 in connection with severe accident management:

- The possibility of external cooling of the reactor pressure vessel has been established. The objective of that is to provide the capability of in-vessel retention of the molten corium in a severe accident situation, whilst the integrity of the reactor pressure vessel is maintained. The task has been accomplished by external cooling of the reactor pressure vessel by way of creating the route for draining the water reserves of the bubble condenser trays into the reactor cavity via the ventilation system of the reactor cavity. The coolant can return to the hermetic compartments from there, meanwhile it cools the vessel wall. The modification has been completed in each unit by 2014.
- In order to ensure an appropriate method of management of the hydrogen generated during a severe accident phenomenon, in addition to the already installed hydrogen recombiners in existence, a further 60 high power recombiners were installed in the hermetic compartments for severe accident management purposes. Hydrogen explosion and endangering of integrity of the hermetic compartments can be avoided by means of these pieces of equipment which reduce the potential for release of radioactive materials. This development was completed for all units in 2011.
- In order to realize the severe accident management strategy, such an accident management electric power supply system had to be constructed, which can ensure the power supply for reduction of the pressure in the primary circuit, the equipment required for external cooling of the reactor pressure vessel and for the accident measurement and instrumentation chains should a total loss of electrical power occur should the occasion arise when there is no onsite and off-site safety power supply available. The independent electric power system has been constructed by way of the installation of mobile diesel generators of 4x100 kW and connection routes from the diesel generators towards the principal safety distributors. This development took place for all units during 2011.

— Accurate monitoring, and knowledge of the technical parameters, is indispensable for the usage of the severe accident management guidelines and for correct technical decision-making. The measurement system that is operable independently of the operational measurements even if severe accident conditions occur include measurement means for reactor pressure, core outlet temperature, water level in hermetic compartments, water level in reactor cavity, hermetic compartment pressure and temperature, hermetic compartment hydrogen and oxygen concentration, spent fuel pool level, dose-rate in reactor hall and release measurements. The system has been implemented in each unit. The measurements are accessible from the Main Control Rooms and Backup Control Room of the units and from the Protected Command Post. The modifications were completed on each unit by 2013.
— The safety improvement modification of the cooling circuits within the spent fuel pools and service shafts of the units was also completed. According to PSA Level 1 results that such am excludable loss of coolant accident within the spent fuel pool cooling system would entail the most severe consequences for the spent fuel assemblies, which would take place in the compartments of the safety equipment of the pools at a water level of the spent fuel pool used during refuelling. In order to reduce the risk, motor-operated valves, controlled by level gauges, were constructed in place of the currently used manual valves. In this way the amount of coolant lost can be kept within acceptable limits and it will be easier to start up the backup coolant circuit. The frequency of a break in unenclosed pipelines can be reduced by replacement of the existing pipeline sections and by applying fewer welds. As a consequence of the modification the damage frequency of the fuel in the spent fuel pool, due to loss of coolant, decreases by two orders of magnitude. The modification was implemented in each unit by 2013.

The Severe Accident Management Guideline package was introduced by 2014, taking into account the above modifications. The implementation of the listed modifications was planned prior to the Fukushima accident. The severe accident management related modifications that took into account the lessons learned from the Fukushima accident are described in Section 6.1.3.

14.3. Safety measures of Paks II Ltd. with respect to design of the nuclear facility

Paks II Ltd. conducts regular and documented reviews in accordance with its integrated management system in order to ensure compliance with the requirements stipulated by laws, international and internal regulations (see details in Section 13.5).

The investment of the new units is in the phase of design. Important input data of the design process are the basic information established during licensing of the site (see Annex A5).

Paks II Ltd. took several steps, prior to the commencement of the process, to ensure the adequacy of the design process. On the one hand, Paks II Ltd. established the management system regulating the design process, which includes several fundamental documents (e.g. design manual) and which have to be fulfilled by everyone contributing to the design process. On the other hand, Paks II Ltd. ensured the suitability of suppliers involved in the design process, prior to its commencement. A part of the assessment of suitability check was the existence of the above described unified management system and its efficient operation at the suppliers.

In line with the relevant laws and regulatory guidelines, Paks II Ltd. developed a multi-level inspection system for the verification and approval of the documentation prepared during the design phase. In addition to the review made by Paks II Ltd. and the Designer, an important element of this inspection system is the independent expert review that is performed pursuant to strict legal provisions.

The successful completion of the above steps is followed by the submission of the documents to the authority. The corresponding inspection levels are summarised in Figure 14.3.

Figure 14.3. Inspection levels

The most significant aspect of the above inspections conducted by Paks II Ltd. is that the licensee has to verify the appropriate demonstration of compliance with the nuclear safety requirements established in the laws in force and with the requirements established in the three contracts concluded between the general contractor and Paks II Ltd., such as the "Engineering, Procurement, Construction Contract" (hereinafter referred to as EPC), the "Nuclear Fuel Supply Contract" (hereinafter referred to as NFS) and the "Operation and Maintenance Support Contract" (hereinafter referred to as O&M), and to verify the appropriate application of standards. Beyond the Hungarian laws, the EPC contract is based on the IAEA, WENRA and EUR standards and requirements; thus, the joint compliance with these requirements ensure that the two new nuclear plant units to be constructed at Paks will be completed, regarding nuclear safety and technical solutions, according to the relevant operating experience and the international best practice.

In the current phase of the investment, the requirement set in Principle 1 of the Vienna Declaration is enforced by the above described inspection

process. The domestic laws, inter alia, include the requirements of the Vienna Declaration, which were assessed in the frame of several international peer-reviews (e.g. WENRA Reference Level benchmark peer-review).

15. Radiation protection

Convention on Nuclear Safety, Article 15

> *"Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits*

15.1. Legal background

The radiation protection related regulatory activities are regulated by a government decree; the radiation protection related regulatory competences belong to the HAEA. The discharges, so the protection of the environment, are overseen by the Capital and County Government Offices, while the competences regarding the radioactivity in the soil, plants and food-stuff belong to the NFCSO working under the Ministry of Agriculture.

The Act on Atomic Energy establishes the legal obligations of the users of atomic energy and the authorities. The relevant laws applied in the field of general radiation protection are as follows:

- *Govt. decree 487/2015. (XII. 30.) on the protection against ionising radiation and the associated authorisation and inspection system, in line with recommendations of the ICRP (International Commission on Radiological Protection) Publication 103 and the IAEA GSR Part 3 determines the fundamentals of radiation protection and the rules of radiation protection related regulatory activities. The regulation is in harmony with the provisions of the Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom. The government decree requires to establish a radiation protection service in each facility associated with atomic energy. Every user shall prepare a radiation protection description and workplace radiation protection rules, which are the documents serving as basis for authorization issued by the HAEA. The decree defines limit values for the radiation exposure to workers and the public, radiation safety principles of workplaces, tasks of the radiation protection service, the order of radiation protection training, and the rules of dosimetry monitoring.*

- *Ministerial Decree 16/2000. (VI. 8.) of the minister of health on the implementation of certain provisions of the Act on Atomic Energy lays down the operation of the National Radiation Health On-Call Service, and the medical treatment of radiation injured and potentially radiation injured persons.*
- *Ministerial Decree 15/2001. (VI. 6.) of the minister of environmental protection on radioactive releases to the atmosphere and into waters during the use of atomic energy and on monitoring of the release derives the annual release limits based on the dose constraints determined by the HAEA.*
- *Govt. decree 489/2015. (XII. 30.) on monitoring radiation conditions relevant for public exposure of natural and artificial origin and on the scope of quantities obligatory to be measured establishes regulations that are compatible with 2000/473/EURATOM recommendation and Council Directive 2013/51/EURATOM of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption. The government decree regulates the operation and tasks of the NERMS as follows:*
  - *to acquire, analyse, register and evaluate results related to environmental radiation dose-rate measured within the territory of the country, radioactive isotopes observed in environmental elements, foodstuffs, drinking water, fodders and to the activity concentration of radon and radon progeny building up in outdoors and in buildings, furthermore to internal radioactive contamination of human body in consequence of an abnormal event causing unplanned discharge of radioactive materials to the environment,*
  - *to perform regulatory evaluation of radiation conditions in the environment of special facilities,*
  - *to supply measurement and monitoring data for the operation of the NERS determined in Govt. Decree 167/2010. (V.11.) on the national nuclear emergency response system,*
  - *to contribute to the authentic information of the public of the environmental radiation conditions,*
  - *to contribute to the fulfilment of the international notification and information obligations related to national radiation conditions and radioactive contamination, and*
  - *to publish the monitoring and measurement results in annual reports and ad-hoc reports to inform the authorities, the European Commission and the public.*
- *Govt. Decree 155/2014. (VI. 30.) on the safety requirements for facilities ensuring interim storage or final disposal of radioactive wastes and the corresponding authority activities sets out the conditions of interim storage and final disposal of radioactive wastes and the rules of the associated regulatory activities.*
- *Govt. decree 118/2011. (VII. 11.) transferred the technical issues of radiation protection related to nuclear installations and their systems and equipment to the HAEA's scope of competence. The appendices of the decree compose of the NSC.*

— *Volume 1 of the NSC requires the regular analysis of radiation protection indicators of operation and utilization of experience within the framework of the PSR.*
— *Volumes 3 and 3a. of the NSC sets out the main radiation protection principles related to the design of nuclear power plants, the stipulations concerning the handling of fresh and irradiated fuel and radioactive waste, and requirements for dosimetry control systems, biological shielding, and systems influencing radioactive release.*
— *Volume 4 of the NSC, containing the requirements for operation, summarizes requirements concerning the execution and documentation of radiation protection activities. The same volume deals with the requirements relating to management of nuclear fuel and radioactive wastes.*

15.2. System of dose limitation

The following table summarizes the dose limits set in Svr.

Table 15.2.: Annual dose limits for workers and for members of the public

Limited quantity	*Persons subjected to exposure*		
	Workers (above 18 years)(1)(2)	*Students and apprentices (between 16 and 18 years)(5)*	*Members of the public (6)*
Effective dose (3)(4)	*20 mSv/year 400 mSv/whole life*	*6 mSv/year*	*1 mSv/year*
Dose equivalent for the lens of an eye	*20 mSv/year*	*15 mSv/year*	*15 mSv/year*
Dose equivalent for the skin	*500 mSv/year*	*150 mSv/year*	*50 mSv/year*
Dose equivalent for limbs	*500 mSv/year*	*150 mSv/year*	*–*

Remarks:

— *(1) The dose limits shall apply to the sum of the annual occupational exposure of workers, to the occupational radon exposure in workplaces, and to other occupational exposure from existing exposure situations.*
— *(2) Pregnant, recently born and breast-feeding women, after the date of the notification thereof, shall not be employed in a radiation hazardous job position.*
— *(3) At the request of the employer, the HAEA may authorise an additional maximum of 10 mSv effective dose, if the worker express his/her consent in writing and the employer demonstrates the meeting of requirements for the principle of justification.*
— *(4) Excluding emergency exposure situations, the HAEA may authorise to exceed the required occupational dose limits for certain individuals, with the condition that the exposure shall be limited in time and shall be limited*

to well defined work areas and tasks, and they shall not exceed the exposure limit values determined by the HAEA for the given case.

— *(5) The dose limits for apprentices aged 18 years or over and students aged 18 years or over who, if in the course of their studies are obliged to work with radiation sources, shall be the same as the dose limits for occupational exposure. The dose limits for apprentices and students under the age of 16 shall be the dose limits for the public.*

— *(6) The dose limits for public exposure shall apply to the sum of annual exposures of a member of the public resulting from all authorised practices but shall not apply to medical exposures.*

15.3. Occupational exposure at Paks NPP

15.3.1. Patterns of annual exposure

Based on the Workplace Radiation Protection Rules of MVM Paks NPP Ltd., every worker employed in a radiation hazardous post (including both outside and plant employees) are monitored – *differing from the past application of the sole radiation protection Category "A", as of 2018, the workers are categorised to either Category "A" or "B" depending on the expected annual exposure. The external radiation monitoring of workers in Category "A" is performed with an authority dosimeter, while those in Category "B" with a facility dosimeter.* In the regulatory dosimetry system, from March 2013 TL dosimeters are used instead of film dosimeters. As additional dose meters, working level neutron dosimeters and dosimeters applicable to measure local dose are used. The internal rules of MVM Paks NPP Ltd. require full-scope operative dosimetry monitoring. In accordance with these rules, every such worker has to wear an electronic dosimeter who performs activity within the controlled area. From 21 March 2013 operative dosimetry is mandatory for all workers in the controlled area of the sanitary building.

The following charts demonstrate the maximum individual doses of workers and the annual collective doses, based on evaluated measurements of regulatory dosimeters:

Figure 15.3.1.-1. : Maximum annual individual doses according to regulatory dosimeter controls

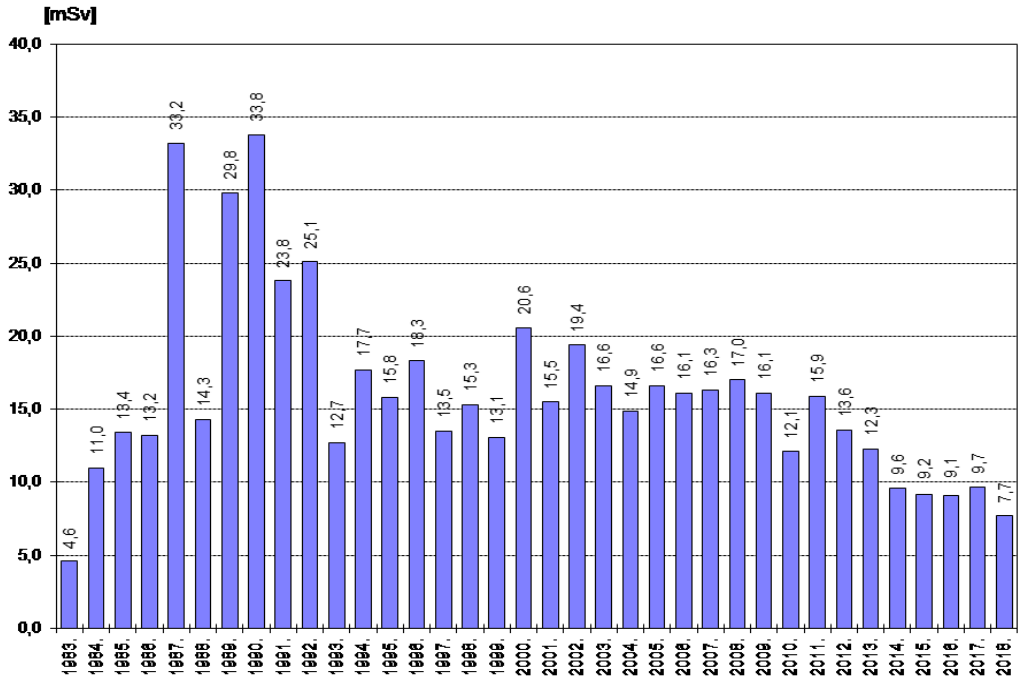
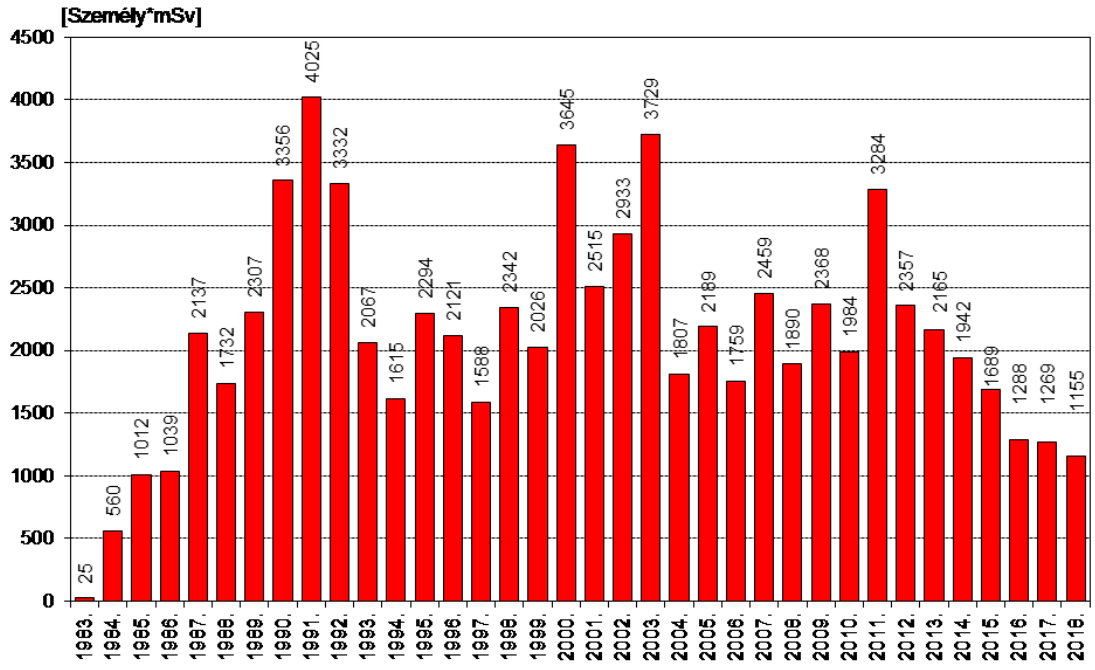


Figure 15.3.1.-2.: Annual collective doses according to regulatory film dosimeter readings



*The collective dose of workers in radiation protection Category "B" was 54.7 person*mSv in 2018.*

15.3.2. Radiation exposure in refuelling outages

At Paks NPP most radiation exposure of the personnel originates from activities during refuelling outages. Taking into account the low share of the radiation burden during operational periods, it is well worth while to evaluate the radiation exposure of personnel by analysing the radiation exposure received during refuelling outages.

