Hungarian Atomic Energy Authority

Hungary's Situation on Managing and Transport of Spent Nuclear Fuel

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advisor

Hungarian Atomic Energy Authority (HAEA)

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Duties of the Hungarian Atomic Energy Authority

- HAEA, established on January 1, 1991
- Public budget organization performing tasks of public interest
- Supervise peaceful, safe and secure application of atomic energy and guarantees it towards the public

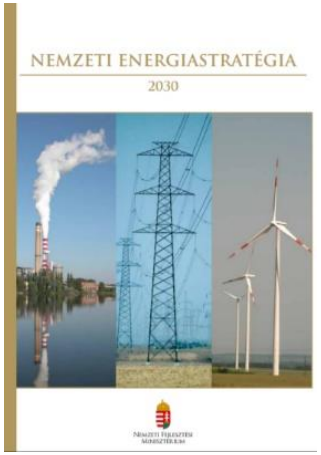






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Hungary's energy strategy



Nuclear power has ~ 50% share in domestic electricity generation

National Energy Strategy (2011) - Long-term commitment to nuclear energy

- **Lifetime extension of the four (VVER-440) units of the Paks NPP** (1982-87, 2012-17), plus 20 years
- **Capacity of the Paks NPP shall be substituted by commissioning new nuclear capacities in due time: two new units (VVER-1200) in Paks (2025-26, 60 years) are in preconstruction phase**

Safe management of RW and SF is essential in the context of Hungary's energy strategy.

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National Policy on SF – principles

Radioactive Waste and Spent Fuel Management Directive in EU *(Council Directive 2011/70/Euratom)*

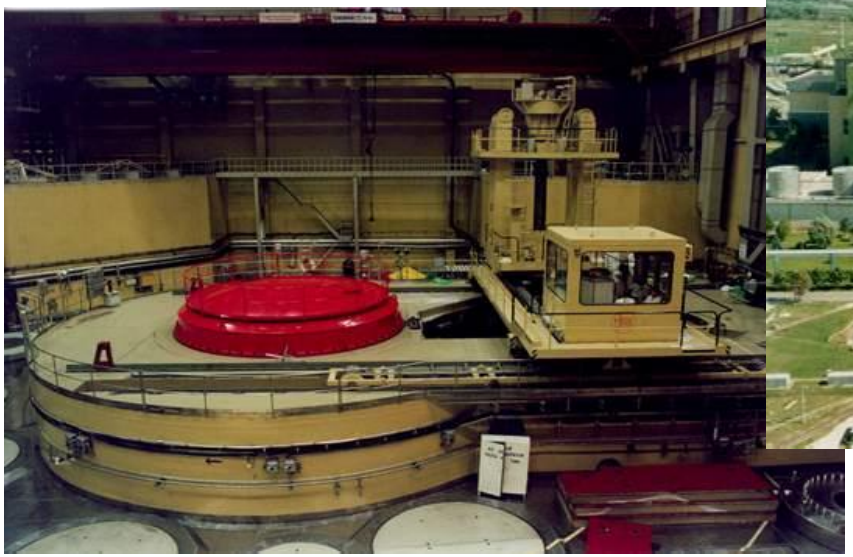
Spent fuel (and radioactive waste)

- shall be managed by recognizing the **ultimate responsibility of the Hungarian State;**
- **shall be disposed of in Hungary** unless an agreement has entered into force between Hungary and another Member State or a third country;
- shall be managed **without place any undue burden on future generations**

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NUCLEAR FACILITIES (1)

- 4 units of the Paks NPP (VVER 440/213 type)





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Paks Nuclear Power Plant

- It operates four identical pressurized water reactors (PWR) of **VVER-440/V-213 type**; both the moderator and the coolant of the reactors are light water.

- The **fuel of the reactors is uranium dioxide**;
  the maximum fuel enrichment is **4.7 %**.

- In each reactor 349 assemblies can be inserted into each reactor core,
  312 out of these are **fuel assemblies** (37 are control rods with follower assemblies).

- The original **nominal thermal power** of each unit was 1375 MW, and the nominal electric power outputs of the four units were 440 MW. As a result of the power uprating program realized between 2006 and 2009, the thermal power of each unit has increased to **1485 MW and the electric power to 500 MW.**

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Nuclear fuel used at Paks NPP

- Nuclear Fuel Assembly designer and manufacturer: TVEL , Russia
- Type of FA: 4.2% and 4.7% with Gd
- Number of fresh fuel / year: 102
- Spent fuel: **after minimum three years of cooling** in the pool **on-site movement** to the **Spent Fuel Storage** facility (not defined as ‚transport')
- **Burn-up issue** *(~30-50 MWd/kg U in the Spent Fuel Storage facility):*

Technological limits prescribed by the manufacturer of FA:
- 58 MWd/kg U for a **fuel assembly**
- 65 MWd/kg U for a **rod**
- 74 MWd/kg U for a **pellet**

