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National policy of spent fuel management for MVM Paks NPP reactors

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Four VVER-440/V213 units each with 500 MW electrical capacity

Started in the years: 1983, 1984, 1986 and 1987

Up-rated in the years : 2007, 2008, 2009 and 2006

15 months fuel cycle: 2016, 2015, 2015 and 2016

Planned operation till: 2033, 2034, 2036 and 2037

Electricity production (2016): 16 054 GWh

- All units operated exclusively with VVER-440 fuel
- Vendor: JSC TVEL (and predecessors)
- Recent long term fuel supply contract since 1999
- Good operational experience with high quality fuel
- Excellent fuel reliability allows continuously high load factors for the units
- Continuous modernization in order to achieve more efficient fuel management
- Growth of the average and maximum discharge fuel burn-up

Enrichment: 4.2% and 4.7%	
Maximal calculated burnups:	
Assembly	54-58 MWd/kgU
Pin	60-65 MWd/kgU
Pellet	70-74 MWd/kgU

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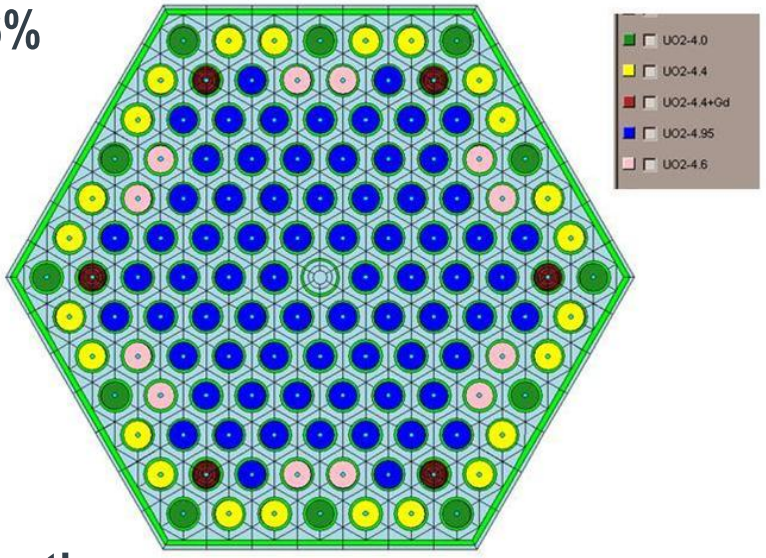
Fuel for the recent, 15m cycle option

- VVER-440 standard 2nd generation fuel assemblies with a hexagonal shroud tube, central tube and 11 spacer grids
- 126 fuel rods with enrichments: 4.0%, 4.4%, 4.6% and 4.95%
- Average enrichment: 4.7%
- Six rods with UO_2-Gd_2O_3 pellets
- Enrichment profile is unique and optimized for our reactors to enable 15 months cycle
- None of the VVER units are operating with 15 months cycle
- Fuel cycle: 4 x 15 month; 102 assemblies/15 months

  (78 ass. with 4.7% and 24 ass. with 4.2%)

Profilisation of fuel assemblies,
type: 1035, 1036
(Average enrichment of FAs: 4,7%)

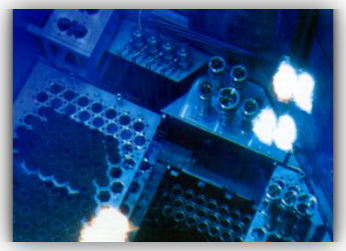


Amount of spent fuel in Hungary

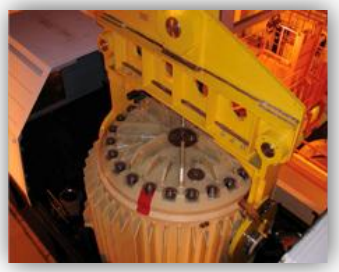
Source of spent fuel	Generated amount of spent fuel	
	No. of Fuel assemblies	Mass of heavy metal
Paks 1-4 operation	17 716	2 126 t
Paks 5-6 operation	6 100	2 874 t
Total:		4 999 t
Training reactor operation	56	69 kg
Budapest Research Reactor operation	1 092	240 kg
Total:		309 kg