The dose planning, radiological permission of particular operations in refuelling outages and identification of necessary radiation protection measures are based on the comprehensive radiation level measuring programme performed by the health physics personnel in the introductory phase of the refuelling outage period just after shutdown of the unit in the immediate surroundings of main components and in rooms involved in refuelling outage work. Data gathered on the radiation conditions could be used for dose planning for the coming years.

As for the personnel performing the maintenance and maintenance related activities, the dose values were determined on the basis of dosimetry data of Paks NPP.

Collective doses for the period 2016-2018 can be found in the following table.

Table 15.3.2.-1. : Exposure of maintenance personnel between 2016 and 2018

Unit/year	*Collective dose [person*mSv]*		
	2016	*2017*	*2018*
I.	*323*	*542*	*174*
II.	*466*	*-*	*222*
III.	*-*	*237*	*298*
IV.	*109*	*155*	*-*

The MVM Paks NPP Ltd. also regularly checks the evolution of internal exposure, via thyroid and tritium excretion measurements, and via whole body measurements. Internal exposure generally has a very low contribution to the annual exposure of workers. *The 0.1 mSv investigation level was not exceeded by any of the employees in 2016, 2017 and 2018.* Concerning the tritium activity-concentration measurement in urine, values reaching or exceeding the recording level (2.5 Bq/cm3) are included in the following table:

Table 15.3.2.-2.: Tritium activity-concentration values measured in urine exceeding the recording level of 2.5Bq/cm3

Year	*Number of events*	*Max. concentration [Bq/cm³]*	*Max. committed effective dose [µSv]*
2016	*7*	*13*	*13*
2017	*8*	*4,74*	*42,5*
2018	*1*	*4,6*	*9.4*

The nuclear power plant itself performs the dosimetry control of workers employed from external companies.

Summing up, it can be established that the official dose limits have not been exceeded during the operation of the nuclear power plant. The radiation exposure of the personnel shows an acceptably low level - also in terms of international comparison.

15.3.3. Application of the ALARA principle

At Paks NPP, optimal radiation protection is ensured by administrative and technical measures.

Technical standards comprise measures aimed at providing protection through distancing, reduction of the radiation field, and minimization of the time spent in the radiation field. During unit refuelling outages, a technical measure that is used is the shutdown cooling schedule, aims at reducing the deposition of corrosion products during cool-down.

The majority of the collective dose is received during the refuelling outages, so the anticipated collective dose of the maintenance works important from radiation protection aspect and the radiation protection measures to reduce the doses are analysed and optimized before the refuelling outages. Subsequent to the refuelling outages, an evaluation is prepared on the effectiveness of the radiation protection measures and, if necessary, further radiation protection measures are decided regarding the upcoming refuelling outages.

When making preparations for work under particularly dangerous radiation conditions, a qualitative ALARA programme is developed for all activities where this is justified by the radiation dose rate of the working area (> 4 mSv/h) or by the type of the activity. The programmes contain all technical and administrative measures that are needed to achieve the optimal radiation protection of the activity in question.

15.4. Radiation exposure of the public in the vicinity of the nuclear power plant

15.4.1. Atmospheric and liquid release

The dose constraint for radiation dose increment as a consequence of a release considering the most affected group of the population in the vicinity of Paks site is:

- 90 μSv/year for Paks NPP units;
- 90 μSv/year for the new units;
- 10 μSv/year for the SFISF.

The release limitation system, required by the Ministerial Decree 15/2001. (VI. 6.) of the minister for environment on radioactive releases to the atmosphere and into waters during the use of atomic energy and on monitoring of the release, compares both the effluent and atmospheric releases to the isotope specific release limits derived from the dose constraints (90 μSv) determined

for the plant. Compliance with limits shall be demonstrated by calculating the release limit criterion.

The release limit shall be derived for all types of releases and for all such radionuclide or radionuclide groups that are assumed to be released.

Calculation of release limit criterion:

$$\sum_{ij} \frac{R_{ij}}{El_{ij}} \leq 1;$$

where:

- El_{ij}: release limit for radionuclide i for release type j (Bq/year);
- R_{ij}: annual release of radionuclide i for release type j (Bq/year).

The usage of the release limit during the last three years is outlined in Table 15.4.1. The data of the table clearly show that the releases were very low.

Table 15.4.1.: Usage of release limit at the four units

Year	*Number of operating units*	*Limit usage [%]*
2016	*4*	*0.261*
2017	*4*	*0.264*
2018	*4*	*0.320*

15.5. Radiation protection control and the environmental monitoring system of the nuclear power plant

The site of the power plant is divided into 2 zones: a free access zone and a controlled zone of the aspect of radiation protection. Radiation levels in the free access zone may not exceed 1 μSv/h. Within the controlled zone, compartments are classified into 3 categories according to permitted radiation levels and surface contamination. These are manageable, restricted manageable and not manageable compartments. Radiation protection is continuously monitored on the plant`s premises by a radiation protection system with 625 measurement channels. Control includes measurement of dose rates and air-activity concentrations in the various compartments, and measurement of the activity of different technological media. Signals from detectors are transmitted to the Dosimetry Control Room, where they are visually displayed with visual and audio warning (alarm and emergency levels) and the measurement results are displayed and archived on computers. In addition to the radiation protection system, local measurements and laboratory tests of samples are performed as well.

Release and environment monitoring are carried out in two fundamental ways at the nuclear power plant:

— the on-line system has a telemetric system the units of which are situated at stacks (iodine and noble gas activity, aerosol and airflow measurement), at water sampling stations (total gamma activity measurement), at the meteorological measuring system, at Type-A environmental monitoring stations (air aerosol and iodine activity, gamma dose rate) and at type-G environmental monitoring stations (gamma dose rate) set up at about 1.5 km from the power plant;
— off-line laboratory measurements serve to enhance the accuracy of data given by the remote measuring system.

The remote data are complemented with sensitive laboratory measurements of a large quantity of samples taken from emissions and from the environment. The stations perform off-line measurements of fall-out, grass, soil, aerosol, iodine, ^{14}C, atmospheric tritium activities and doses (via TL dose meters).

In addition, type-C sampling stations, which measure doses (via TL detectors), are situated within a 30 km radius of the nuclear power plant. Regular replacement and evaluation are part of the environmental monitoring programme. Moreover, numerous samples are collected in the environment surrounding the nuclear power plant, e.g. water, mud, fish, plants, milk and soil. So far, measurements have shown only in some cases and only insignificant amounts of radioisotope activity generated by the nuclear power plant in the environment; the additional dose of the population from releases is below the nSv/year range.

At the SFISF radiation protection monitoring was also commenced on both the site and the surroundings of the facility. Experience so far shows radiation levels to be very low, and the additional exposure of the population caused by releases is below the nSv/year range.

Monitoring of releases and the environment is constantly carried out by the competent authorities as well, independently of the monitoring system operated by the licensee. Basically, the same monitoring results were obtained.

15.6. Radiation protection at Paks II Ltd.

As a response to the request submitted by the legal predecessor of Paks II Ltd., the MVM Paks II Nuclear Power Plant Development Ltd., on 15 October 2012, the Office of the Chief Medical Officer of the National Public Health and Medical Officer Service established 90 μSv/year (effective) dose constraint for the members of the public for the new nuclear power plant units to be constructed at the site of Paks NPP as artificial sources of ionising radiation.

The same authority, on 27 November 2014, established an 18 mSv/year effective dose constraint for the workers for normal and anticipated operation situations.

From the 1st January 2016 the radiation protection authorisation tasks related to dose constraints and other areas were transferred to the HAEA, thus the demonstration of the obligations laid down in radiation protection licenses will be submitted to the HAEA in the future.

Currently, the most important tasks in the field of radiation protection are the design inspections and the establishment of technical and administrative conditions required for the fulfilment of facility level radiation protection obligations, in close cooperation with the operator of the existing units, the MVM Paks NPP Ltd.

15.7. Radiation protection regulatory activities

As described under Section 15.1, as far as general radiation protection is concerned the competences are shared among the HAEA, the Capital and County Government Offices proceeding in environmental protection competence and the Ministry of Agriculture. The measurement system of authorities consists of several verification and monitoring networks complementing each other, which belong to sectors in accordance with the task-sharing specified in the Act on Atomic Energy.

The HAEA, during regular and eventual on-site inspections, regularly inspects the workplace radiation protection conditions of the nuclear power plant.

The territorially competent inspectorate of the Department of Environmental Protection and Nature Conservation of the Baranya County Government Office verifies the fulfilment of requirements related to release limits and other environmental stipulations contained in resolutions applicable to Paks NPP. The Department of Environmental Protection and Nature Conservation of the Baranya County Government Office is an environmental protection licensing authority of the first instance but it also participates in other licensing procedures as a co-authority.

The regulatory monitoring of radiation conditions around special facilities is performed based on data supplied by monitoring systems and networks operated by the ministry led by the minister responsible for health, the ministry led by the minister responsible for environmental protection, the ministry led by the minister responsible for agricultural policy and the ministry led by the minister responsible for supervision of food chain, taking into account that primarily the monitoring is the obligation of the operators. The monitoring and data supply centres of the system are the Information Centre of the Radiological Monitoring and Data Acquisition Network of the Health Sector (National Public Health Centre), the NFCSO and the Regional Environmental Monitoring Centres.

The authority evaluation of the radiation protection aspects of the operation of the plant is made in annual reports published since 1984. As it is generally not possible to trace radioactive substances released by the plant into the environment, or it is possible only in a few specific cases, the radiation doses of the public can be estimated only by migration and food-chain models. Annual effective doses estimated for a distance of 3 km fell into the 100-500 nSv range.

Besides the regulatory system, other monitoring systems also operate within the country. In order to collect monitoring results measured at various places into one central database the Government created the NERMS. The chairperson of the Technical Committee managing the NERMS is a professional designated by the minister supervising the HAEA based on the proposal of the director general of the

HAEA. NERMS, in its annual report, publishes the most important data with a summary evaluation.

16. Emergency preparedness

Convention on Nuclear Safety, Article 16

> *"1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.*
> *2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.*
> *3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency."*

16.1. Emergency response plans and programmes

16.1.1. Legal background

The Act CXVIII of 2011 on disaster management, and on the amendment of the related acts and its implementation laws, the Govt. Decree 234/2011. (XI.10.) and the Govt. Resolution 1150/2012 (V.15.) on establishment along with the rules of organization and operation of the Disaster Management Coordination Inter-ministerial Committee regulate the structure of the national disaster management system, the prevention, preparation and response related tasks of the ministers and state organizations involved in the response to disasters as well as the tasks of the disaster management coordination organization of the government.

16.1.2. Operation of the Hungarian Nuclear Emergency Response System

The structure and tasks of the National Nuclear Emergency Response System (hereinafter referred to as HNERS) are outlined in the Govt. Decree 167/2010 (V. 11.) on the national nuclear emergency response system.

Under normal circumstances, organizations of the HNERS are in the state of readiness and carry out preparatory work and training. The concerned organizations perform on-going tasks related to measurement data acquisition,

information acquisition, radiological data exchange and planning, information or co-operation.

In nuclear emergency, tasks related to the coordination of public radiation protection on the national level are implemented by the central organ of the professional disaster management organization, namely the Ministry of the Interior National Directorate General of Disaster Management (hereinafter referred to as MoI NDGDM). *The professional decision support is provided by the Nuclear Defence Working Committee of the Disaster Management Coordination Inter-ministerial Committee, which was operated by the MoI NDGDM until 30 April 2019. The IAEA review mission recommended to simplify the HNER system, and this was supported by the lessons learned from the International Nuclear Emergency Response Exercise conducted in 2017 (Convex-3-2017). The amendment to the. Govt. Resolution 1150/2012. on establishment and on the rules of organization and operation of the Disaster Management Coordination Inter-ministerial Committee (GCC) transfers the operation of the Nuclear Emergency Response Working Committee of the Disaster Management Coordination Inter-ministerial Committee (GCC NERWC) under the competence of the HAEA on 1 May 2019. This modification forecasts significant acceleration in information flow.*

Within the nuclear installation, the person responsible for implementing tasks related to the response to a nuclear emergency is the chief executive of the installation; at national level it is the chairperson of the GCC; while in in the counties and in the capital it is the chairperson of the regionally competent County (Capital) Defence Committee.

The chairperson of the County (Capital) Defence Committee is the government's commissioner, his/her deputy is, as far as response to disasters is concerned, the manager of the regional office of the professional disaster management organization.

A National Radiation Monitoring and Warning System (hereinafter referred to as NRMWS) - responsible among others for monitoring the radiation situation in Hungary - operates to provide the information required for the decision support and decision making activities of the GCC.

The central body of the NRMWS is the Nuclear Emergency Information and Evaluation Centre working at the Directorate General for National Disaster Management of the Ministry of Interior (hereinafter referred to as NEIEC). The tasks of the NRMWS include the continuous monitoring, warning and verification of the national radiation situation, as well as supporting warnings and notifications according to the operating status of the NERS by maintaining the early notification conditions of the national nuclear emergency response.

In a nuclear emergency situation, it is the task of *the user of atomic energy* and HAEA to evaluate the nuclear safety and radiation conditions. Data and information for evaluation are provided by the *Nuclear Emergency Response Organisation of the HAEA* and the NEIEC operated by the National Directorate General for Disaster Management of the Ministry of Interior. Early detection tasks on the basis of monitoring of the national radiological conditions are

fulfilled by the National Directorate General for Disaster Management of the Ministry of Interior. The nuclear emergency response related Real-time, On-line, Decision Support System – RODOS also operates there, as well as the Hungarian Centre for the European Radiological Data Exchange Platform (EURDEP).

16.1.3. National Nuclear Emergency Response Plan

The HAEA operates a High Level Working Group consisting of the state administration organizations concerned for the regular review of the National Nuclear Emergency Preparedness and Response Plan (hereinafter referred to as NNERP). The NNERP is approved by the chairperson of the GCC.

The High Level Working Group revised the NNERP again by February 2018 and renewed the NNERP taking into consideration the legislative changes. In order to provide more detailed technical regulation and guidance containing good practices, guidelines and expert aids pertaining to certain chapters and annex of the plan *were also reviewed*. The list of guidelines and expert aids published to date is the following:

- Legal basis of the NNERP;
- Emergency situations of domestic and foreign nuclear and radiological facilities;
- Critical tasks of the NNERP;
- Evaluation of critical tasks of the NNERP;
- Organized help in defence;
- Structure and operation of the NRMWS;
- Accident monitoring strategy;
- Planning work of the organizations related to preparedness participating in the NNERP;
- Communication between the organizations participating in the NNERP;
- Development and continuous maintenance of organisational nuclear emergency response plans;
- Preparation, conduct and evaluation of nuclear emergency exercises;
- *Preparation, conduct and evaluation of alerting exercises of the HNERS*;
- Decision-making with reference to, introduction and implementation of urgent protective actions;
- Local management of radiological emergencies;
- Organization of treatment of radiation injured.

16.1.4. Nuclear emergency response system of the nuclear power plant

The emergency preparedness of Paks NPP is adapted to the National Nuclear Emergency Response System; its framework is laid down in the Comprehensive Emergency Management Plan.

One starting point to the preparation for emergency situations is the system of emergency classification, which is a pre-defined set of technological and radiation protection criteria, and which characterizes the severity of an

emergency situation. The classification of an emergency situation entails the implementation of predefined measures. Classification enhances the uniform international and domestic understanding of severity and response to the impact of the emergency.

In an emergency situation, the actions determined upon the declaration of the emergency class shall be introduced or shall be prepared for their introduction in zones designated by concentric circles around the installation. Among the planning zones, the smallest in radius (3 km) is the "precautionary action zone", in which the measures shall be prepared for in advance and implemented without undue delay in emergency. This circle is surrounded by the next, "urgent protective action zone" (30 km) and then the largest one (300 km), the "zone of restriction of foodstuff consumption" is located. Concerning the latter two zones (to be more accurate the Hungarian parts of the 300 km), specific laws *and the NNERP* determine the *radiation protection criteria* and intervention levels, taking account of which shall be provided for determining the protective actions to be introduced.

Evaluation of radiological conditions is supported by the on-line, real time computer based dispersion simulator of the NPP, which calculates the expected and averted doses by taking the environmental radiation and meteorological data into consideration, even in case of simultaneous or delayed releases from more units.

The 30 km urgent protective action zones of foreign nuclear power plants located near the country borders do not affect Hungary. Within the 300 km protective actions zone of food consumption restrictions, the same legally determined *radiation protection criteria* and intervention levels shall be applied as for the similar planning zone of Paks NPP.

16.1.5. Comprehensive Emergency Management Plan of Paks NPP

The main document of emergency preparedness in the nuclear power plant is the Comprehensive Emergency Management Plan. The structure of the plan is modular; besides regulation of the general emergency operation it contains different modules for different types of emergencies, such as nuclear emergency, general disaster, fire and civil emergency. The plan contains organizational and technical measures aimed at the assessment, limitation and management of emergencies.