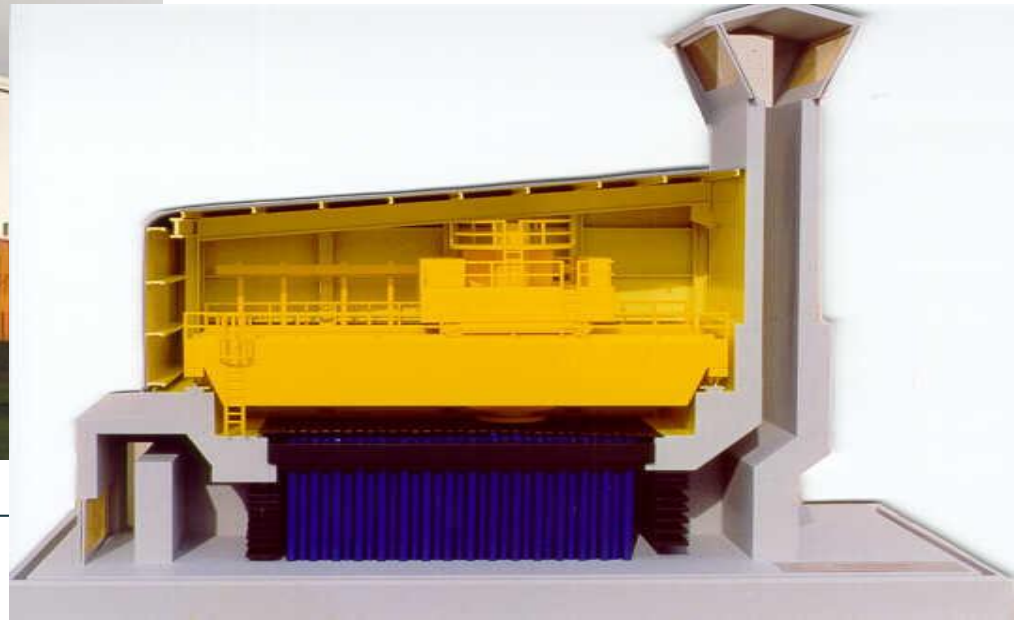
No legal definition of high-burnup fuel –
technical parameters as limitations are used.

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NUCLEAR FACILITIES (2)

- Spent Fuel Storage (Modular dry vault type)
  same site as NPP





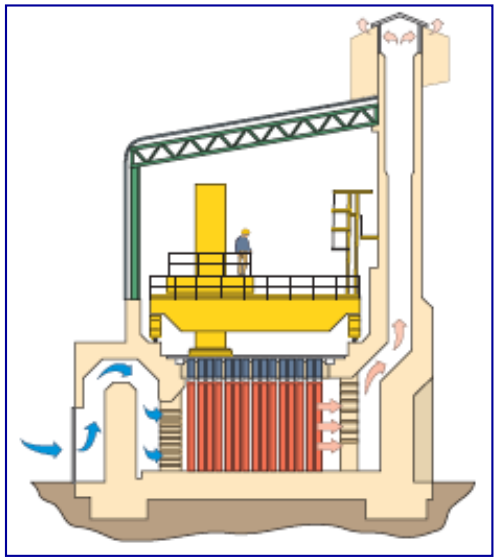
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Spent Fuel Interim Storage Facility

SFISF: *Entered into operation in 1997 with 3 vaults*

- Modular vault dry storage (MVDS) type, planned for 50 years of storage
- SFAs in tubes in inert N_2 atmosphere, cooling is provided by passive airflow
- Exclusively for SFs from the storage pools of Paks NPP after min 3 years cooling





- In **September 2019, 9397 SFAs** were stored in the facility ***(+690 since December 2016)*** (*acceptance is limited to 500/year)*
- Current total capacity: 11 416 SFAs in 24 vaults
- Total capacity need till the end of the life time: 17 717 SFAs

Continuous improvement in the SFISF:

- Construction of new vaults for extension
- Reconstruction and modernisation of control technique
- **new storage concept** aiming to further increase the number of SFA's in a vault
  - **Idea:** detailed safety analysis (criticality, heat generation, radiation protection) shows that SFAs have been cooled for decades can be stored in modified vaults with **significantly denser storage tube arrangement.**
    (Taking advantage on SF having been stored/ cooled for decades in SFISF, the arrangement of storage tubes in the future modules can be denser than earlier.)