Spent fuel policy

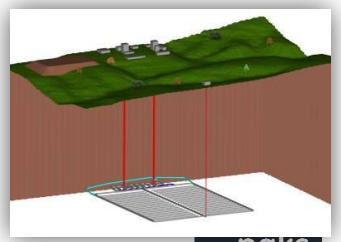
- First step: at reactor storage during 3-5 years (spent fuel pool)



- Second step in the past (until1998): spent fuel reprocessing at Mayak without sending back the HLW – 2331 FA

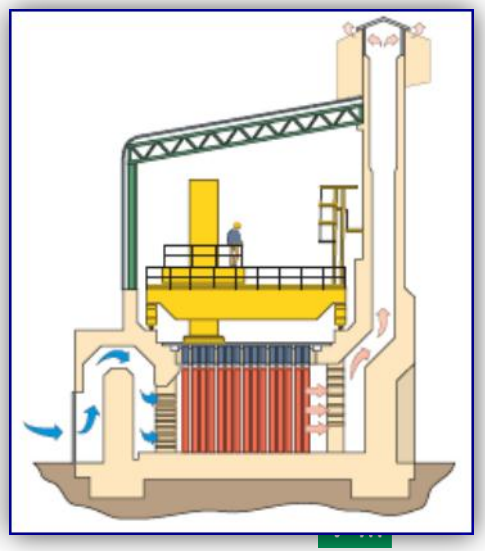


- Second step at the present: Interim Spent Fuel Storage Facility (storage duration: appr. 50 years) – 9007 FA
- About 5000 tHM of spent fuel is expected from the operation of recent and new Hungarian reactors.
- Third step, long term solution is uncertain; present reference scenario is: direct disposal in a Hungarian deep geological formation



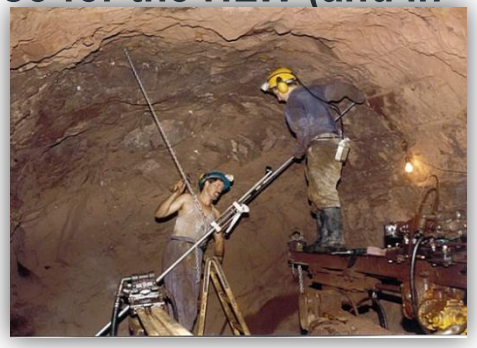
Interim storage of the spent fuel

- ISFS facility (commissioned in 1997)
- Modular, vault type, dry storage facility
- The individual fuel assemblies are stored in tubes, filled with inert N_2 atmosphere
- The cooling is provided by passive air flow
- Present capacity of ISFS facility: 9308 FAs in 20 vaults (more than 9000 FAs stored at the moment)
- Expansion (4 new vaults) in progress, but a total of 36 vaults are possible (for more than 17 000 FAs - all spent fuel from Paks unit 1-4)