Based on the assessment of emergencies, it lays down the current emergency *planning category*, defines the procedure of emergency management and control, the composition and operation of the Emergency Response Organization of the nuclear power plant, and the emergency responsibilities of particular individuals. Emergency tasks and necessary tools and resources are specified in emergency response scenarios. An alerting system ensures the rapid activation of the Emergency Response Organization of the nuclear power plant.

The plan stipulates the order of internal and external alerts and communication and the method of operation and control of the necessary telecommunication devices. The protection of personnel, i.e. registering their whereabouts, arranging their rescue, dealing with the method of their protection and their decontamination, is regulated in detail. The plan also includes a list of materials and technical equipment used for emergency response. The detailed regulation of the required tasks is contained in the modules and in the related procedures and implementation instructions of the plan. The plan also sets out regulations concerning the preparation, training, and exercises of the personnel.

The Comprehensive Emergency Management Plan is regularly revised and modified based on experience obtained in practice and according to changes introduced in domestic and international requirements.

The regular review and, if appropriate, revision of the Comprehensive Emergency Management Plan directly supports the principles set out in Principle 2 of the Vienna Declaration, as it allows the implementation of the effective national and international requirements, provisions and good practices in the procedure of the facility, thus supporting the development of safety provisions.

Based on the cooperation agreement of the Paks II Ltd. and the MVM Paks NPP Ltd., the MVM Paks NPP Ltd. performs the emergency management tasks in the phase of construction.

16.1.6. National system of preparedness and exercises

On-site and off-site exercises, including national and international exercises, are organized regularly in accordance with long term and annual plans.

As a member state of the OECD NEA, Hungary regularly takes part in the INEX international nuclear emergency exercises. Similarly, Hungary is a regular participant of the ConvEx nuclear emergency response exercises organized by the IAEA and also participates in the exercises organized within the framework of the ECURIE system.

According to the annual training and exercise plan approved by the GCC, the organs of the HNERS take part in the following types of exercises:

- alerting exercises to test the readiness and availability of the contact points of the organization, and the availability of the staff;
- methodological exercises, when the HNERS organization alone without the other participants is to solve and drill the emergency tasks based on a specific emergency scenario;
- full scope exercises to inspect the performance of the entire HNERS;
- in addition, the HAEA participates in international communication tests initiated by the European Commission, the IAEA and other countries bases on bilateral relations.

Additionally, the individual organizations hold partial exercises independently of the central emergency management. The sectoral emergency response plans also set out the order of communication test to inspect the availability and reliability of the contact points.

The whole personnel of the nuclear facilities shall be prepared for the emergency tasks. The members of the facility emergency response organization are regularly trained for their specific tasks. The facility level exercises are carried out according to the annual training and exercise plan submitted to the HAEA that is derived from the long term training and exercise plan. Types of exercises are grouped according to their objective (practicing or testing), participation (complex, management or partial) and to type of initiation (announced or unannounced). During the preparation of complex and management exercises, the nuclear facility communicates with the off-site emergency organizations to facilitate the cooperation.

The national and international nuclear emergency response exercises held in recent years, *such as the ConvEx-3 international exercise held in June 2017 and the ECUREX international exercise held in November 2018,* demonstrated the adequacy of the laws governing the disaster management and national emergency response system developed within the modern state administration structure.

Pursuant to Principle 2 of the Vienna Declaration, the HAEA pays special attention to the assessment of its own and the national level nuclear emergency preparedness and the enhancement of safety culture. The ConvEx-3, the ECUREX and other international nuclear emergency exercises simulate the cooperation among the organisations under defined circumstances. The evaluation of exercises and the utilisation of the lessons learned have special importance in further development of procedures and provisions.

16.2. Communication to the public and neighbouring countries

16.2.1. System of public communication in a nuclear emergency, media relations

In emergency the alarm process is carried out with the help of the disaster management system and the public media. An acoustic alarm and information system is operated by the disaster management in the 30 km radius of Paks NPP. 227 modern public alarm and information devices operate in 74 settlements. The acoustic heads have local uninterrupted power supply, thus they are still operable in case of short circuit. The high power sound emitters are applicable to broadcast *pre-recorded and live voice* besides siren signals. The system may be launched upon the order of the chairperson of the general assembly of the three counties concerned from the Protected Command Post of the MVM Paks NPP Ltd., from the nuclear power plant management centre, from mobile equipment, from central duty service of the MoI NDGDM and from the duty service of the Tolna county Disaster Management Directorate. In emergency, it

is the duty of the national public media to provide appropriate information, but the nuclear power plant is also ready and prepared to issue press releases and to notify the public via the media, i.e. through local and nation-wide radio, television and the press, in agreement with the HAEA. As a means of providing rapid information, mayors of settlements located in the vicinity of Paks NPP and the authorities involved in the emergency response receive SMS notification as well on the related events of the nuclear power plant.

Supported by MVM Paks NPP Ltd., itself, municipalities located around the NPP have established the so-called Association for Social Control and Information. This organization ensures a more direct link between the nuclear power plant and the settlements involved, and it also serves for information and preparation of the public for emergency situations. It supplies regular information about emergency preparedness activities of MVM Paks NPP Ltd. based on links with national media.

Regarding an emergency occurring in a neigbouring country near the Hungarian borders, the central organizations of the national emergency response system, based on the information received from the partner authorities via the public media would inform the public about the emergency and the actions to be taken during the emergency.

In these days the social media has a growing role in informing the public, so the MoI NDGDM, together with its strategic partners, has developed a freely downloadable application for smart phones and tablets called Emergency Information Service (VÉSZ). By means of this system those having a smart phone can immediately be informed of actual emergency situations in a county or in the country, issued alert messages and alert signals around their place of residence, their destination or monitored road if travelling.

The user who has downloaded the application can set for himself/herself that from which part of Hungary he/she wants to obtain prompt notification to the device. He/she can designate the notification zone as adjusted to the place of residence, some counties, the vicinity of larger domestic lakes or as the whole country. The system is also able to monitor the actual position of the user via the GPS sensor of the mobile device, and to send the requested notifications to the smart device as adjusted to the position. It is able to display the notifications on a map.

Beyond the mobile application, both the MoI NDGDM and the HAEA maintain Facebook sites to inform a wide number of people. Visitors of social sites may have insights to the daily activities of the organizations, more and more people can learn about the activities meant to prevent or respond to emergencies or disasters and about the regulatory activities for the peaceful use of atomic energy.

16.2.2. International relations

International conventions

Hungary was among the first nations to sign the following multilateral conventions concluded in 1986:

- the Convention on early notification of a nuclear emergency;
- the Convention on assistance in the case of a nuclear accident or radiological emergency.

In order to prepare for the implementation of the convention on assistance in the case of a nuclear accident or radiological emergency the IAEA established the international Response Assistance Network (RANET) and the corresponding database, which contains the available assistance capabilities (such as field survey of contaminated area, appropriate treatment of radiation injuries, local professional support) of the member states.

The capabilities of the following parties are appeared in the database of the IAEA: HAS CER, Ministry of Foreign Affairs and Trade, HAEA, MoI NDGDM, Hungarian Meteorological Service, National Research Directorate for Radiobiology and Radiohygiene (*as of October 2018 National Public Health Centre, Radiobiology and Radiohygiene Department)*, MVM Paks NPP Ltd. Laboratory capabilities, measurement devices and radiation protection and nuclear expertise were offered for assistance by Hungary with the stipulation that the conditions for providing the actual assistance shall be specified by Hungary on a case-by-case manner.

Hungary, as a Member State to the Vienna Convention, signed the Joint Protocol relating to the Application of the Vienna Convention on Civil Liability for Nuclear Damage and the Paris Convention on Civil Nuclear Liability in 1990.

In 1991, Hungary agreed to utilize the International Nuclear Event Scale (INES), which was introduced by the IAEA.

From its beginning, Hungary is an active participant of the regional harmonization project related to emergency preparedness and response launched by the IAEA. This project provided significant assistance to the revision and renewal of the National Nuclear Emergency Response Plan.

Hungary is member of the European Community Urgent Radiological Information Exchange (ECURIE) system, in the framework of which the accident country shall provide direct notification to the European Commission and the affected member states.

In 2016, the European Commission awarded the RESPEC (Radiological Emergency Support Project for the European Commission) tender to the HAEA for the third time in a row. In the project running from 1 April 2016 the HAEA Emergency Response Organisation provides technical support to the European Commission in

nuclear or radiological emergencies threatening the EU and during the emergency exercises serving the preparation for such situations.

The support to be provided in a nuclear emergency situation covers the analysis of the situation, evaluation of atmospheric dispersion of a release, the recommendations on the introduction of the necessary protective actions and public information.

In the frame of the new contract of 3-year period, the HAEA organised the European level annual nuclear emergency exercises (ECUREX).

Bilateral inter-governmental agreements

Bilateral agreements have been concluded with the following countries in the areas of early notification, of information on mutual interest, and co-operation: Austria (1987); the Czech Republic (1991); Slovakia (1991); the Federal Republic of Germany (1991); Slovenia (1995); Romania (1997); Ukraine (1997); Croatia (2000) and Republic of Serbia (2014).

International data exchange

Hungary pursues bi-lateral radiation data exchange with Austria, Croatia, Slovenia and Slovakia. Beyond that data is also forwarded to the European Radiological Data Exchange Platform (EURDEP). Data exchange is managed via the NEIEC operated by the MoI NDGDM.

Based upon the Austrian-Hungarian bilateral agreement, a piece of modern high-sensitivity radiation monitoring equipment is operating in Gerjen, in Tolna County. The station provides data every half hour to the NEIEC of the MoI NDGDM that are forwarded to the Austrian Federal Early Alarm Centre.

At the same time, the MoI NDGDM also monitors the radiation data obtained from the 10 similar measuring stations of Austria and is provided with access to the national background monitoring data.

The planned extension of Mochovce Nuclear Power Plant in the territory of the Slovak Republic is in progress, which initiated further development of the radiological data exchange existing between the two countries in the following areas:

- three radiological remote monitoring stations are to be installed and operated by the Hungarian disaster management organizations in Slovakian territory between Mochovce NPP and the Hungarian national border;
- mutual exchange of measurement data of aerosol measurement stations operated by the Austrian government within the territory of Hungary and Slovakia.

Through the development of radiological data exchange Hungary and the Republic of Slovakia demonstrate their commitment to improve nuclear safety in a way that reinforces the confidence and safety perception of the public. The

early detection capability of the radiological remote monitoring stations facilitates the credible and timely information of the public as well as alerting of them should it be necessary.

D. THE SAFETY OF INSTALLATIONS

17. Site selection

Convention on Nuclear Safety, Article 17

> *"Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:*
> *(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;*
> *(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;*
> *(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;*
> *(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation insofar as they are likely to be affected by that installation and, upon request, providing the necessary information to such Contracting Parties in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation."*

17.1. Site characteristics

17.1.1. Location and surroundings of the site of Paks NPP

Paks NPP is situated about 115 km south of Budapest. The nuclear power plant is situated 5 km to the south of the town of Paks, 1 km to the west of the River Danube and 1.5 km to the east of National Main Road No. 6. Its geographical co-ordinates are 46°34'24" (northern latitude) and 18°54'53" (eastern longitude). The site is used exclusively for activities related to the generation of nuclear energy.

The technological components may be delivered to the power plant by road, rail or water.

Detailed evaluation of the site from meteorological, hydrological and geological aspects is included in Annex A3.

17.1.2. Public, external human-induced hazards

About 200 000 persons live in the 30 km vicinity of the nuclear power plant.

The region is mainly characterized by cultivated land. The only industrial installation in the vicinity of the plant is the SFISF. This facility is independent of the Paks NPP; it has own Safety Analysis Report and as the licensee of the interim storage facility, the PURAM holds the operation license.

There is no airport (neither civil nor military), there are no take-off or landing safety zones or military establishments either in the near or wider vicinity of the power plant. *According to regulations related to airspace usage, flights are permitted to cross the area in a radar-controlled airspace only above an altitude of 5,950 m above sea-level; while flying is prohibited within a 3-km zone around the nuclear power plant and can be only authorized individually.* Based on conservative estimates the probability of heavy transport or military aircraft crashing and falling on the nuclear power plant onto the most sensitive area from safety point of view is under the regulated screening value ($1x10^{-7}$/year).

Analysis of road and waterway accidents during the transport of hazardous substances based on up-to-date statistics indicates that the probability of a release of hazardous substances that would reach the plant site and cause processes actually jeopardizing the safe shutdown of the units (e.g. poisoning or explosion) is under the regulated screening level.

17.2. Site selection of Paks II, evaluation of the geological suitability

The two new nuclear power plant units will be constructed in the north from Paks NPP, in its close vicinity. In harmony with the legislation in force, the site of the new nuclear facility shall be comprehensively investigated and evaluated before designing. During this process, the suitability of the site shall be demonstrated and the input data for design shall be determined in a systematic manner.

From the regulatory side, this process consists of two steps, during which the survey programme is approved at the first step by the site investigation and evaluation license, while the acceptance of the results is approved by the site license (see further details in Annex A5).

All the external hazards were investigated during the site investigation and evaluation. Due to the characteristics of Paks site, the geological factors mean the greatest risks to be managed, thus a special investigation was made in this area, in the framework of the so-called Geological Research Programme (hereinafter referred to as GRP). The aim and task of the GRP performed in 2015-2016 was to provide a basis for the evaluation of the planned site of the new units from geological point of view.

Based on the 3D geological-geophysical model developed in the frame of the GRP the tectonic circumstances, and the fault systems and their neo-tectonic activity were simulated. The development history of the area and its structure changes were reconstructed from the Miocene age to present. At the same time, the geological model served as a basis for the hydrogeological and geodynamic model calculations.

During the geotechnical analyses of the GRP, the geotechnical soil parameters required for the determination of the seismic hazard and soil liquidation potential that would be critical from the design of the new units, were determined. The analyses showed that there was no such geotechnical condition, which excludes the construction of the new units on the surveyed area. From geotechnical point of view, the investigated area is suitable to host the new units.

The probabilistic earthquake hazard analyses made in the frame of the investigation determined the seismic characteristics of the design basis earthquake (maximum soil acceleration, response spectrum, time period) and the surface hazard curve. According to the outcomes of the analyses, the average maximum horizontal free surface acceleration of an earthquake having 100,000 year re-occurring periodicity is 0.34 g.

Potential soil liquidation was evaluated based on the results of seismic hazard analysis and geotechnical analyses by deterministic and probabilistic methods. It can be concluded that potential soil liquidation cannot be excluded on the site. Liquidation has to be taken into account in several layers, which may primarily appear in the flood-sand. Nevertheless, the soil liquidation hazard can be managed by well-tested technical solutions.

The state of the art research methodologies, used in the frame of the GRP, applied the available modernest technical solutions, both in the local and regional environment of the site. The objective interpretation of the data derived from the investigation revealed the strengths of the site, as well as the relevant external (human and nature originated) hazards. These provide proper input data to design specifications, in line with Principle 1 of the Vienna Declaration.

17.3. Impact of the construction of the new units on the operation of Paks NPP

The area designated for the construction of the new units is located in the direct vicinity of Unit 4 of Paks NPP in operation. The new nuclear facility may have an impact on the safety of the units in operation, in any stage of their lifecycle.

The identification, assessment and mitigation of the potential impacts on the operation of Paks NPP are obliged and made possible by rules and provision on different levels, as follows:

- *In accordance with the Cooperation Agreement between the MVM Paks NPP Ltd. and Paks II Ltd., MVM Paks NPP Ltd. is informed about every public administration regulatory proceeding and gets all necessary information from Paks II Ltd., based on which it can evaluate whether and how the proceeding influences the licenses and the operating units of Paks NPP. Paks II Ltd. may initiate a proceeding only after obtaining a consent from the MVM Paks NPP Ltd.*
- *The HAEA obliged the existing nuclear facilities and those being in pre-construction phase to mutually share all nuclear safety related data and evaluate the received data from the viewpoint of the impact on nuclear safety. The evaluation shall be repeated after every notification of change.*
- *In line with the legal provisions, the HAEA shall involve the MVM Paks NPP Ltd., as a client, to its proceedings in the frame of its regulatory oversight activities.*

The impact of the new units and the impacts of the construction works have to be analysed by the existing power plant. As soon as the approved schedule required for the construction is available, the construction as an external man-made hazard has to be analysed and evaluated.

At the same time, the operation of the existing four units, as a hazard induced by their operation, has to be taken into account. Accordingly, the existing Nuclear Emergency Response Organisation revised its Emergency Management Plan, which now includes the evacuation of construction workers, their supply with protective equipment and their potential sheltering as new tasks.

18. Design and construction

Convention on Nuclear Safety, Article 18

> *"Each Contracting Party shall take the appropriate steps to ensure that:*
> *(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;*
> *(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;*
> *(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface."*

18.1. Requirements concerning design and construction in the Hungarian system of regulations

Volume 3 (for operating nuclear power plants) and Volume 3a. (for new nuclear power plant units) of the NSC contains general nuclear safety-related requirements concerning the design of nuclear power plants. The requirements lay down in detail the principles and rules well known from international practice. The requirements reflect the most recent nuclear safety standards and stipulate in detail the principles being commensurate with the international practice.

18.1.1. Application of defence-in-depth principle

The above regulation requires that the defence-in-depth principle shall apply to each safety related activity in such a way that any failure can be compensated for or corrected, and the occurrence of a severe accident situation can be prevented.