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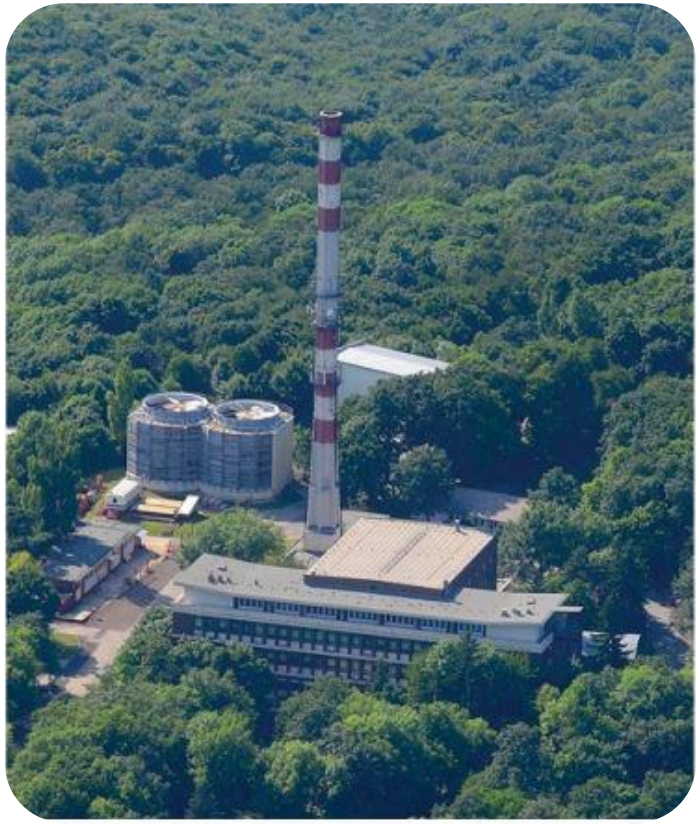
NUCLEAR FACILITIES (3)

- Budapest **Research Reactor**
  (10 MWth VVR SM type)



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Budapest Research Reactor /cont'd/



- VVR-type
  (light water-cooled, water-moderated)
  Soviet design **10 MWth reactor**.
- It went critical in 1959 (2 MWth), total refurbishment: 1993.

- **Core conversion -> 19,75%**

The conversion has been completed in 2012 (the previous 36% enrichment fuel assemblies were removed).

- The purpose of the research reactor is training, neutron-physics, reactor-physics research and radioactive isotope production

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Budapest Research Reactor /cont'd/

Main technical data

Reactor type: with beryllium reflector	Light-water cooled and moderated tank-type reactor
Fuel:	**VVR-M2; 19,75 % ^{235}U initial enrichment**
Core geometry:	Hexagonal (height: 600 mm; diameter: 1000 mm)
Core content:	**190 fuel assemblies**
Nominal thermal power:	**10 MW**

SFAs are stored in an inside interim SF storage

Inventory: Sept 2019 156 SFA

Dec 2016: 104 SFA *(Δ52)*

- **Average burnup in the core: ~38 MWd/kg U**
- **Average burnup in the interim SF storage: ~58 MWd/kg U**

- Technical limitation for FA: **maximum 5 years in the zone** – according to the manufacturer company *(stated in the certificate)*

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NUCLEAR FACILITIES (4)

Budapest Technical University Training Reactor
(100 kWth pool type)





Budapest Technical University Training Reactor



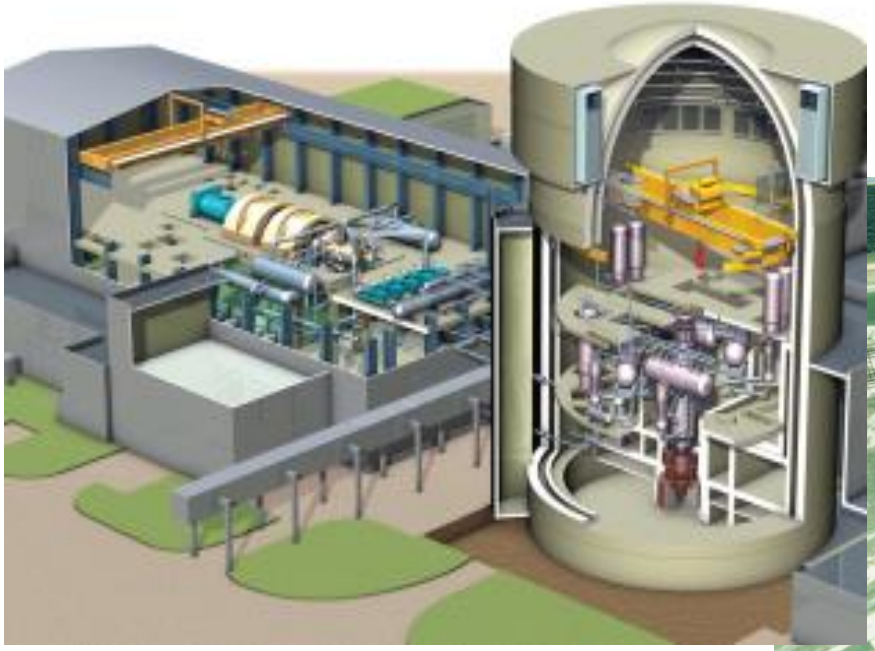
- pool-type (water moderated, water cooled, with graphite reflector) nuclear reactor has been in service since 1971
- operating with a core built of EK-10 (uranium) fuel assemblies (23-24 assemblies in Al cladding) having **10% enrichment**
- maximum thermal power is 100 kWth
- research and training purposes (neutron-physics, reactor-physics research, instrumentation development, activation analysis and radiochemistry)