In addition, such specific supplementary systems, structures or components shall be provided for the protection of the public and the operating staff that are

designed to mitigate the consequences of beyond design basis events and accidents.

18.1.2. Application of proven and verified technologies

Equipment based on proven and verified technologies shall be available for the following functions:

- to shut down the reactor safely and to maintain it in a safe shutdown condition in each operating state;
- removal of residual heat after reactor shutdown;
- reduction of release of radioactive materials and meeting of regulatory release limits.

The classified safety systems, structures and components shall meet the strictest applicable manufacturing, structural, inspection, maintenance and operational standards.

New design constructions are only acceptable for use provided that they are based on adequate research and development efforts. Before commissioning and during the service, all constructions shall be tested, paying special attention to new characteristics.

The scope of those safety-related systems, structures and components shall be determined which shall be designed to be inherently safe and/or as far as possible insensitive to any human error. The potential failure modes shall be identified, in support of which acknowledged probability analysis methods should be applied, where appropriate.

18.1.3. Reliable, stable and easily manageable operation

In order to achieve a reliable, stable and easily manageable operation, the nuclear power plant regulations lay down, among others, the following principles in the fields of instrumentation, informatics and control engineering:

- Control and measuring instrumentation shall be installed in order to control safety parameters, systems, structures and components during normal operation, anticipated operational events, and design basis incidents.
- An adequate communication system shall be established between different locations.
- The monitoring of operational parameters (important to safety and indicative of the condition of the plant) shall be ensured. Systems shall ensure the automatic registration and archiving of measurement data and instructions given to certain systems and components.
- Adequate control and regulating instruments shall be utilized in order to maintain the operational parameters, systems and components within the required operational range.

Moreover, the regulations require the establishment of a unit control room, a back-up control room, and an emergency control room, and they also specify requirements to be considered for their construction.

18.2. Fulfilment of requirements at Paks NPP

The design of units of Paks NPP was completed in two phases and was based on Soviet standards. When preparing the design bases, a strictly conservative engineering practice was used.

Paks NPP was designed in such a manner that during normal operation and in case of anticipated operational occurrences, the first three physical protective barriers (fuel pellets, fuel cladding and pressure boundary of the cooling circuit) must not be breached (thus the fourth barrier i.e. the containment inhibiting the release of radioactive substances had no function here). During those design basis incidents that were used for the design of the nuclear power plant, with a low probability of occurrence, the fuel matrix shall not be damaged or melted. However, to a certain extent the cladding of the fuel elements and the tightness of the primary circuit may be damaged, thus the containment function becomes necessary. The nuclear power plant was designed in such a way that as a consequence of design basis incidents the amount of radioactive substances released into the environment and the radiation dose of workers may not exceed corresponding health limits. Management of incidents and accidents that are more severe than design basis incidents but the probability of which are very low was not directly taken into account among the design principles of the units.

Elements of the defence-in-depth principle were accomplished in the nuclear power plant according to the requirements of Soviet standards.

These requirements went through a significant development, and the Hungarian regulations were completed via the harmonisation with the international requirements. In harmony with Principle 2 of the Vienna Declaration, the licensee shall comprehensively and systematically review the compliance with the new requirements, when new pieces of legislation are issued, and initiate safety improvement measures, if needed.

Based on the experience gained from deterministic incident analyses, probabilistic safety analyses (level 1 and 2), severe accident analyses and on the summarized evaluation of all results, recommendations were made for safety improvement modifications and further complex analyses (see details in Section 14.2.).

In harmony with Principle 2 of the Vienna Declaration, the safety analyses are subject to a comprehensive and systematic review within the frame of the PSR, and its outcomes are used for safety improvement measures. As a consequence of the implemented measures, the safety of the units was further increased; this is clearly revealed by the core damage probability data in Section 19.1 and19.1.. According to the regulatory requirements the extension of the service lifetime of units is possible only if all planned safety improvement measures are

completed, including the measures and modifications designed for management of potential severe accidents. The required safety improvement actions and the actions designed for severe accident management were accomplished in all units of Paks NPP in 2014; accordingly, as a result thereof *each of the four units can operate for additional 20 years*.

18.3. Compliance with the requirements by Paks II Ltd.

As described in Section 14.3, the Paks II investment is currently in its design phase. The relevant national design requirements are in line with the most recent international requirements and good practices. The compliance with the requirements for the construction license is evaluated by Paks II Ltd. in the frame of a multi-level review process, and the licensing documentation will be submitted after its successful completion.

19. Operation

Convention on Nuclear Safety, Article 19

> *"Each Contracting Party shall take the appropriate steps to ensure that:*
> *(i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;*
> *(ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;*
> *(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;*
> *(iv) procedures are established for responding to anticipated operational occurrences and to accidents;*
> *(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;*
> *(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;*
> *(vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;*
> *(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal."*

19.1. Safety analyses

When Paks NPP was established and commissioned, Hungarian practices followed those accepted in developed countries. Based on the Technical Design provided by the supplier, a Pre-construction Safety Analysis Report was prepared, which was followed by the Pre-commissioning Safety Analysis Report that was aimed at providing the basis for the FSAR.

As time passed gradually more deficiencies were revealed in the Safety Analysis Reports when compared to Western requirements. For this reason, the safety of the nuclear power plant needed to be re-evaluated in the framework of the AGNES project in 1992 to reassess the safety of Paks NPP to bring it in line with standards of the 1990's. The AGNES project brought reassuring results, it did not reveal any major deficiency. Analyses of the first PSR performed for the units were based on the above results of the AGNES project with the addition of some other elements.

In the framework of PHARE projects, with the support of the EU, in 2003 testing of the applicability of the accident localization system (confinement, bubble condensers) of the VVER-440/213 type units came to an end. The confinement used at the VVER-440/213 reactors of Paks NPP was proved by the complex assessments to be adequate for design objectives; in other words, when a design basis incident takes place the environmental release can be managed within the regulatory limits.

Within the framework of the continuously developed and extended Level 1 PSA, probabilistic safety analysis concerning events of technological origin for full power and shutdown states, and also those concerning internal flooding, fire, high energy pipe ruptures and events of seismic origin have been completed. The value of core-damage frequency was calculated and sensitivity and uncertainty analyses were performed. All probable external effects jeopardizing safety were assessed, *and then the probabilistic safety assessment of external hazards was completed.*

Probabilistic safety assessments of external hazards have been completed. According to the results of Level 1 PSA the frequency of core damage, taking into consideration all operating states further taking account of the internal and external hazard factors, is under 10^{-4}/year which is the limit specified for operational units (See Figure 19.1.).

The core damage risk induced by initiating events occurring within the technology decreased with more than a magnitude, comparing to the first evaluation performed, both for the operating reactor and for reactor shut down for maintenance and refuelling. The results of internal flooding and earthquake risk assessment are also better, than the results of previous analyses.

The internal flooding had included a new additive risk since 2016; accordingly, the risk of internal flooding slightly increased. This additive element appeared due to a novel analysis assumption that the damaging impact of the medium may cause damage to the neighbouring room as well, and the failure of the equipment may

increase the core damage frequency. The MVM Paks NPP Ltd. started a modification to deal with the above issue; after its completion, the risk from internal flooding will practically decrease to the previous low level.

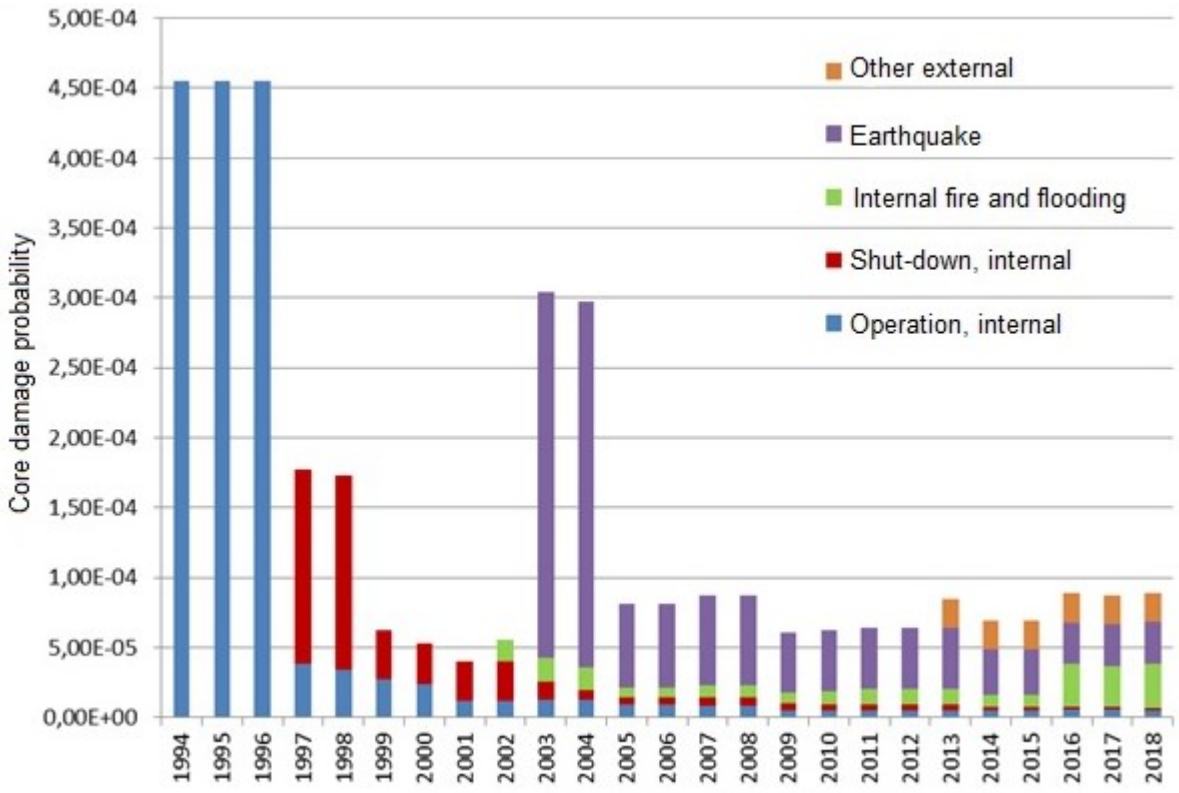
The PSA analysis of external hazards other than earthquakes was completed in 2012. The review of this analysis was performed in many areas, the quantitative review of the results will be performed until the end of 2019.

The average value of core damage from accident processes calculated for a year for Unit 3, as the reference unit:

- *Internal, technology originated initiating events, nominal power operation $5.2 \cdot 10^{-6}$;*
- *Internal, technology originated initiating events, shut-down for refuelling outage $1.4 \cdot 10^{-6}$;*
- *All operating states, internal fire and flooding $3.2 \cdot 10^{-5}$;*
- *All operating states, earthquake $3.0 \cdot 10^{-5}$;*
- *All operating states, hazards beyond earthquake $2.0 \cdot 10^{-5}$.*

Figure 19.1.3. shows the core damage probability on Unit 3 in the period of 1994-2018 induced by internal originated events, and internal and external hazards.

Figure 19.1.: Overview of core damage risk



In order to determine the risk of a large radioactive release, a Level 2 PSA containing all formerly analyzed operational states and initiating events was elaborated. In the framework of this analysis the load bearing capacity of the containment was determined for internal pressures occurring during severe accidents and significantly exceeding the design pressure.

Incident analyses were made for the full scope of the design basis. The documentation of the PSR described the accepted methodology of analyses and also presented the results of the analyses that had been performed. The list of applied initiating events includes all events considered to be globally important plus the cases characteristic for VVER reactors. The most sophisticated and uptodate computer programs were used for analyses.

All accident analyses were repeated at first to substantiate the elevated thermal power of the units, and then again to justify the acceptability of application of modernized fuel containing burn-up poisons.

Based on the analysis of basic accident scenarios performed within the framework of severe accident analyses, conclusions were drawn about processes inside the reactor and phenomena inside the containment, including the dispersion of radioactive materials. Based on the analyses the new accident management strategy and the scope of modifications necessary to implement were determined. The Severe Accident Management Guidelines containing the new accident management strategy were introduced in Unit 1-4 and the modifications necessary for the prevention, management of accidents and for consequence mitigation have also been implemented (see more details in Section 14.2.4.).

In compliance with the latest international recommendations and the requirements of the EU, the analyses of incidents in the extended design basis and demonstration of the compliance with the respective criteria have taken place, as well as the safety analysis of external hazard factors was achieved.

19.2. Operational Limits and Conditions

The document describing the operational limits and conditions of the Paks NPP was the TS (hereinafter referred to as TS) until 23 October 2018, which was a significant element of the operational documentation. As of 24 October, as the legal successor of the TS, the OLC document was introduced.

In 1988, the TS was developed by the operating organisation based on the design and operation documentation of the nuclear power plant. The TS included all those general requirements, basic rules and operational limiting parameters, which ensured the conditions of the safe operation of the nuclear power plant, in its modes of operation and operational states taken into account during its design. The primary aim of the operational conditions and limits established in the TS was to prevent, if met, such situations that may induce accident conditions, and if such conditions occur, then to allow mitigation of their consequences.

After its introduction, the TS was amended many times based on the operational experience, and because of its form and extent its effective application was hindered; additionally, it was not in full compliance with the international guidelines published in the meantime. The review of the TS and dealing with the problems were attempted in the past, but due to the continuous modification projects and the lack of detailed regulations, these attempts were unsuccessful.

The HAEA, amending the guideline titled as Operational limits and conditions for an operating unit (2015), established the national regulation allowing the comprehensive review of the TS and the development of the OLC for its replacement. In addition to the domestic regulatory requirements, the Paks NPP, during the development of the OLC, took into account the IAEA Safety Standard Series No. NS-G-2.2 guidance on Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants. The technical specification related parts of Volumes 1-2 of NUREG 1431 US standard regulating the operation of nuclear power plant were taken into account for the determination of the structure of the OLC and the fundamental rules of its application.

Taking into account the above regulations, the licensee established specific aspects for the justification of the content of the OLC to identify the subject systems, system components, which facilitated to avoid those deficiencies learnt during the application of the TS. As a result of the modification, an OLC document was developed, which includes more information on the rules of application comparing to the TS and consists of a more efficiently useable structure and operating states. The limits defined in the TS were not altered significantly in the OLC compared to TS. Paks NPP validated the draft OLC with the contribution of the operating personnel. The draft OLC was revised taking into account the issues and non-compliances revealed during the validation, then the operating personnel were trained for its application.

The operator shall maintain the document in uptodate condition. Modifications necessary because of the technical changes of the plant, implementation of safety improvement measures, and technical modernization and scientific development may be introduced and applied after regulatory approval. The personnel using the document receive regular training on the modifications.

19.3. Documents regulating operation

The quality management system of the MVM Paks NPP Ltd. encompasses the regulations (codes, procedures), instructions (maintenance, handling, operation, inspection etc. instructions) relating to the processes necessary for operating the units, and the respective forms and records. The scope of regulating documents covers procedures to be followed during both normal, accident and emergency situations.

The procedures include activity level regulations or, if it is justified due to the complexity or safety impact of the given activity or it is stipulated by an individual requirement, it may be regulated at instruction level related directly to the activity within the specific process.

The regulatory and procedural documents in force as well as their attachments (instructions and sheets) are accessible for the employees of the nuclear power plant via the intranet site of the company. The concerned employees receive on-line training on the occasional and periodic modifications. The effective copies of all elements of the documents regulating operation and in-service testing are available for those performing operation, both electronically and as hard copies at the operative workplaces.

The information required for the suppliers are provided according to the relevant contract provisions. The process of preparation, entering into force, review, retention and withdrawal of the documents regulating operation are controlled based on the effective procedure in the system regulating the operation. The executors of activities are involved as commenters to the process of document elaboration.

19.4. Emergency operating procedures

The plant began the development of the system of symptom-based emergency operating procedures (hereinafter referred to as SBEOP) in 1996, the completed procedures were introduced in 2003 after validation on the plant simulator and after full training of the personnel.

Subsequent to the introduction of SBEOP for power operation it is the objective of Paks NPP Ltd. to create such system of procedures that are built on each other and by the application of which the personnel can handle every operational incident and accident.

In order to achieve the above objective the whole system that had been introduced in 2003 was reviewed by the end of 2009. Accordingly, the shutdown symptom-based operating procedures (hereinafter referred to as S-SBEOP) for the non-power operation states and for the incidents of the spent fuel pool as well as the severe accident management guidelines (hereinafter referred to as SAMG) were completed.

The procedures for non-power states were introduced in 2011 for all units. The introduction of severe accident management guidelines, unit-by-unit, was accomplished during the years 2011-2014 in accordance with the plans, following the implementation of the related technical modifications.

Principle 2 of the Vienna Convention is met by the review of the SBEOP and SAMG documents in the case of the completion of technical modifications, and by their revision, upon need, according to the technical modifications. These documents were and are modified accordingly, with regard to the safety improvement measures of the TSR.

19.5. Technical support

19.5.1. Maintenance

The maintenance organization of the nuclear power plant is divided into professions (mechanical engineering, electrical and control, and civil engineering) but each operates according to unified principles. *In the reporting period, a new organisational unit was established within the maintenance organisation for increasing the effectiveness of maintenance planning and management, which consists of experts having excellent knowledge of operational activities and limitations.*

The system and implementation rules of maintenance and refuelling outages, *including the description of online maintenance (OM)*, in details is described in Annex A4.

19.5.2. Technical background

Technical and preparatory organisations

In the present organizational system of Paks NPP, technical support is basically divided according to professions. The safety function and responsibility of technical support is ensured through the following items:

- System analysis, condition monitoring, establishment and execution of technical tasks for safe and economical operation of the nuclear power plant based on the assessment of operational and maintenance events;
- Provisions ensuring that the units meet the actual technical and safety requirements by utilizing international nuclear energy industry results;
- Technical justification, planning and execution of safety improvement measures, modifications and investments;
- Condition monitoring, trend analysis, ageing management and lifetime management tasks in the technical engineering, electrical, instrumentation and control engineering, architecture and chemical engineering areas, and execution of tasks and assessments serving for preserving the qualified state of equipment;
- Execution of technical and closely related safety and economical calculations, analyses and reviews;
- Technical design, preparation of technical applications to the HAEA, maintenance of respective technical documentation;
- Preparation for archiving of technical documentation, and delivery of archive material to storage;
- Justification and preparation of technical developments (e.g. technical optimization, technical changes, increase of efficiency, decommissioning);
- Investment optimization using value analysis methodology;

- Preparation and licensing of operation beyond design lifetime, as a primary strategic objective of Paks NPP, company-level management and coordination of associated tasks;
- Operation of Paks NPP technical documentation system, technical documentation management, operation of document archives;
- Provision of key-data management activity for technical databases;
- Maintenance-technological justification, preparation, planning, licensing of maintenance and repair works, provision of their documentation, elaboration and licensing of maintenance, repair, assembly technologies and programmes;
- Work scheduling of planned preventive and periodic maintenance and repair activities;
- Recording, evaluation and feedback of maintenance experience, design and licensing of execution plans needed for maintenance, repair and trouble- shooting work;
- Development of medium- and long-term fuel consumption strategies;
- Planning of nuclear fuelling, fuel supply, stocking, and coordination of associated tasks. Supervision of safe operation of fuel;
- Development of medium, long-term and annual maintenance programmes of Paks NPP;
- Updating the cyclic maintenance plan of plant equipment;
- Draw up of company-level development and investment programme.

The technical background for performing the tasks above is available in each area of operation and construction relevant from safety of the nuclear facility. Accident situations are to be managed by the Emergency Response Organization that has the necessary technical resources. The technical means are available in the property of the company to manage the design basis incidents, severe accidents and the situations identified during the TSR.

Technical support for other activities is available from the technical support organizations, e.g. the HAS CER, NUBIKI Nuclear Safety Research Institute Ltd., VEIKI Energia+ Energetic Development and Construction Ltd.

Decision support committees

Permanent or ad hoc committees may be set up to make recommendations concerning emerging tasks. The tasks and operation of such committees are specified by the entity establishing them. The most important committees are the Technical Forum and the Maintenance Working Committee.

Domestic and foreign support organisations

The MVM Paks NPP Ltd. maintains close relations with all Hungarian companies performing technical support for the plant. The MVM Paks NPP Ltd. maintains relations with those foreign companies (or their successors) that have contributed to the design and construction of the plant or in the manufacturing of its equipment, e.g. TVEL, ATEP, Škoda and Hidropress.

Close relations are maintained with foreign companies with considerable experience in nuclear industry. Some of the significant companies with which the MVM Paks NPP Ltd. maintains working relation are Westinghouse, EdF, Nuclear Electric, Rosenergoatom.

Based on contracts currently in force, the general design services are provided together by HAS CER and NUBIKI Nuclear Safety Research Institute Ltd.

19.6. Reports to the HAEA

Section 32 (1) of Govt. decree 118/2011. (VII. 11.) establishes reporting obligations of the licensee. Accordingly, two categories can be differentiated. The licensee of an operating nuclear power plant shall prepare regular and event reports, and submit them to the HAEA.

19.6.1. Regular reports

The licensee shall submit the following regular reports on the operation of the nuclear power plant unit and its nuclear safety related activities to the nuclear safety authority:

- *quarterly report: notifying the HAEA of the operational history, current issues of operation and most important factors affecting operation;*
- *annual report: based on the quarterly reports, but as more information being available due to longer periods of time elapsed, a more comprehensive description, evaluation and analysis;*
- *periodic safety review report.*

Regulatory guideline establishes regulatory requirements for the content of annual and quarterly reports, the method of the fulfilment of reporting obligations and provision of data needed for the calculation of regulatory safety indicators.

19.6.2. Event reports

The MVM Paks NPP Ltd. notifies the HAEA of events subject to immediate reporting, non-immediate reporting or urgent information providing obligation. The events falling under immediate reporting obligation were listed in a guideline, which was updated due to the replacement of the TS by the OLC. Accordingly, as of 24 October 2019 the reporting criteria are established in the appendix of the HAEA decision VE-6806. The HAEA shall be informed within 2 hours after an immediate reportable event, while within 14 hours after a non-immediate reportable event. Those events fall under urgent information providing obligation, may attract the attention of the media (e.g. unplanned downloading of the units).

The INES classification of all events subject to reporting shall be performed, and the provisional rating shall be submitted to the HAEA within 16 hours following the occurrence. All occurrences subject to reporting are to be submitted to the HAEA also in writing within 24 hours of their occurrence. An event-investigation

report should be submitted to the HAEA within 45 days of the occurrence of the event.

Based on the information shared in its daily morning meeting, and information recorded in the operative minutes or other reports, the HAEA:

- *May order event investigation to be conducted according to the guideline;*
- *May request the submission of the event investigation report conducted by the licensee;*
- *May request further information on a given issue.*

In addition, the HAEA may order an event investigation based on a resolution, which shall be fulfilled by the licensee by submitting the event investigation report made according to the recommendation of the guideline.

19.7. Experience feedback

19.7.1. Own operating experience

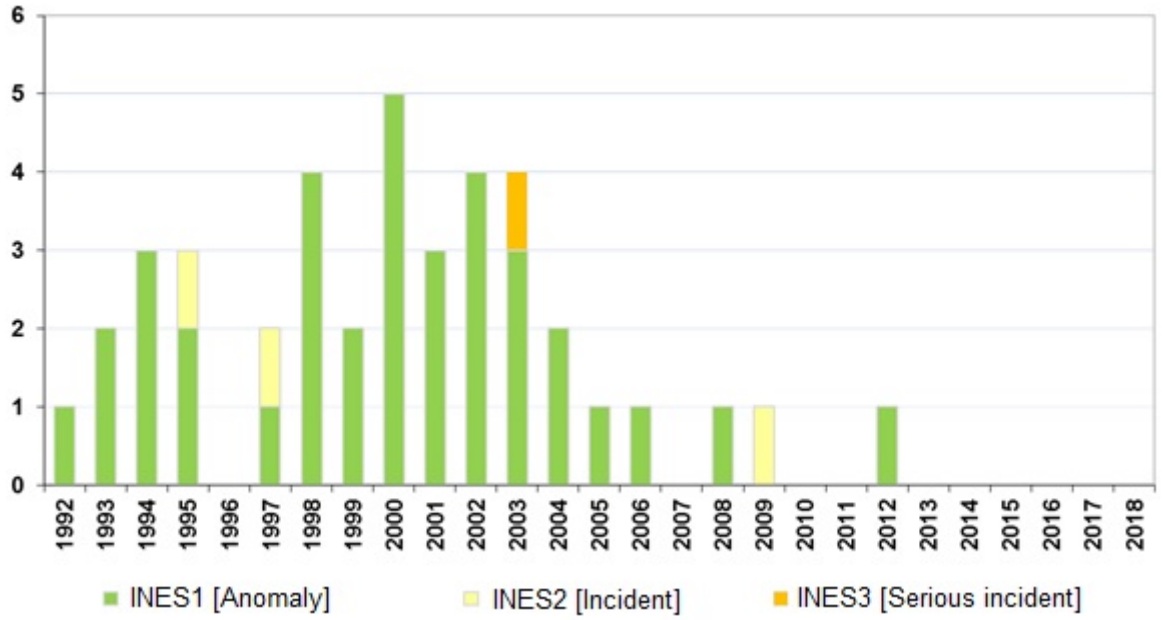
Data acquisition and processing became profession-specific as far as equipment and activities are concerned within the mechanical, instrumentation and control and electric engineering areas. As a result of this, monitoring and the utilization of data received also differ in depth and complexity. A joint database from different areas has been developed in order to ensure a uniform system of data acquisition and processing.

Analysis of reliability and availability indicators should be the basis of replacement, modernization or modification of components or equipment. These data are used in safety analyses as well. The power plant shows good indicators regarding safety systems even by international comparison. In order to achieve a unified and uniform system of data acquisition within the power plant, a plant-level regulation framework has been prepared.

Safety-related events occurring at the nuclear power plant are investigated with the involvement of the concerned technical staff. Events are investigated at different levels, which are intrinsically determined by the severity of the event. Events reported to the HAEA *and those the investigation of which is ordered by the HAEA by a resolution or in a letter* are investigated at plant level, *in accordance with Guideline 1.25* while other events are investigated at NPP level *in the frame of professional area investigation or expert evaluation*. From 1992 onwards, events are classified according to the INES scale introduced by the IAEA, and previous events were also classified retrospectively. Since 2000, several events have also been analysed by probabilistic methods.

During the period of 1992-2018 the safety related events that occurred at Paks NPP were classified to INES as seen in figure 19.7.1. No INES-1 or higher event took place in the reporting period.

Figure 19.7.1.: Number of INES 1,2,3 events from 1992



The results of investigations, *the revealed non-compliances* and the corrective measures are widely presented. Responsible personnel and deadlines related to corrective measures are always defined and as such are always traceable. Not only single events but also trends are monitored, including the reliability of safety systems. Should any trends be revealed, modifications or other technical or administrative measures are carried out if needed. Experience gained from every event is used for educational purposes via simulator training. The permanent and regular revision of operating instructions and the *OLC* offers evidence of the feedback of operating experience.

Once every quarter, the Operation Control Committee reviews the safety indicators, the lessons learned from event investigations, and the status of accomplishment of all measures taken. The Operation Control Committee is an organization operated by the Safety Directorate; it places disputed issues on the agenda for consideration. The head of the Safety Directorate has the right of decision in this forum.

19.7.2. Feedback of experience of other power plants

It is of vital interest to Paks NPP to learn and make use of operating and other experience imparted by other installations and international information sources. The MVM Paks NPP Ltd. takes part in the work of significant international nuclear organizations (IAEA, OECD NEA). Closer co-operation exists by way of participating in the professional work of various groups comprising operators of nuclear power plants, such as WANO and the Club of VVER-440 Operators. The closest cooperation may take place between the partner plants. Links such as these enable many kinds of mutually advantageous occasional or long-term activities to be identified, including joint projects, exchange of experiences, and data supply.

19.7.3. Peer reviews

The following table shows international reviews that were carried out at Paks NPP.

Table 19.7.3.: International safety review mission performed at Paks NPP

Year	Subject of the review	Review performed by
1984-1987 annually	Operation, maintenance	Experts invited by the Soviet supplier
1988	OSART (full scope)	IAEA
1990	Operation, maintenance	Experts from 4 countries invited by the power plant
1991	Design for safety	IVO
1991	Post-OSART review	IAEA
1992	1st peer review	WANO
1992	ASSET	IAEA
1993-1996	Site seismicity - 6 occasions; seismic safety programme – 2 occasions	IAEA
1995	Post-ASSET review	IAEA
1995	Follow-up of the 1st peer review	WANO
1996	Assessment of the accomplishment of safety improvement measures	IAEA
1997	Nuclear Liability Insurance Engineering Inspection	International experts of the insurance pool
1997	Quality assurance audit	Blayais Nuclear Power Plant
1999	PSA analysis of low power states (IPERS) (VEIKI-Paks NPP joint studies)	IAEA
2000	Pre-OSART mission	IAEA, Paks NPP
2001	OSART mission	IAEA
2001	Nuclear Liability Insurance Engineering Inspection	International experts of the insurance pool
2003	Review of Unit 2 event	IAEA
2003	Review of Unit 2 event	WANO
2003	Expert mission concerning the development of organizational operation	IAEA
2004	Expert mission on organizational development	IAEA
2004	Follow-up mission of the serious incident that took place at Unit 2	WANO
2005	Follow-up missions of OSART and expert missions	IAEA
2005	2nd peer review	WANO
2008	Follow-up of the 2nd peer review	WANO
2012	3rd peer review	WANO
2014	Follow-up of the 3rd peer review	WANO
2014	OSART mission	IAEA

2014	Corporate level peer review	WANO
2016	*4th peer review*	*WANO*
2016	*Corporate level follow-up peer-review*	*WANO*
2016	*OSART follow-up mission*	*IAEA*
2018	*Follow-up of the 4th peer review*	*WANO*

The MVM Paks NPP Ltd. hosted three international review missions in 2016: the peer-review mission of the Moscow Centre of WANO, the company level follow-up peer-review and the IAEA OSART follow-up mission.

During the 4th WANO peer-review the group identified 14 areas for improvement. This number can be considered as low in international comparison as well as comparing to the previous WANO review. It can be stated based on the outcomes of the review that such severe non-compliance was not identified by the reviewers at Paks NPP that might jeopardise the safety of operation.

During the OSART follow-up mission, the reviewer group found the issues totally solved in seven areas, while concluded appropriate progress for solution in 16 areas. The international experts identified improving performance in every area; they proposed the continuation of the efforts and initiated developments in many cases.

In 2014, based on the conclusions drawn by the WANO peer-review, the MVM Ltd. and the MVM Paks Ltd. established a plan of nine actions in four areas recommended for improvement in order to enhance operational effectiveness and to strengthen cooperation between the MVM Ltd. and the MVM Paks Ltd. During the follow-up, the WANO reviewers did not find the actions done by the MVM Ltd. in the field of management and leadership properly effective, and they recommended further actions in the given area. The steps taken in the field of independent oversight and communication received better evaluation, the international experts concluded "proper progress" therein.

The 4th WANO peer review was conducted in 2018. During the follow-up, the reviewer group evaluated the effectiveness of actions and their progress in 14 areas for improvement. They stated that the power plant correctly revealed the causes of the issues identified by the peer-review of 2016 and determined the direction of the corrective actions. Four out of 14 areas for improvement received "solved" qualification, while 10 areas were qualified as "progress well"

In conclusion it can be established that all of the safety reviews were terminated with positive general evaluation, however the experts gave several recommendations based on the international experience to further improve the safety performance. Implementation of action plans developed for the resolution of the issues plays a major role in increasing the level of safety.

As part of its post-Fukushima renewing process the WANO performs peer reviews every four years at its members. Taking into account also the follow-up reviews the plant receives international reviews at least every two years.

19.8. Radioactive wastes

19.8.1. Amount of waste stored on December 31, 2018

The amount of low and medium level solid radioactive waste in the nuclear power plant is altogether 9,438 barrels of 200 litres.

The amount of liquid waste stored in the plant in the radioactive waste storage barrels is 7,950 m^3, which consists of evaporation residue, decontamination solution, ion exchanger resin and evaporator acidifying solution.

Up to 31 December 2018 48.3 m^3 of high level radioactive waste was generated altogether, the required disposal volume of which is 103.2 m^3.

19.8.2. Management of radioactive wastes in Hungary

On 29 September 1997 Hungary signed the Joint Convention established under the auspices of the IAEA on the safety spent fuel and the safety of radioactive waste management, which was promulgated by Act LXXVI of 2001. A detailed discussion of the issues related to radioactive wastes and spent fuels can be found in the report submitted within the framework of the Convention; below only the most important characteristics are cited.

As of 1 March 2018, radioactive wastes are categorised according to Annex 12 of Svr. Beforehand this activity was regulated by Decree 47/2003. (VIII. 8.) of the minister responsible for health on certain issues of interim storage and final repository of radioactive wastes and radiation health issues of naturally occurring radioactive materials concentrating during industrial activities. The waste categorization requirements were reviewed together with their transfer to the competence of the HAEA, and they were amended in several points. The previously not applied very low level radioactive waste category was introduced into the Hungarian regulation, and the categorization criteria for high level radioactive wastes were further elaborated.

The safe management of radioactive wastes of the nuclear power plant is the responsibility of the entity generating the waste, i.e. MVM Paks NPP Ltd. The collection, processing and interim storage of wastes is part of the operating tasks; preparations for safe final disposal of long-lived, high activity wastes are being made according to the Parliament Resolution 21/2015 (V.4.) OGY on the national policy on spent fuel and radioactive waste and the national programme meant to govern its implementation, both developed in line with the Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

A1. DETAILED DESCRIPTION OF IN-SERVICE INSPECTIONS

Types of in-service tests

The preparation, scheduling, performance, evaluation and documentation of tests and inspections performed regularly or in an ad hoc manner on systems, sub-systems and components of the nuclear power plant are regulated by an instruction of MVM Paks NPP Ltd.

An inspection programme has to be implemented in order to demonstrate that the plant systems and components continuously, throughout the service life of the plant are capable of performing their intended functions according to their design. The inspection programme is realized by means of technology tests. The tests are performed at Paks NPP on the basis of testing instructions. These can be unified, paper based instructions or electronic format instructions installed on the unit computer.