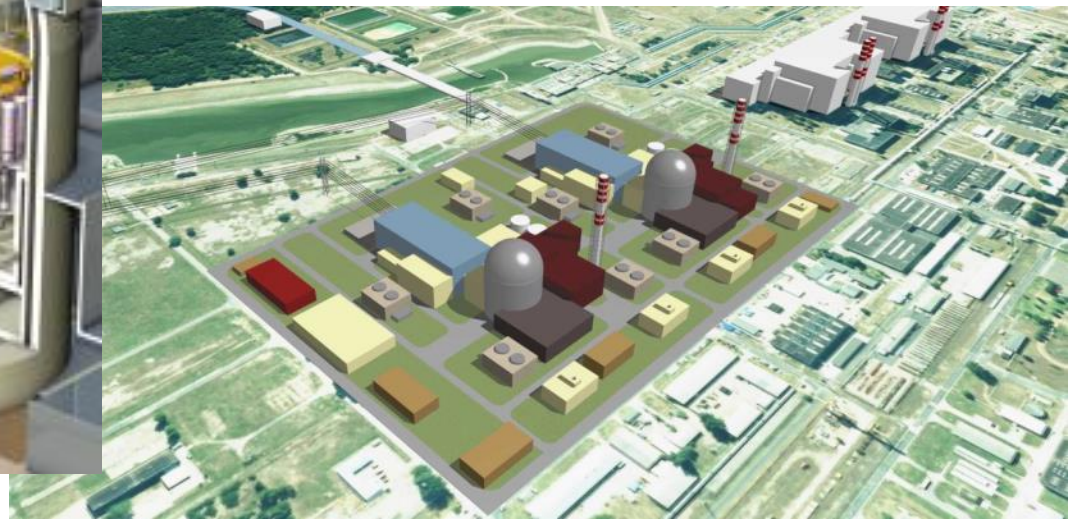
The **fuel has not been replaced** since the startup of the reactor (1971).
The **average burnup** of the fuel can be calculated from the integrated released energy, which is approximately 400 MWdays.
This corresponds to a burnup level of **0.7 MWdays/kg.**

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NUCLEAR FACILITIES (future)

- New reactors: units 5 and 6 at Paks Nuclear Power Plant





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Construction of new reactors - in progress



2014: Intergovernmental agreement on the peaceful use of nuclear energy by Russia and Hungary

- Two VVER-1200 type reactors at the Paks site
- Implementation agreements

(MVM Paks II. NPP Development Ltd. -Russian Joint-Stock Company Nizhny Novgorod Engineering Company Atomenergoproekt)

- EPC contract (Engineering, procurement, construction and commissioning)
- Operation and maintenance support contract
- **Agreement detailing fuel supply and the handling of spent fuel**

The European Commision's direct approval was necessary for the third agreement

2017: Site License was issued

Now: waiting for the Construction Licence Application

*Commissioning Licence shall be granted only if the safe storage of radioactive waste and **spent nuclear fuel** is ensured in harmony with the latest justified scientific results and international expectations and experiences.*

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FA in the *'future-NPP'*

- The agreement detailing fuel supply and the handling of spent fuel states that **Hungary will buy nuclear fuel from Russia** for twenty years.
- The parties also agreed that **spent fuel can be stored in Russia** for twenty years **or reprocessed by them** before being returned to Hungary.

- Type of the fuel: not decided yet, could be MOX, too

All experiences on transport of MOX from other MS are very welcomed for Hungary for future challenges

National Programme for RW &SF management



Paks NPP



Storage of SF

SFISF, Paks



Training & research reactors

Other institutions

Non NPP SF

Russia

Storage of long-lived waste

Disposal of institutional LILW-SL

Disposal of operational and decommissioning LILW-SL

Disposal of operational and decommissioning HLW and LILW-LL

Decision

Disposal of SF

Disposal of vitrified HLW



RWTDF, Püspökszilágy

NRWR, Bátaapáti





Future HLW repository

Disposal of long-lived waste

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SF transport experiences

NPP: no transport of SF during normal operation of the NPP
as the SFAs are **stored in the SFISF** at the same site
(considered as MOVEMENT)

Research Reactor: rare occasion for transport of SF from the BRR
(core conversation in 2012 – not a real high-burnup SF)

Training Reactor: the fuel has never been replaced –
if once it will be removed: not high burnup fuel transport

Future NPP: fuel ?? could be MOX

Transport examples: (1) repatriation of HEU SF to Russia
(2) damaged spent fuel transport to Russia

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(1) Repatriation of HEU SF

- HEU spent fuel from Budapest Research Reactor To Russian Federation:

  The last HEU transport container left the territory of Hungary November 2013

- Completion of repatriation project 2008-2013
  US Government, GTRI

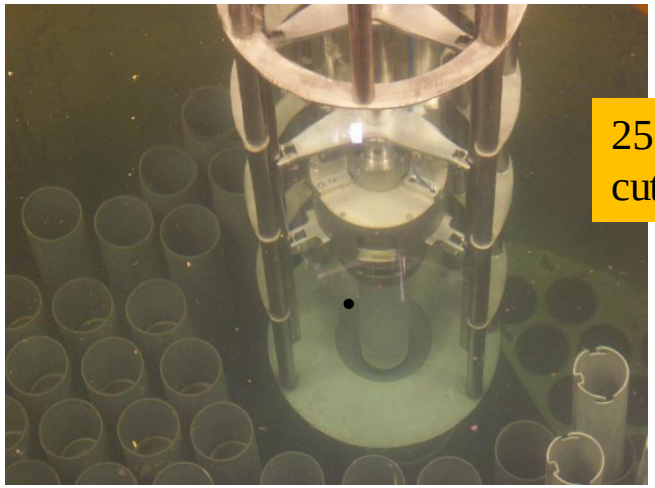


- Hungary was the ninth nation which completely **removed all HEU fuel** from its territory.

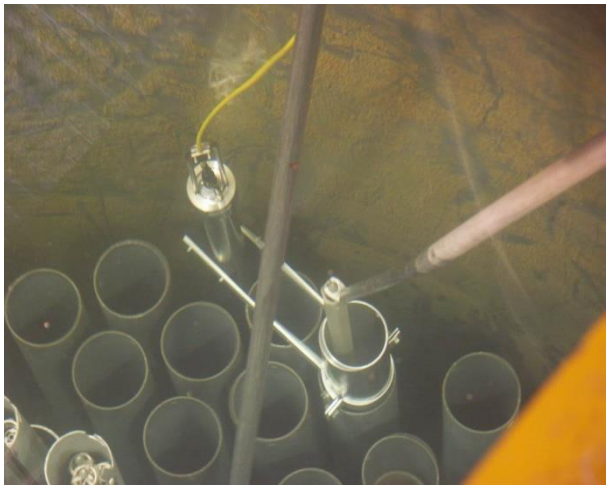
  (Fulfillment of commitment from the Nuclear Security Summit in 2012, Seoul)

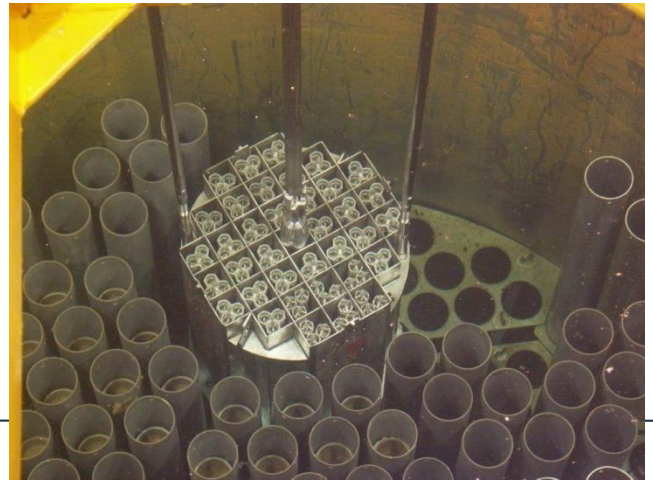
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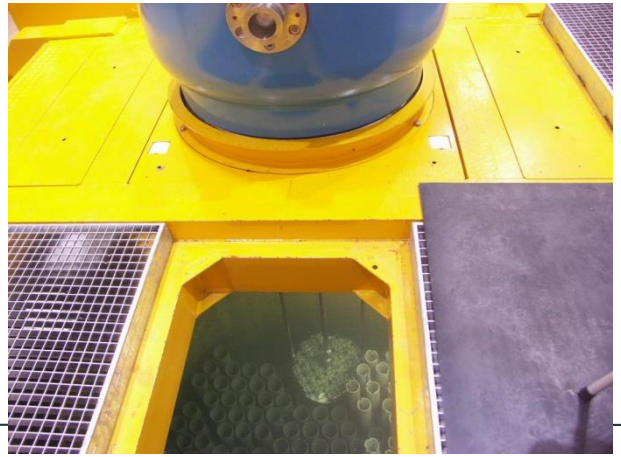
Preparing for the loading (cutting and IAEA inspection)



252+82
cutting







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Road transport of the loaded containers













Rail transport of the loaded containers (*Budapest-Koper/SLO/*)









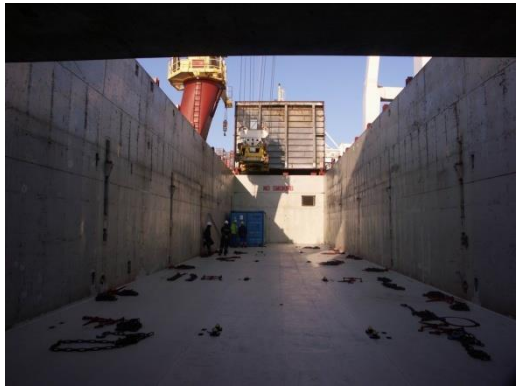


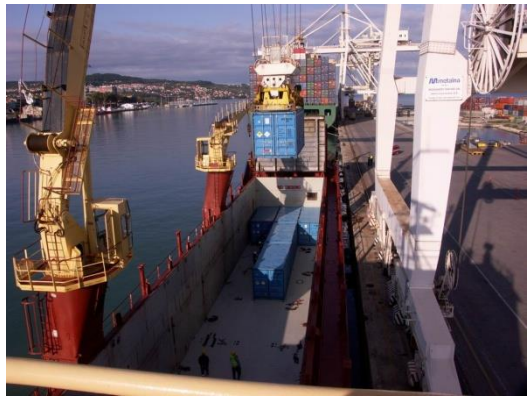


Maritime transport of the loaded containers

(Koper/SLO – Murmanszk /RU)