On the basis of the instruction, the processes and activities related to tests are regulated in the following classification:

- in-service technological test – this is a function for testing systems in standby and readiness state of operation to check the main function of the equipment or systems with the minimum possible power decrease and lowest risk;
- *tests related to the planned and prepared online maintenance of the safety system components – checks of the conditions set for the systems operable before online maintenance and confirmation of operability of safety systems after their online maintenance;*
- unit shutdown technological test – checks of the operability of equipment and systems taking part in the shutdown, checks of system of conditions of change of operation mode during unit shutdown, and obtaining of information for maintenance, repair works;
- refuelling outage technological test – check of the operability and function of the equipment and systems that are to be operated after the maintenance during the refuelling outage;
- unit start-up technological test – this is a full-scope test of the systems and equipment following the refuelling outage in the scope required for unit start-up by utilizing the opportunity provided by the operation mode to screen out the possibility of failures increased because of the maintenance, inspection works that entailed dismantling;
- non-scheduled technological test – this is a test of failed systems and equipment and their backups according to the prescriptions or checking of the main functions of the systems and equipment for any other reason by the lowest possible risk, according to the conditions of the TechSpec in such cases (e.g. post-maintenance, or when a non-compliance is detected during an inspection) when it is necessary.

Scheduling of in-service tests *and tests related to online maintenance*

The in-service tests *and those tests related to online maintenance* have to be scheduled considering the requirements of the Operational Limits and Conditions. Scheduling of the in-service tests takes place in two steps. The first step is the annual schedule; the second step is the weekly operative schedule. The schedule is prepared for the period of the refuelling outages, separately for each unit determined with the accuracy of shifts. Concerning systems consisting of redundant systems, components or sets, the in-service tests of the particular systems, equipment are scheduled so that the tests are shifted to equal periods from each other. It is allowed to modify the time of execution of the tests determined in the schedule of the fuel cycle to be performed either earlier or later depending on the cycle time. *The tests related to online maintenance have to be performed prior to starting the maintenance within the maximum interval demonstrated by PSA analyses or after completion of the maintenance. Scheduling is part of maintenance scheduling, which is part of long term and medium term plan of the plant.*

Evaluation of in-service tests *and tests related to online maintenance*

The records evaluating the tests are the basic documents for verifying acceptability. Evaluation is done by the organization responsible for the performance of the test. As a result of the evaluation the maintenance, reconstruction, quality management concepts and cycle times may be modified.

All records of operational technological tests have been kept by the power plant since 1992 and they have been processed carefully. *Tests on to online maintenance are related to maintenance activities. The respective records are part of the documents demonstrating safe operation, so the management of these records takes place the same manner as the records of the in-service technology tests.*

Over a period of time the in-service tests *and the tests related to online maintenance* have verified the adequate availability of components, structures and systems and means of protection. The supplementary measures due to any unsuccessful test are always carried out without delay according to the valid procedures.

Tests related to refuelling outages

During refuelling outages three groups of tests are performed:

- before shutting down the unit, tests are scheduled to verify the systems necessary for shutdown and cooling down;
- during the refuelling outage of the unit, upon completion of the maintenance of safety systems, the adequacy of these are tested before handing over the next system for maintenance;
- after the refuelling outage of the unit, the systems necessary for start-up and operation of the unit are thoroughly tested.

Tests are scheduled depending on technological conditions. The sequence of tests and the conditions for establishing further operational states are regulated.

Among the above listed groups, the one performed after the unit refuelling outage contains the most tests. These are the following:

- functional and interlock tests of individual components;
- leakage and pressure retaining tests of systems;
- full logical and real functional testing of protection systems;
- pressure and *leakage test* of the main cooling circuit and of steam generators, depending on cycle times;
- integral leakage test of the hermetic zone;
- criticality tests on the reactor, in order to verify the physical calculations;
- unit start up tests performed at different power levels.

The scope of tests to be performed after unplanned maintenance is decided after special consideration, when the nature of interventions and the time elapsed are already known.

Introduction of electronic testing instructions in relation to extension of service lifetime means a significant change in the system of tests. The essence of the method is that the testing process is supervised by the unit computer, thus information occurring during the test is recorded, and the subjectivity about measuring of valve travelling times is eliminated. The application of the method means important contribution also to the frequency test of rotating machines. Data of electronic testing instruction may be processed within the system of origin and can be uploaded to the central database where, as lifecycle data, may be analyzed further. Data obtained from the system forms the basis of development for a symptom-based maintenance strategy.

System of requirements relating to material testing

At Paks NPP, the unified programme and criteria for periodic material testing were elaborated simultaneously with the commissioning of the units and on the basis of Soviet requirements and standards, pre-commissioning tests and international experience, and *with the involvement of Hungarian and international experts.*

These requirements were approved by the former National Energetics and Energy Safety Engineering Inspectorate, competent at that time, *and any modification of the requirements and periods requires the permission of the HAEA*. During the preparation for the service life extension of the units these documents were revised according to modern requirements. The documents are revised regularly, and necessary modifications are made.

The NSC requires the periodic material testings of nuclear power plant components. The NSC stipulates that the licensee shall develop and implement a documented in-service inspection programme in relation to systems,

structures and components important to nuclear safety to demonstrate the integrity *and safe operability* of the systems, structures and components and determine the actions necessary to maintain the safe conditions.

Periodic material testings

The scope of periodic inspection is defined by material testing frame programmes, which specify the testing area, the method of testing, the scope and frequency of testing, reference to the corresponding item of the acceptance standards, technological conditions needed for the test, engineering safety requirements and the anticipated method of documentation for each component or group of components. The full-scope periodic and non-destructive material testing of primary and secondary circuit equipment comprises the following units:

- reactor and its sealing units;
- upper chamber;
- reactor internals;
- main circulating pipeline;
- steam generators;
- pressurizer;
- hydro-accumulators;
- primary circuit components and piping;
- local *leakage tests (at the border of the hermetic compartments);*
- secondary circuit components and piping;
- clamping structures;
- fuel containers.

The criteria for the evaluation of tests – relevant to all inspection methods and types – are contained in the volume entitled "General Methodology and *Two-level* Acceptance Standards for Non-Destructive Material Testing".

A2. AGEING MANAGEMENT

Basic concepts of ageing management

The MVM Paks NPP Ltd. meets the regulatory requirements related to ageing management in a manner, which enables the plant operator to create the safe conditions for operation of the plant even beyond the design lifetime (30 years). This concept is in accordance with

- international and national experience related to ageing and lifetime management;
- the aspects of nuclear safety;
- the continuous development of scientific and technical knowledge.

MVM Paks NPP Ltd. conducts a systematic lifetime management activity for the components of safety classes 1-3, and for those 4 non-safety class components (hereinafter referred to as ABOS 1-3+) whose failure may jeopardize the operation of components providing a safety function. According to the concept:

- The technical conditions of the required safety level for components fulfilling an active function is ensured by utilizing the maintenance effectiveness monitoring system;
- Environmental qualification is made for electrical and I&C components operating under harsh environments, and the qualified state is continuously maintained;
- Systematic ageing management is conducted for components fulfilling passive function:
  - individually for critical components,
  - in groups for other components (commodity groups).

The systematic ageing management in relation to components fulfilling passive function consists of:

- determination of postulated degradation mechanisms and ageing sensitive locations;
- application of measures mitigating and preventing ageing effects;
- determination of parameters to be inspected for ageing monitoring;
- timely detection of ageing effects by operational and in-service condition testing (e.g. technical safety reviews, non-destructive material testing, operational tests.);
- monitoring of aged condition (ageing monitoring system), condition evaluation;
- development of acceptance criteria used for condition evaluation;
- development and implementation of corrective measures for non-compliances (e.g. repair, replacement, administrative measures);
- improvement of effectiveness of component ageing management programme (feedback of condition information into the programme);
- possibility of administrative verification regarding ageing management (quality management, coordination, documentation);

— utilization of operational experience.

These activities are performed in approx. 150 ageing management programmes, the technical aspects and contents of which are in compliance with the Hungarian requirements and additionally with the international practice [NUREG 1801, IAEA *Specific Safety Guide SSG-48, IAEA SRS 82 (IGALL), and consider international R&D results (e.g. EPRI, NUGENIA) in the subject].*

Representatives of Paks NPP actively participate in the work of IAEA IGALL programme and so obtain first-hand information on the documents developed in relation to ageing management and long term operation in the frame of IGALL and other activities. Paks NPP follows the international requirements and documents and as soon as possible adapts them to its daily practice. As a result of this activity, a high level harmonization can be observed between the practice of the plant and the recommendations of IAEA SSG-48., too. Paks NPP ageing management programmes follow the structure and contents of the publicly available IGALL ageing management programmes, which contain proven practices of more than 20 Member States that offered their practices for the IGALL programme. In Phase 4 of IGALL a regulatory working group was also established, which provides an easier access for the HAEA to the information. As a consequence, adapting international standards and development of requirements is accelerating in the field of ageing management.

According to the above, Hungary complies with Principle 3 of the Vienna Declaration, since both the NPP and the authority systematically follow the international standards and those are implemented in the national legislation.

Selection of critical components at ageing management

The components screened for ageing management were selected primarily during the review of components playing a prominent role in the cooling and safe shutdown of the reactor core, and of structures inhibiting the release of radioactive substances (principle of defense-in-depth). During the selection procedure, the document Technical Report Series 338 of the IAEA entitled "Methodology for the Management of Ageing of Nuclear Power Plant Components Important to Safety" together with the related Hungarian regulations in the NSC have been taken as prevailing aspects.

As a consequence of taking the above aspects into account the plant performs systematic ageing management for passive components in safety classes ABOS1-3+ (about 25,000 items/unit). The components covered by the ageing management programme belong to one of the following groups:

— Items listed in the NSC as ‘critical components’. Ageing management of each of these components is performed individually.
— Components managed on system component group (commodity group) level. Several components aged similarly belong to the same group.

The set of critical components also mean the items that need long term lifetime management activity or the replacement of which would mean serious financial and technical challenge. The critical components are as follows:

- reactor pressure vessel and its support structures;
- reactor pressure vessel internals;
- nozzles of main circulating loop and the connected pipelines;
- pressurizer;
- steam generators;
- main gate valves;
- main circulating pumps.

The ageing management programme of each critical component contains the ageing management of its seismic reinforcement.

Regarding the other mechanical components and civil structures, the plant may decide if it performs ageing management in commodity groups or by way of an individual ageing management programme. Regarding electrical and instrumentation and control components operated in a harsh environment, the plant maintains the environmental qualification.

Procedures

The MVM Paks NPP Ltd. implements comprehensive ageing management as required by the NSC. Examination of technical issues related to systems, structures and components, determination of ageing management related tasks, implementation of the comprehensive ageing management and operation of specific ageing management programmes are based on the procedures: "Process of comprehensive ageing management" and "Operation of ageing management programmes". The procedures specify and harmonize the tasks of the organizational units involved in the implementation of ageing management.

Current status of ageing management

Taking account of the differences of the technical areas, ageing management at the Paks NPP is carried out within the four areas: mechanical, electric, I&C and civil engineering. The systematic and coordinated activity is ensured by the respective procedures.

The Paks NPP reviews and updates its comprehensive ageing management programme every year according to the requirements of the NSC. An annual report is submitted to the HAEA to describe in detail the ageing management related activities of the preceding year, the condition of the most important equipment, and if any experience with ageing management programmes required actions. It is also to be mentioned that a comprehensive review of ageing management takes place every 10 years within the PSR in line with the IAEA and WENRA recommendations.

Harmony of ageing management and planned in-service inspection is ensured on the level of national legislation. Accordingly, from the aspect of regulatory

assessment, the evaluation of the ageing management programme and in-service inspection are interconnected. The licensee of the Paks NPP sends the annual in-service inspection programme schedule to the authority at the beginning of each calendar year, which is assessed during the regulatory review and it is confirmed if the planned in-service inspection activities consider the non-compliances or progress of ageing effects. The authority develops its own annual inspection plan covering both the comprehensive and ad hoc inspections based on this information.

Based on the above, Hungary is in compliance with the Principle 2 of the Vienna Declaration, since the review of the ageing management programme takes place regularly and systematically, both on annual (short term) and on long term basis in the PSR.

Component-specific ageing management programmes have been developed by the areas, based on which the implementation of comprehensive ageing management is performed. Electric area is an exception, where ageing management of cables according to specific programmes are only the supplements of environmental qualification. During the development of specific ageing management programmes the formerly applied condition monitoring programmes and results had been used.

Results of ageing management are of major significance in the licensing process of service life extension in the determination of the technical and safety margins of important equipment and in the development and implementation of lifetime management strategy. Ageing management utilizes the national and international good practices and results. New, previously not known degradation mechanisms may arise during the work, for the learning of which the targeted research and development might assist.

A3. SITE EVALUATION OF PAKS NPP

The HAEA has been receiving new data, submissions, assessments for many years concerning the site from the three licensees (MVM Paks NPP Ltd., PURAM, Paks II Ltd.) acting next to each other. The HAEA therefore required the licensees to mutually inform each other and exchange the results of the surveys and analyses ordered or performed by them. This ensures that each licensee will use the latest available information in their documents.

1. Meteorology

Based on the measurements performed at Paks, the annual mean temperature is slightly increasing. The length of extremely cold periods (-25 °C below zero) spans a few days only. Experience shows that the nuclear power plant is able to prevent the freezing of components caused by such cold weather by taking temporary measures. It is often the Paks meteorological station that report the most intensive night cooling in the entire country, as the sandy soil of the region allows strong heat emission, thus the microclimatic layer cools down more easily on clear nights. No specific tendencies can be found regarding maximum temperatures.

Precipitation varies geographically, in this regard the role of the Danube (because of its closeness) is undoubted.

The dominant wind direction is north-westerly though surveys have found that north-easterly winds are becoming more predominant during winter. No significant new trends have been found concerning wind speeds.

Other effects (e.g. hurricanes, extraordinary rain or snow) are so rare in the region that they were not even taken into account when the plant was designed. Survey of protection against external natural hazards has been completed. The administrative and technical actions intended to manage the deficiencies have mostly been completed.

Since the installation of the nuclear power plant, weather conditions have proved to be rather capricious within the range of values characteristic for Hungary's climatic zone, but it cannot be shown that the plant has had any effect on the microclimate. For the time being, climatic changes have not affected the safe operation of the nuclear power plant.

2. Hydrology

In the vicinity of the site the only significant surface water is River Danube, which is of slightly low-course nature here. The power plant is situated at 1,527 river km from the mouth of the Danube. The Danube is well regulated in the region.

The average yield of the river in the region is 2350 m^3/s, the average water speed is 1m/s, the average height of the water is 88 m above Baltic Sea level.

The large quantities of warmed cooling water released into the Danube from the nuclear power plant are as significant as the amounts of heat flows that determine the natural heat balance of the river, thus the natural river water may become heat polluted under unfavorable conditions. If all four units are in operation during autumn, some 10 to 11% of the total yield of the river has to be removed for cooling. The plume of hot water returned to the river completely mixes on its way to the border of the country (some 80 km), but no obvious temperature rise can be measured after the midway of this section. According to Decree 15/2001. (VI . 6.) of the minister responsible for environment and to the water use license issued jointly for the four units, the warming up of the cooling water returned to the river may not exceed 11 °C, or 14 °C if the temperature of the water is below 4 °C, the temperature of the hot plume 500 m after discharge point shall not exceed 30 °C. The cooling water temperature is continuously measured by the licensee; the limit has never been exceeded. This parameter is randomly checked by the competent authority, exceedance of the 30 °C temperature limit has never been detected.

By comparison with previous data, the water quality has improved. This can be explained by the fact that industrial and agricultural production have fallen back both in Hungary and in certain neighbouring countries where our river waters mostly originate.

Statistical analyses of floods with different probabilities of occurrence have assessed the differences between icy and ice-free conditions of high water levels. The flood level with a probability of 10-4/year (0.01%) is 96.36 mB (above the Baltic Sea) as calculated for icy waters and 95.62 mB as calculated for ice-free waters. Floods usually begin at the 93.3 mB water-level, and the persistence of this does not even reach 1 day/year (0.18 day). The landfill level of the power plant site has been defined at 97.00 mB; this level is 40 cm higher than the formation level of the flood-control dike in the vicinity of the power plant, and 24 cm higher than the highest water-level calculated to occur once every 10,000 years.

3. Assessment by earth sciences

3.1. Geology, tectonics

Geological research has shown that there are three main groups of formations in the geological composition of the region: Pleistocene-Holocene surface sediments, Neogene basin sediments, and the Paleozoic-Mezozoic basin basement.

3.2. Seismic-tectonic characteristics

The final evaluation of the seismicity of the site was elaborated with the help of experts of the IAEA and accepted by the HAEA. The value considered in original design was 6 on the MSK scale based on the catalogue of historical earthquakes in Hungary and on the isoseistic map that can be drawn from this. Seismicity is low in Hungary as a whole, even though stronger vibrations (with epicenter intensities of about 8 on the MSK scale) do occur, they are few in number. These are rather unevenly distributed regionally. Based on the frequency of seismic disturbances in the time period from the middle of the 19th century to the present day, a quake of intensity 4 on the MSK scale can be expected once a year while one of intensity 8 (MSK scale) may occur once every 40 to 50 years. Relations between known tectonic elements and available seismologic data can be shown only in certain cases. The focal depth of quakes in Hungary is usually 9 to 12 km, and the quakes are usually of the strike-slip nature.