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(2) Damaged SF Issue at Paks NPP



Apr 2003: Fuel cleaning incident (INES 3)

Cause of the incident: inadequate cooling of the fuel elements in the fuel rod cleaning system, which were heated due to the radioactive decay of short-lived fission products. These were kept cool by water circulated by a submerged water pump. However the cooling was inadequate, leading to the damage to some elements through a build-up of steam around them, depriving them of most of their cooling. The investigation proposed that the severe damage probably occurred **when the lid was released**, causing **thermal shock to cladding** because of the sudden entry of cool water into the system, and explosive steam production

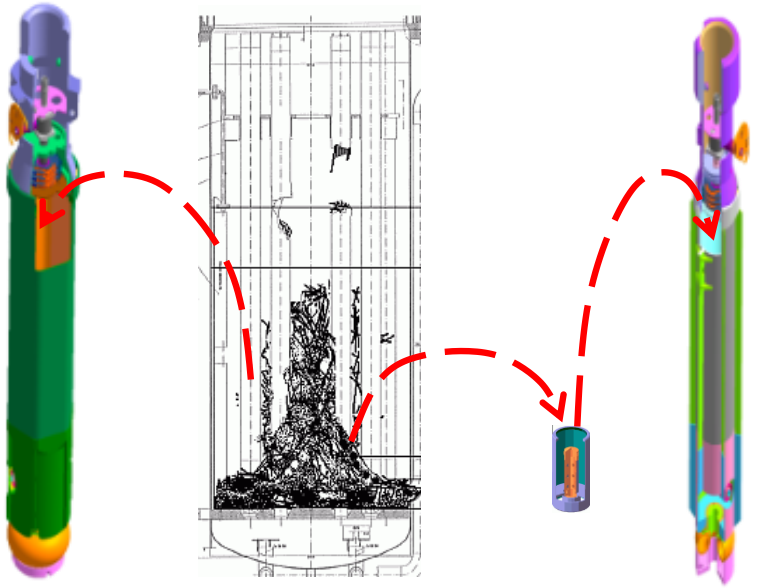


- **cladding** on the majority of the 30 fuel elements **had been broken**, with radioactive **spent uranium fuel pellets** spilling from the elements **into the bottom of the cleaning tank**

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Management of the damaged SF

- The 30 fuel assemblies that became damaged during the incident in 2003 were loaded into **68 capsules** after their removal from the cask in 2006-2007.
- The goal was to **prepare the encapsulated fuel** for dispatching and reprocessing in Russia.



- Transportation was coordinated by Hungarian experts with the involvement of Russian experts

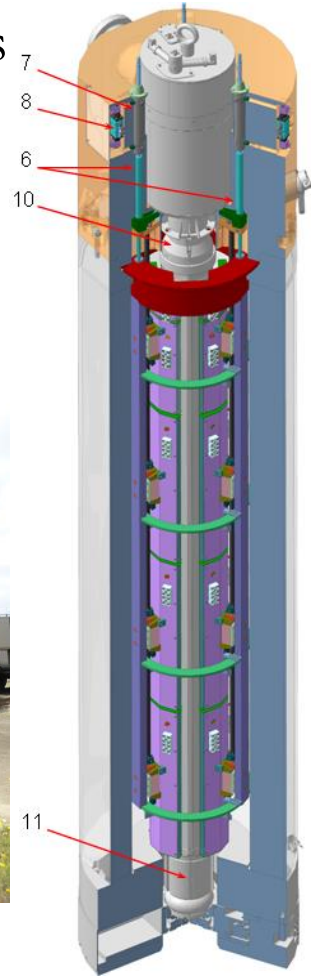
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Transportation to Russia

- The drying of the capsules was executed in 2013, the capsules were successfully shipped to Russia in 2014.







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Transport requirements: SSR-6, ADR/ADN/RID

- Both shipments were carried out according to the **IAEA Regulations for the Safe Transport of Radioactive Material** (now: SSR-6, previously TS-R-1)

As Hungary is a contracting party to the international agreements concerning the mode specific regulations of dangerous goods: the obligations appears in the national legislation as e.g.:

- European Agreement Concerning the International Carriage of Dangerous Goods by Road **(ADR)** - **Class 7: Radioactive materials**

- Convention concerning International Carriage by Rail (COTIF) Appendix C Regulations concerning the International Carriage of Dangerous Goods by **Rail (RID)** Annex - **Class 7: Radioactive materials**

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Link between IAEA SSR-6 and the mode specific transport regulations of RM

IAEA Safety Standard Series No. **SSR-6**
Regulations for the Safe Transport of Radioactive Material

Only RM

UN Model Regulations on the Transport of Dangerous Goods

All DG incl. RM

ADR/RID/ADN
by UNECE
(road, rail, inland water)

IMDG Code
by IMO
(maritime)

ICAO TI (A. 18)
by ICAO
(air)

All DG incl. RM

Appear in the Hungarian legislative system : OBLIGATORY REQUIREMENTS

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Answers to the Participant Questionnaire

1. In Hungary MOX has never been used so far.
Due to the normal operation of the NPP **690 SFA** has been moved to the Spent Fuel Interim Storage Facility since **December 2016** and **at the Research Reactor +52 SFA is stored** - changing the spent fuel inventory.