The characteristics of an SL-2 safety shutdown earthquake (peak ground acceleration, uniform hazard response spectra) were determined by calculation using probabilistic seismic hazard analysis based on a 10,000 year recurrence rate. Calculation of free-field characteristics has taken into account the non-linear transmission of upper loose soil layers. Input for these calculations was taken from the results of the site geo-technical study programme. Maximum peak ground acceleration of an SL-2 earthquake is 0.25g.

On the seismic profiles taken at the site and its surroundings, several fault lines can be observed in the Pannonian layer, which suggest movements 6 million years ago. Based on the data obtained it can be presumed that the fault lines generally follow the W-SW → E-NE direction, while a few of them follow the SW → NE direction. At the same time none of the profiles of the minimum 45,000 year old Quaternary upper layer had penetrating fault lines. Detailed geological and geophysical analyses performed at the site and its surroundings show that there is no obvious sign of a Quaternary fault. No Quaternary faults can be found in the loess to the west of the site either. Deterministic analyses showed no faults reaching the surface. In spite of this, low-probability activity of structures within the Pannonian layers around the Paks site was taken into consideration in the probabilistic hazard assessment.

A joint evaluation of data of micro-seismic monitoring put into operation in 1995 and that from the recent neo-tectonic scientific results was performed in 1998. These studies justified that the assumptions taken as the basis for the evaluation of site seismicity and for analysis of the present activities were correct; there is no need for their revision. Microseismic monitoring is being continued by Paks NPP and the results are annually published for scientific purposes.

3.3. Soil liquefaction

The basis for the assessment of soil liquefaction was a detailed geotechnical analysis of the site, that followed the recommendations of the IAEA 50-SG-S9.

The upper soil layer of about 30 m at the site is young river-water sandy, gritty, loose sediment with a shear wave speed of 250 to 355 m/s, which is Type V according to Table 3.1 of the Hungarian standard / EUROCODE 8 standard. This layer covers the Type B Pannonian layer (qualified as soil of around a minimum 500 m/s shear wave speed).

According to the calculations, the critical zone is between 10 to 15 meters, typically in the depth of the flood sand, where the FS safety factor is around 1.2 along several meters down. In harmony with the recurrence rate of soil liquefaction, the next is a layer of higher safety between 16 to 18 meters. Then in the next thinner layer the safety factor decreases under 1.2. According to MSZ EN 1998-5:2009 the FS_{min}*=1.25.*

3.4. Building settlement

The hydrogeological characterization of the site is ongoing in the design of the new nuclear power plant units. Anticipated movements of Paks NPP (and Paks II) can be determined based on the hydrology model developing with the new units and the necessary interventions can be designed afterwards for the quake effects of the given frequency and intensity. Development and testing of the geohydraulic model are difficult because of the extreme Danube water levels occurring due to climate change.

In line with Principle 2 of the Vienna Declaration, these assessments ensure a continuous monitoring of the technical conditions of the currently operating Paks NPP and the design phases of the planned new nuclear power plant units.

A4. MAINTENANCE AND INSPECTIONS

The maintenance activities of the nuclear power plant aim at maintaining or returning the technological equipment in or into a state capable to fulfill its function, to avoid, mitigate or eliminate the consequences of failures with through reasonable expenditure. The most important requirement during maintenance is nuclear safety. The key element of the maintenance system is that of being well planned with optimal realization of preventive maintenance and condition dependent maintenance. Certain components may operate until failure, this is also part of the maintenance strategy.

Refuelling outages consist of the following activities:

- technical-safety reviews implemented within the Periodic Inspection Programme;
- periodic and individual maintenance works;
- inspections laid down by material testing frame programmes;
- work from regulatory requirements;
- repairing failures occurred during operation;
- safety improvement measures, modifications, reconstructions.

Periodic maintenance work performed on units in operation is accomplished on equipment with sufficient backup that can thus be handed over during the rated operation of the given unit. This reduces the work to be done at refuelling outages.

From 2017, a new element in the maintenance strategy of Paks NPP is the online maintenance. It had been prepared for a long time during the joint project of the authority and the operator aimed at application of risk-informed decision making method. The studies started from the assumption that taking out of one of the trains of the essential service water system basically makes inoperable many other safety system trains (e.g. low and high pressure emergency core cooling system, containment spray system), the operation of which needs the operation of the given train of the essential service water system. Formerly, these pipe sections could be taken out for maintenance according to the TS only when one of the twin units were in refuelling outage, but the other unit using the same train was operating. The supporting PSA calculations showed that the increase of core damage frequency is compensated and the early or large release frequency is decreased because of the taking out of one train of the safety systems for maintenance (altogether for 30 days in a year jointly for the two units) during power operation makes it possible that during refuelling outage these safety system trains and the corresponding equipment need to be made inoperable only for a shorter period, when the containment is open. One of the factors is that the work volume during refuelling outages is less by the introduction of online maintenance. Based on this preliminary hypothesis the licensee has performed detailed assessments, and by obtaining a positive result it has requested a license to introduce the online maintenance. The calculations have also demonstrated that the risk profile for one fuel cycle becomes more even and so the peak risks decrease and by controlling the particular states and safety impact of inoperable

equipment (configuration control) the risks become more manageable. During regulatory licensing the deterministic safety analyses aspects, mainly the assessment of actual compliance with the single failure criterion, appropriate determination of the scope of components concerned by online maintenance and determination of the documents to be modified were taken into account.

Regular maintenance circles serve as means of assessing the condition of operating equipment or those in stand-by mode. Maintenance or repair of equipment is scheduled on the basis of the potentially revealed deficiencies.

Preparation is a key element of maintenance, which is the task of the centralized technical organization. Such a task is, for example, the management of the activities of preventive maintenance programme in the work management system and compilation and updating of the documentation describing the operation history of the equipment.

Refuelling outage strategy

One of the most important factors affecting the availability of Paks NPP is the time required for refuelling outages. Recently, considerable efforts have been made to optimize or, if possible, decrease the time period of refuelling outages.

The long-term strategy is aimed at implementing a series of measures that can reduce the time taken by refuelling outages to an optimal level both from the aspect of economic efficiency and the adequate use of the workforce.

A new element is the "interim refuelling outage" for that unit, where the in-service inspection cycle has been changed to 8 years in relation to mechanical components of safety class 1.

- Short refuelling outage: works to be performed cyclically, and repair of spontaneous failures.
- Interim refuelling outage: fuel loading and unloading, barrel removal, internal inspections of main gate valves and valve revision that can be implemented at low reactor level.
- Long refuelling outage: fuel loading and unloading, inspection of reactor pressure vessel and vessel internals, internal inspections of main gate valves and valve revision that can be implemented at low reactor level, hydrostatic pressure test of steam generators (can be implemented during interim refuelling outage if necessary).

The order of executing maintenance activities

The activities of maintenance, as a main process of the plant, are regulated under the production subsystem and the hierarchically subordinated process instructions and procedures. These documents include:

- the systems and components in question and their parts;
- maintenance related preparatory activities;
- the activities to be performed;

— documentation, evaluation and experience feedback of maintenance activities;
— materials used directly or indirectly during the activities.

Related to maintenance, quality supervision activities are performed in accordance with regulating documents of main processes of inspection and industrial safety.

The system of requirements ensures that all activities corresponding to civil, electrical, instrumentation and control and mechanical engineering related maintenance of the Paks NPP are of adequate quality. Several kinds of supervising methods and regulation guarantee were introduced at the MVM Paks NPP Ltd.

Compliance with quality requirements is inspected during maintenance supervision and quality control activities; in some cases, the HAEA staff also inspects the activities.

The basic documents of maintenance work are the work instructions, maintenance instructions and the corresponding quality control plan, technical decision sheet, along with the maintenance records, plans, technology descriptions and permits.

The procedure for scheduling the long, interim and short refuelling outages and the procedure for online maintenance include all tasks related to documentation and specifies the responsible personnel. The management body of the refuelling outage scheduling is the Maintenance Working Committee. Its work is regulated by a meeting rule. The implementation of the refuelling outage is determined by the refuelling outage authorization plan, the refuelling outage net diagram, and other directives in force.

Separate instructions regulate the planning and accomplishment of planned preventive and periodic maintenance work. The lowest level of maintenance regulation consists of several hundred equipment-specific maintenance technologies.

The method of involving external contractors in maintenance is also regulated in detail. External contractors at Paks NPP are involved in order to accomplish individual tasks on the grounds of classical service contracts. The factors ensuring supervised work are: the contract, the authorization of the applied technology, the system of work instructions, the handing-over of the working area, and the obligatory inspection exercised by executives of the given professional area.

A5. ACTIVTIES AIMED AT SUSTAINING THE CAPACITY OF PAKS NPP

In January 2014 the Government of Hungary and the Government of the Russian Federation concluded an agreement on the cooperation in the field of peaceful use of nuclear energy, which was promulgated in the Act II of 2014. Among others, the Agreement deals with the cooperation in relation to new nuclear power plant units.

Within the frame of the Agreement, on 9 December 2014 the MVM Paks II Ltd. and the Russian Joint-Stock Company Nizhny Novgorod Engineering Company Atomenergoproekt signed three implementation contracts about two new nuclear power plant units of 1200 megawatt each to be constructed at Paks. These were:

- *the so-called Engineering, Procurement and Construction Contract (EPC);*
- *Operation and Maintenance Support Contract;*
- *Nuclear Fuel Supply Contract including the details of spent fuel management.*

After the signature of the contracts, preparatory activities for construction Unit 5 and 6 of Paks NPP has started, the milestones of which are described below.

1. Site survey and assessment license

In April 2014 the MVM Paks II Ltd. submitted its application for obtaining the license for site survey and assessment and started the preparation for fulfilling the obligations and tasks of its role as a licensee. On 14 November 2014 the HAEA approved the site survey and assessment programme with certain conditions. *The fulfillment of the licensee functions has been continuously reviewed by the HAEA.*

2. Preliminary Safety Information Report

On 1 September 2015, the MVM Paks II Ltd. submitted the Preliminary Safety Information Report (hereinafter referred to as PSIR) to the HAEA. The legal basis for submission and assessment of the PSIR is provided by the Act on Atomic Energy and the NSC. Accordingly, prior to the planned commencement of the construction licensing process of the nuclear facility the licensee of the nuclear facility may inform the atomic energy oversight organization on the preliminary compliance of the planned nuclear facility with the safety requirements by submitting the PSIR. In the PSIR, the preliminary compliance of the design of the planned nuclear power plant unit shall be demonstrated using information of units of the same design that are already operating or under construction also describing the potential differences from them. The review of the PSIR is not a formal regulatory licensing procedure. Basically, it aims at allowing the HAEA to become acquainted with the major technology characters and technical solutions of the planned unit

design and to preliminary assess if the unit is able to satisfy the system of national safety requirements and to prepare for reviewing the construction license application.

After the assessment the HAEA informed the MVM Paks II Ltd. of the results of the assessment in order for them to be able to develop the PSAR to be attached to the construction license application in due quality by considering the comments.

3. Site license

The HAEA issued the license (No. HA5919) approving the site investigation and evaluation programme on 14 November 2014. During 2015 and 2016 the MVM Paks II Ltd. implemented the activities of the GRP included in the site investigation and evaluation programme to assess the site and its surroundings.

On 26 October 2016, the MVM Paks II Ltd. submitted to the HAEA the site license application for the site of the new nuclear power plant units, in which it had to be demonstrated that there are no such site characteristics which would exclude the construction. Beyond that it also had to be demonstrated that the site investigation and evaluation programme had been implemented according to the license and the site related design data had to be described.

As part of the licensing process the HAEA organized a public hearing in Paks. During the public hearing the participants could take questions and tell their opinion concerning the site licensing process. Besides the public, also representatives of social and political organizations showed up in the event.

The HAEA granted the site license needed for the preparation of the construction on 30 March 2017. The license contained several requirements the implementation of which has been reviewed by the HAEA on a continuous basis.

4. Environmental license

The environmental impact assessment related to construction of new nuclear power plant units was launched on 19 December 2014. As a part of it, the assessment of significant cross-border effects took place according to the provisions of the Espoo Convention. 11 state parties (Austria, Czech Republic, Greece, Croatia, Malta, Germany, Romania, Serbia, Slovakia, Slovenia and Ukraine) reported themselves affected and requested participation in the international session of the process that was provided for them according to the Convention.

On 29 September 2016 the environmental authority at the first instance granted the environmental license for the Paks II investment. According to the provisions of the Espoo Convention, on 21 December 2016 the license was sent also to the affected parties that participated in the process.

Two Hungarian environmental non-governmental organizations (the Energy Club and the Greenpeace Hungary) appealed against the regulatory decision closing the environmental impact assessment process (i.e. the environmental license as a first instance resolution) and requested a legal review on 17 October 2016 at the authority of first instance. The environmental authority of second instance assessed the appeal between 23 November 2016 and 18 April 2017. On 18 April 2017, as closing of the public administration legal review process, the Pest County Government Office affirmed the environmental license of the Paks II investment.

According to Hungarian legislation, the decision of the authority of second instance can be appealed in front of the court. The two environmental non-governmental organizations (the Energy Club and the Greenpeace Hungary) submitted their claim after the legal deadline, so it was rejected by the competent court on 8 September 2017. In consequence, there is no further standard opportunity for legal remedy against the environmental license of the realization of the Paks II investment.

Currently, compliance with the requirements of the environmental license related to the construction phase is being addressed. It means the performance of air pollution protection measurements, development of a noise protection plan and taking care of safety of protected kinds of animals and plants.

5. Licensing of buildings of the construction staging area

Until the closure of data collection of this National Report, the HAEA granted construction licenses to four buildings of the staging area. Altogether 80 buildings are expected to be built within the construction staging area (warehouses, assembly workshops, office buildings, etc.).

The construction works of the first building, the 22/11 kV transformer ensuring the electricity supply for the construction area started in May 2018 and the station was commissioned in the first quarter of 2019.

A6. LIST OF LAWS

1. Acts and amendment acts

Act CXVI 1996	on Atomic Energy
Act I 1997	on the promulgation of the Convention on Nuclear Safety signed in Vienna on 20 September 1994 under the auspices of the International Atomic Energy Authority
Act CXL of 2004	General Rules of Administrative Proceedings and Services[10]
Act LXXXII of 2006	on the promulgation of safeguards agreement and protocol on the implementation of Article III, (1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons, and on the Additional Protocol enclosed to the Agreement.
Act LXII of 2008	on the promulgation of Amendments to the Convention on the Physical Protection of Nuclear Material, adopted by the International Atomic Energy Agency (IAEA) in 1979 and promulgated by Legal Decree 8 of 1987, signed on 8 July 2005 at the Diplomatic Conference organized by the IAEA
Act XLIII of 2010	on central state administrative organs and on the legal status of government members and state secretaries
Act CXXVIII of 2011	on disaster management and amendment of certain corresponding acts
Act CXXVIII of 2011	on disaster management and amendment of certain corresponding acts
Act C of 2012	on Penal Code
Act I of 2013	on Labour Code
Act II of 2014	on the promulgation of the Intergovernmental Agreement between the Government of Hungary and Government of the Russian Federation in the field of peaceful use of atomic energy
Act XXIV of 2014	on the promulgation of the Intergovernmental Agreement between the Government of Hungary and Government of the Russian Federation on granting the state loan provided for financing the construction of the nuclear power plant in Hungary

[10] The Act ceased to be in force on 31 December, 2017.

Act VII of 2015	on the investment related to maintaining the capacity of Paks NPP and the amendment of certain corresponding acts
Act CXVI of 2015	on the amendment of certain energy related acts
Act CV of 2016	*on the promulgation of the modifications in 2015 and 2016 of the Convention concerning International Carriage by Rail (COTIF) and its annexes in unified structure*
Act LXXXI of 2016	*on the amendment to certain energy related acts*
Act CXLIII of 2016	*on the amendment to energy related acts*
Act CL of 2016	*on general public administration procedure*
Act I of 2017	*on public administration judicial procedure*
Act L of 2017	*on the amendment to certain acts related to the entering into force of the act on the general public administration procedure and on the public administration judicial procedure*
Act LXXV of 2016	*on the amendment to energy related acts*
Act CCVIII of 2017	*on the amendment to certain energy related acts and certain associated acts*
Act XLV of 2018	*on the amendment to the Act CXVI of 1996 on Atomic Energy*

2. Government decrees and amendment government decrees

Govt. Decree 314/2005. (XII. 25.)	on the environmental impact study and the licensing procedure of unified environmental use
Govt. Decree 148 /1999. (X. 13.)	on promulgation of the Espoo Convention on Environmental Impact Assessment in a Transboundary Context signed on 26 February 26 1991
Govt. Decree 179/2008. (VII. 5.)	on the promulgation of the Agreement on support and financing of repatriation of spent fuel of the Budapest Research Reactor concluded between the Government of Hungary and the Government of the United States of America
Govt. Decree 204/2008. (VIII.19.)	on the promulgation of the Agreement on cooperation regarding repatriation of spent fuel of the Budapest Research Reactor concluded between the Government of the Russian Federation and the Government of Hungary

Govt. Decree 34/2009. (II. 20.)	on licensing of transboundary shipment of radioactive wastes and spent fuels
Govt. Decree 167/2010. (V.11.)	on the National Nuclear Emergency Response System
Govt. Decree 323/2010. (XII. 27.)	on the National Public Health and Medical Officer Service, on fulfillment of public health administration tasks, and on the designation of pharmaceutical administration organ
Govt. Decree 112/2011. (VII. 4.)	on the scope of activities of the HAEA in connection with its international obligations including the European Union, its authority and penalizing rights, the assignments of its co-authorities and on the Scientific Committee assisting the HAEA's activity.
Govt. Decree 118/2011. (VII. 11.)	on the nuclear safety requirements for nuclear facilities and the corresponding HAEA regulatory activities
Govt. Decree 190/2011. (IX. 19.)	on physical protection requirements for various applications of atomic energy and the corresponding system of licensing, reporting and inspection
Govt. Decree 234/2011. (XI. 10.)	on implementation of Act CXXVIII of 2011 on disaster management and amendment of certain corresponding acts
Govt. Decree 246/2011. (XI. 24.)	on safety perimeter of nuclear installation and radioactive waste repository
Govt. Decree 247/2011. (XI. 25.)	on independent technical expert proceeding in nuclear energy issues
Govt. Decree 213/2013. (VI. 21.)	on the Professional Committee of the Central Nuclear Financial Fund
Govt. Decree 214/2013. (VI. 21.)	on the rule of supports to be provided to the monitoring and information purpose municipal associations from the Central Nuclear Financial Fund
Govt. Decree 215/2013. (VI. 21.)	on the designation of the organization fulfilling certain tasks related to radioactive wastes and spent fuel, its activities and the financial resources thereof
Govt. Decree 155/2014. (VI. 30.)	on the safety requirements for facilities ensuring interim storage or final disposal of radioactive wastes and the corresponding authority activities
Govt. Decree 180/2014. (VII. 25.)	on the promulgation of the Agreement on the early notification in radiation emergency between the Government of Hungary and the Government of the Republic of Serbia
Govt. Decree 487/2015. (XII. 30.)	on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system

Govt. Decree 489/2015. (XII. 30.)	on monitoring radiation conditions relevant for public exposure of natural and artificial origin and on the scope of quantities obligatory to be measured
Govt. Decree 490/ 2015. (XII.30)	on the reports and interventions regarding missing, found or seized nuclear and other radioactive materials and other actions pertaining to radioactive materials following their report
Govt. Decree 357/2014. (XII. 29.)	on the amendment of Govt. Decree 118/2011. (VII.11.) on the nuclear safety requirements for nuclear facilities and the corresponding regulatory activities and Govt. Decree 190/2011. (IX.19.) on physical protection requirements for various applications of atomic energy and the corresponding system of licensing, reporting and inspection
Govt. Decree 184/2016. (VII. 13.)	*on the detailed rules of verification of skills and registration of civil engineering-technical experts, civil engineering designers, technical building inspectors and responsible construction supervisors of buildings and structures belonging under the effect of the act on atomic energy, and on the rules for data content of the registration*
Govt. Decree 379/2016. (XII. 2.)	*on the amendment to certain government decrees associated with the review of central offices and reinforcement of settlement (capital district) offices*
Govt. Decree 382/2016. (XII. 2.)	*on designation of organizations fulfilling regulatory tasks associated with traffic administration tasks*
Govt. Decree 385/2016. (XII. 2.)	*on fulfillment of public health tasks of the capital and county government offices and settlement (capital district) offices, and on the designation of health state administration body*
Govt. Decree 179/2017. (VII. 5.)	*on the promulgation Annex of Appendix C of the Vilnius Protocol of 3 June 1999 amending the Convention concerning International Carriage by Rail (COTIF), and on certain issues related to its application within Hungary*
Govt. Decree 489/2017. (XII. 29.)	*on the general and specific rule of fire protection authority procedures*
Govt. Decree 532/2017. (XII. 29.)	*on supplementary procedural rules of the aviation authority*
Govt. Decree 457/2017. (XII. 28.)	*on the amendment to certain government decrees corresponding to the entering into*

	force of the general public administration procedure
Govt. Decree 27/2018. (II. 28.)	*on the amendment to certain government decrees associated with atomic energy*
Govt. Decree 70/2018. (IV.9.)	*on the amendment to certain government decrees associated with atomic energy*
Govt. Decree 94/2018. (V. 22.)	*on tasks and competences of members of the Government*

3. Ministerial decrees and their amendments

Decree 16/2000. (VI. 8.) of minister of health	on the execution of certain provisions of the Act CXVI of 1996 on Atomic Energy
Decree 15/2001.(VI. 6) of minister of Environment	on radioactive releases to air and water during the use of atomic energy and its control
Decree 47/2003. (VIII. 8.) decree of minister of health, social affairs and family	on certain issues of interim storage and final disposal of radioactive wastes, and on certain radiohygiene issues of naturally occurring radioactive materials concentrating during industrial activity
Decree 7/2007. (III. 6.) of minister of justice and law enforcement	on the rules of registration for and control of nuclear material
Decree 47/2012. (X. 4.) of minister of interior	police tasks corresponding to the use of atomic energy
Decree 55/2012. (IX. 17.) of minister of national development	on special professional and further education of employees of nuclear installations, and on the scope of professionals authorized to perform activities corresponding to use of atomic energy
Decree 5/2015. (II. 27.) of minister of interior	on the fire protection rules specific in the use of atomic energy and the reinforcement methods thereof during the activities of the authorities
Decree 4/2016. (III. 5.) of minister of national development	*on the fees to be paid for certain public administration procedures and administration services of the Hungarian Atomic Energy Authority*
Decree 2/2016. (I. 15.) of the minister of human resources	*on the amendment to certain ministerial decrees corresponding to the entering into force of the government decree on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system*
Decree 89/2016. (XII. 29.) of the minister of agriculture	*on the amendment to ministerial decrees of certain environmental protection and nature*

	conservation, forestry, fishery and hunting subjects corresponding to the review of central offices and background organization of ministries operating as a budget organization
Decree 49/2017. (XII. 21.) of minister of national development	*on designation of the entity exercising the owner rights and assuming the responsibilities over Paks II Nuclear Power Plant Private Company Limited by Shares*
Decree 52/2017. (XII. 22.) of minister of national development	*on the promulgation, amendment and setting aside certain ministerial decrees associated with energy corresponding to the entering into force of act on general public administration procedure and for other purpose*
Decree 4/2018. (VII. 5.) of the minister of innovation and technology	*on the amendment to certain ministerial decrees corresponding to atomic energy*
Decree 6/2018. (VII. 19.) of the minister of innovation and technology	*on the amendment to the Decree 55/2012. (IX. 17.) NFM of the minister of national development on special professional and further education of employees of nuclear installations, and on the scope of professionals authorized to perform activities corresponding to use of atomic energy*

A7. NATIONAL ACTION PLAN ON THE IMPLEMENTATION ACTIONS DECIDED UPON THE LESSONS LEARNED FROM THE FUKUSHIMA DAIICHI ACCIDENT

Review of TSR tasks for the period 2016-2018. is described below.

4. Completed TSR tasks

The Hungarian National Action Plan meets the necessary criteria and it is in harmony with the respective ENSREG recommendations. In 2015, in order to keep track of plan implementation, the international review was repeated. In relation to Hungary it was concluded that the progress of completing the tasks is according to the schedule, several tasks were completed within or well within the deadline.

Until the end of 2018 40 out of the 46 tasks were realized. (By 2016, 24 closed tasks were reported as closed in the Seventh National Report).

From 2016 to the end of 2018 the authority closed further 12 tasks, the technical content of 5 actions were implemented, but the administrative part, meaning the modification of internal procedures was not completed. The tasks in delay were re-scheduled in the resolution closing the PSR process. This means 6 tasks. Final deadline of implementation of the re-scheduled tasks is 31 December 2022, as specified also in the PSR.

The licensee has justified in an analysis that the safety risk represented by the remaining tasks is acceptable; the delay of the tasks does not considerably increase the safety risk.

4.1. Actions completed in 2016

1.1.1. The electric supply of machine racks and travelling band screens of the essential service water system was modified to receive power from the safety electric supply. The action was necessary since in a lasting loss of power situation, after certain time, the screens of the BQS pumps at the suction head may clog that can lead to loss of essential service cooling water supply. After the modification, in a lasting loss of normal electric power supply, when 4-unit loss of power situation occurs, the operation of diesel generators ensuring the electricity for the safety systems also ensures the electric power for the operation of the machine racks and travelling band screens for the dirty Danube water, and by this means the essential service water supply can be maintained.

1.1.2. For the situation after a design basis earthquake, water tanks containing demineralized water were constructed to ensure cooling down and maintenance of cold state of Units 3 and 4 reactors. The action was aimed at keeping the level of environmental release to the lowest possible. According to the original design 3 demineralized water tanks were constructed in the direct vicinity of the Sanitary Building, at 2 m of the eastern façade. The tanks have important role during an

earthquake, but the Sanitary Building has never been verified for seismic events, not during the design and neither during the later leakage and lifetime re-calculations. The damage of the building and its eastern façade was dangerous to the tanks and the servicing systems and pipeline. The tanks were reconstructed next to the main building, between the tank house and the machine building where an earthquake cannot endanger the tanks and the servicing pipelines.

1.1.3. Construction of a protection solution against condenser cooling pipeline damage to avoid flooding of the turbine hall and cable tunnels. The justification of the modification is to ensure appropriate protection to shut down the condenser coolant pumps if the cooling pipeline damages due to an earthquake or other cause. After the action the capacities of the pipeline trenches will be appropriate to contain and drain the discharged water. If it is necessary, the dike can be further elevated, or additional dam can be constructed to avoid the flooding of the turbine hall or the cable tunnels. Water proof wall penetrations were constructed to avoid water penetration into the machine room of the essential service water pumps.

1.1.4. Emergency electrical power supply of the submersible pumps of the bank filtered well plant was constructed. The bank filtered well plant provides a permanent water source with a practically unlimited quantity of water independently of the water level of the Danube that can be used in severe accident situation to cool the reactors if the essential service water is lost. In a severe accident situation, the normal electric power supply will be lost, and this is the justification of the modification that consisted of construction of appropriately protected electric power supply of the submersible pumps by permanent or mobile diesel generators.

1.1.5. The way of putting in use of the external cooling supply opportunities for the steam generators have been incorporated in procedures. In particular, an instruction under the Comprehensive Emergency Management Plan (hereinafter referred to as CEMP) was supplemented with the modified coolant supply. The chapters of the instruction describe the possible water sources and connection points and declare that the instructor of the task "shall decide which water source should be used and to which connection point the equipment to supply the steam generators with coolant should be installed". The CEMP also contains the necessary steps to return to normal operation and the requirements for regular maintenance and operability inspection of the pipeline.

1.1.6. The Technical Support Centre in the Protected Command Centre was extended in space and upgraded in instruments to cope with simultaneous severe accident of more units. During the modification, not an independent new system was installed, but a system operated for years was supplemented with two work stations identical to the other operator stations of the center in terms of hardware, software and functions.

1.1.7. The procedure for radioactive waste management for severe accident situations was developed. The risk and potential routes of liquid radioactive releases were examined, and a release monitoring system was installed. Management of liquid radioactive waste in severe accident situation is regulated in the CEMP. The SAMG limits the management of radioactive water in order to

ensure sufficient quantity of water to supply and remove the decay heat. A declared, stable state is required for being able to return to the normal operation radioactive waste management procedures based on the internal regulations. Until that point, the liquid radioactive waste is only stored, and separation of the potentially usable coolant takes place.

1.1.8. The list of those components important to nuclear safety has been determined, which can be susceptible to electromagnetic waves (including the effects due to lightning) and need modification to be protected against the electromagnetic impacts. A detailed EMC compliance review of the equipment and components has been performed and disturbance signal, shielding effectiveness and electrostatic charge measurements have been carried out in the vicinity of the relevant locations of safety systems. Electromagnetic effect of lightning, electromagnetic compatibility and electrostatic discharge tests have also been performed in the vicinity of the susceptible equipment. The tests have not revealed any non-compliance and so no action has been necessary.

1.1.9. Soil liquefaction initiated by an earthquake was not part of the design basis of Paks NPP taking into account that the probability of liquefaction is less than 10^{-4}/year for unloaded soil and especially for the soil loaded by buildings based on the results of site survey and assessment. The seismic PSA, although only rather roughly addressing the risk of liquefaction and especially its consequences, has called the attention to the severity of potential consequences of the phenomenon, and the danger of cliff-edge effect as well as to the need of quantifying the margins available against soil liquefaction. The conclusion from the results has been that soil movements after an earthquake cannot cause unacceptable damages for the buildings, civil works and underground lines.

4.2. Tasks completed in 2018

1.2.1. For the inoperability of the essential service waster system, the cooling water source available from the closed section of the discharge water canals can be used to supply the nearby, diesel-driven fire water pump station of Units 3 and 4. Based on the design, the fire water system has two roles in an emergency situation: to supply fire water and to supply cooling water to the essential service water system while the water level in the discharge water canal makes it possible.

1.2.2. A severe accident training programme was developed for the Emergency Response Organization (hereinafter referred to as ERO) Technical Support Centre personnel, shift engineers, unit shift supervisors and ERO Managers. In the practical session of the training, understanding of severe accident scenarios and SAMGs and effective use of the severe accident measurement chain took place by using the severe accident simulator. The training programme contains basic and refreshing components and cyclic practical sessions.

5. Actions that can be completed with a close deadline

2.1. Construction of storage capacities for water from external alternative source and opportunity to set the boron concentration has been established. However, the second part of the action, the modification of the SAMG to describe how the coolant path should be set to use this water source is still pending. After completion of the administrative modification the action could be closed.

2.2. An alternative way of supplying external cooling water to the spent fuel pools from a yard area connection point, suitable for flexible hose connection, has been implemented. However, the modification of the SAMG procedures to describe how it can be operated in severe accident is still pending. After completion of the administrative modification the action could be closed.

2.3. The opportunity for alternative direct water supply of the spent fuel pool protected against external hazards should be integrated into the existing procedures (as for other TSR actions). The possibility of using the new borated water source should be examined in all SBEOP and SAMG strategies (supply to main cooling circuit, hermetic compartments). The modified SBEOP and SAMG will be part of the standard training material. Emergency response to severe accidents has been extended to manage multi-unit events. The Support System Guideline (SSG) will be developed, this will be referenced in the other procedures (SBEOP, SAMG). After development of the SSR and inclusion of references the task could be closed.

2.4. Seismic modification of the shelters (No. 1009 and 1010) has been already completed and accepted by the HAEA. Reinforcement of the building structure of the Protected Command Centre has been completed, but the task is not yet closed due to administrative deficiencies.

2.5. Based on the construction license, the local works in the scope of Safety Class 3 (ABOS3) have been completed (reinforcement of air technique support, partition wall, purchase of diesel generator, building of storage building). Modification of the Protected Command Centre is Safety Class 4 scope (partition wall, electric assembling, climate assembling).

6. Tasks rescheduled by the PSR resolution

3.1. Protection of the personnel and equipment shall be ensured by the reinforcement of the fire brigade barrack also for design basis earthquake. Based on the decision of the Technical Meeting, instead of construction of a new fire brigade barrack, the renovation of the existing barrack will take place. The technical specification was developed, its coordination and approval are in progress. After approval of the specification, the public procurement process for the design will be launched.

New deadline: 31.12.2021.

3.2. Severe accident diesel generators protected against external hazards (earthquake, extreme weather conditions, flooding) and having independent supplies (of the other water and electric power supply of the nuclear power plant) shall be installed. The design basis of the diesel generators shall consider:

- *In all such accident situation, when total loss of on-site power should be considered, it shall be able to supply all necessary consumers;*
- *Involvement of the other (even all) units shall be assumed in the accident;*
- *The cooling requirements of the reactor and the spent fuel pool shall be taken into account;*
- *They shall be available even if the design basis loads of the currently installed emergency diesel generators are exceeded;*
- *The accident diesel generator shall be able to fulfill its task on the long term (e.g. exceeding the mission time of the installed emergency diesel generators).*

The company manufacturing the previously selected Cummins diesel generator indicated that due to profile cleaning, it did not want to deliver diesel generators to the nuclear power plant. In spite of that, the Cummins undertook the transfer of two diesel generators but wanted to modify the contract and specify such a technical condition system (on the installation, running, commissioning, test operation), which made the project impossible, since the parameters did not satisfy the conditions specified in the technical specification determined according to the TSR. It was concluded that new type of diesel generators shall be designed for the project.

New deadline: 31.12.2021.

3.3. The system preventing slow over-pressurization of the containment shall be implemented. Agreement was reached with the contracted party, the design process has been completed, licensing is expected to start in 2019.

New deadline: 31.12.2021.

3.4. Construction of a Backup Command Centre equivalent to the Protected Command Centre. During the construction and modification licensing of the Backup Command Centre the deficiencies revealed by the HAEA had been managed, the licenses has been issued. The public procurement process for the implementation has been completed, however, the costs are disputed with the constructor, which hinders the progress of the project. Related to the task, the other task 1.31 related to the Backup Command Centre, requiring the installation of the informatics mirror storage computers is also to be implemented.

New deadline: 31.12.2022.

3.5. The amendment to Govt. Decree 346/2010. on the government purpose networks that took place in April 2017 requires the licensee to use the Unified Digital Radio System in wireless communications. The technical specification has been completed. The development plan has been completed and approved. The

public procurement process is in progress, the construction is expected to start in 2019.

New deadline: 31.12.2021.