2. There is **no legal definition** for **high-burnup UOX** as the control and operation of nuclear facilities is not based on the burnup of the fuel but other parameters and conditions **defined by the manufacturer** of the fuel.
In scientific documents ~50 MWd/kgU is referred as appr. value for high burnup SFA.

3. No use of MOX fuel and no legal definiton for MOX in Hungary.

4. Management of spent fuel is not based on its burnup so unique operation constraint does not exist.

5. No example in Hungary for MOX spent fuel transport. Two cases have been presented, when HEU or damaged fuel were transported with special reasons.

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6. No additional technical and regulatory requirements for transport of higher burnup spent fuel compared to the requirements of IAEA SSR-6.

7. There is no difference in the approach to assess the structural performance of the various burned-up spent fuel.

8. No experience of MOX/high burnup spent fuel transport.
The requirement of SSR-6 are obligatory through the mode-specific regulations for transport of dangerous goods: ADR/RID/ADN, IMDG Code, ICAO TI

(a) **Confinement system** (SSR-6 Para 681): ADR/RID: *„**6.4.11.9** It shall be assumed that the confinement system is*

(b) **Containment system** (SSR-6 641, 642, 645) ADR/RID: *„**6.4.7.7** The design shall include a*

(c) **Heat dissipation** (SSR-6 653-666) **ADR/RID: *„6.4.8.2*** *A package shall be so designed*

(d) **Shielding** (SSR-6 617) ADR/RID *„**6.4.2.11** A package shall be so designed that it provides sufficient shielding to ensure that, under routine conditions of carriage and with the maximum radioactive contents that the package is designed to contain, the radiation level at any point on the external surface of the package would not exceed the values specified in 2.2.7.2.4.1.2, 4.1.9.1.11 and 4.1.9.1.12, as applicable, with account taken of 7.5.11 CV33 (3.3) (b) and (3.5).*

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9. The two transport events which have been presented involved not high burnup nor MOX fuel but HEU and damaged spent fuel.

10. No new cask designs appeared in Hungary dedicated to transport of higher burnup/MOX spent fuel.

Contact:

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Nuclear Fuel Cycle in Hungary

Fuel assemblies imported



Closed Uranium mine
(yellow cake - extraction from water)



Power reactors



Research reactor



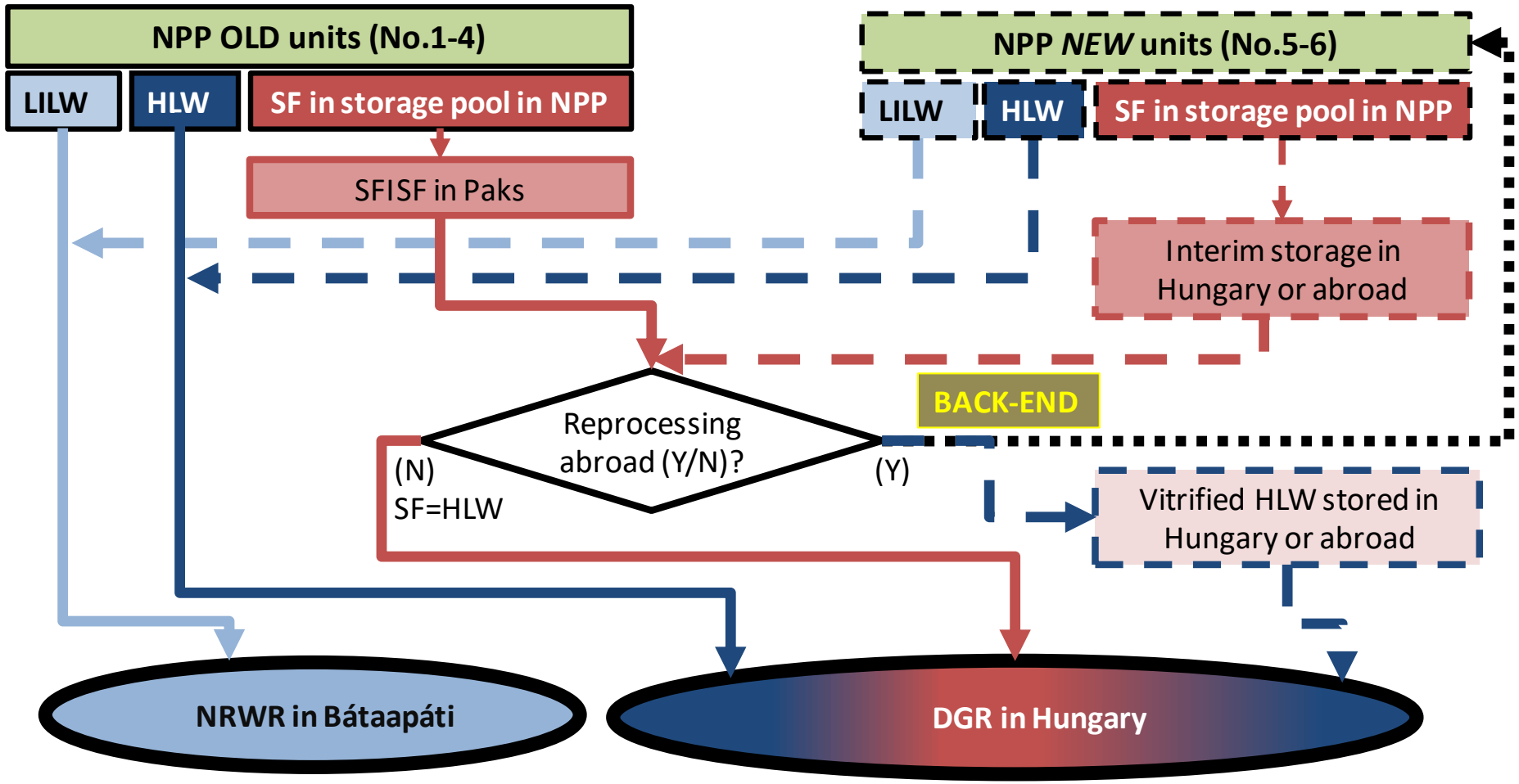
Training reactor



Interim storage of spent fuel

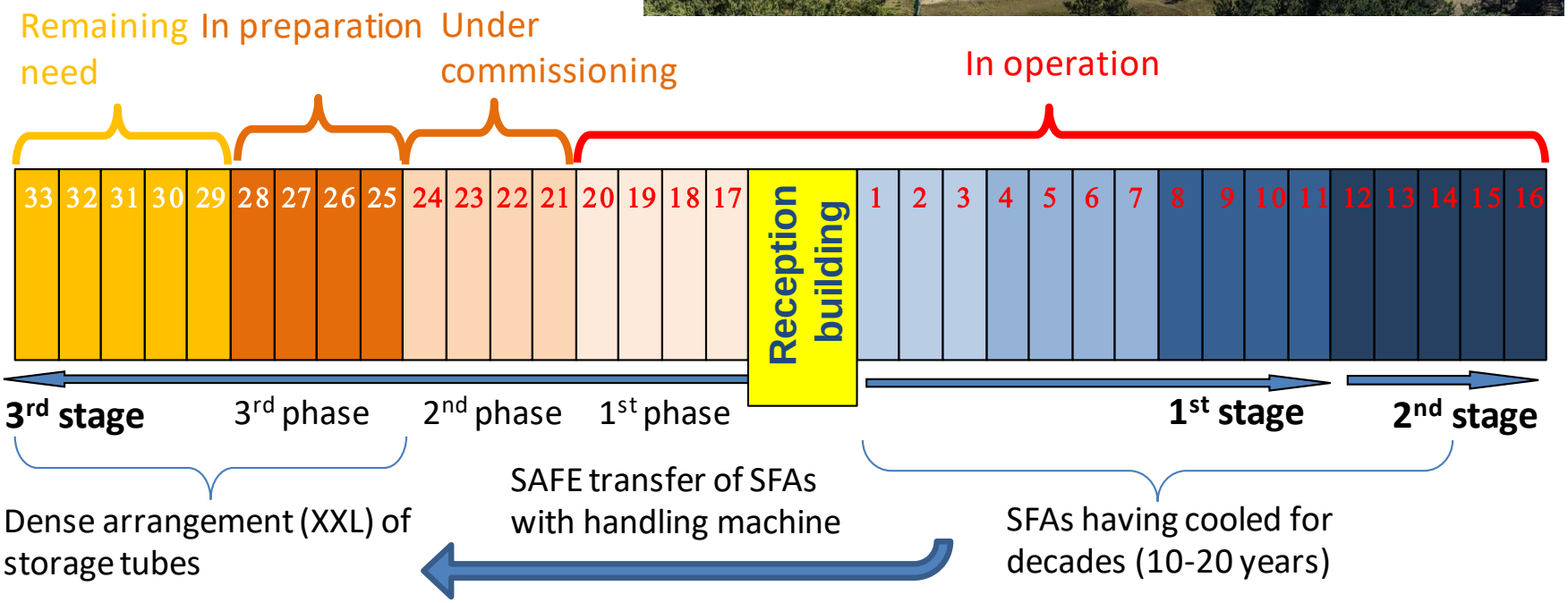
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Effects of new units



Extension of SFISF





	No. 25-33	No. 17-24	No. 1-16
Capacity	703 SFAs(XXL)	527 SFAs (quadrangular)	450 SFAs (triangular, original)
Emplacement	transfer from the tubes where SFAs have been already cooled for decades in SFISF	directly from NPP storage pools	directly from NPP storage pools