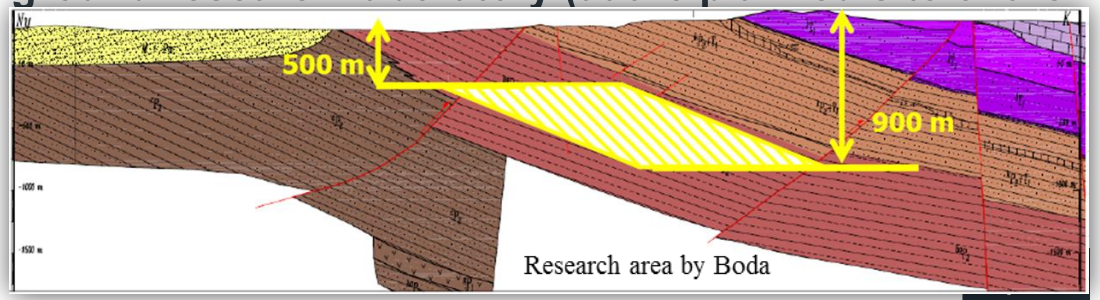


Final disposal facility for HLW and spent fuel

- No final decision has been made on the management of spent nuclear fuel. Reference scenario: direct disposal of SF.
- The construction of a deep geological repository is necessary also for the HLW (and in case of reprocessing for the residual waste).
- Boda Claystone Formation as possible site selected
  - investigated as part of the Mecsek Uranium Mine
  - 1995–98: investigations in a depth of 1000 m
  - 2003: investigation process was resumed
  - geological disposal facility planned in a depth of 500-900 m



- No evidence found that may exclude the suitability of this potential host formation.
- Important milestones expected:
  - Research program: 12 deep bores (400–1600 m)
  - 2030: establishment of underground research laboratory (at the planned site of the disposal facility)
  - 2055: start of construction
  - 2065: commissioning of the disposal facility



Legal basis - Atomic Energy Act

- Lays down the basic principles
- Defines the main tasks - PURAM was appointed
  - Development of the National Policy and National Program,
  - Final disposal of RW,
  - Interim storage of SNF and the back-end of the fuel cycle,
  - Decommissioning of nuclear facilities.
- To cover the above mentioned tasks the Central Nuclear Financial Fund was established in 1997
- MVM Paks NPP is the major contributor to this fund

Public Limited Company for Radioactive Waste Management

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National Program - Management of spent fuel

- MVM Paks NPP is operating within the European Union
- 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
- EU countries draw up and implement national programs for the management, including the disposal, of all spent nuclear fuel and radioactive waste generated on their territory
- EU countries should have in place a comprehensive and robust framework and competent and independent regulatory body, as well as financing mechanisms to ensure that adequate funds are available
- Public information on radioactive waste and spent fuel and opportunities for public participation are available
- The export of radioactive waste for disposal in countries outside the EU is allowed only under strict conditions.

National Program - Management of spent fuel

- Possible scenarios according to the National Program:
  - A: Direct disposal of the spent fuel – reference scenario
  - B: Reprocessing of the SF with or without interim storage
  - C: Advanced reprocessing of SF (separation of minor actinides) – industrially not available at this moment, further research needed.
- Use of any reprocessed fuel is not feasible on the recently operating units; MOX/REMIX fuel could be possible later on for VVER-1200 units
- The construction of a deep geological repository in Hungary is necessary also for the HLW and in case of reprocessing for the residual vitrified waste.

- Decision points defined in the National Program
  - Interim storage of SF from Paks-2 (in Hungary or in a foreign country);
  - Decision on reprocessing (early, during decommissioning or never)
  - Early: no further expansion of ISFS – but interim storage of vitrified waste and advanced need for financing
  - Use of reprocessed U and Pu;
  - Interim storage of vitrified waste (location and duration).

Financing

- Central Nuclear Financing Fund (KNPA)
  - Separated state fund
  - Under the supervision of Ministry of National Development
- All users of nuclear energy generating radioactive waste or spent fuel during their activity shall bear costs of the waste management (in case of nuclear installation: decommissioning as well)
- Paks NPP: annual payment to KNPA
- Main tasks of KNPA: financing the costs connected to the
  - Interim storage of spent fuel (7%)
  - Final disposal of L(M)LW (8%)
  - Spent fuel and HLW (48%)
  - Decommissioning of the facilities - Units 1-4 and ISFS (22%)
- New units: payment starts with the commercial operation of Unit 5 and Unit 6.
- Annual payment is calculated based on the cost estimation of the long term program taking into account the actual discount rates


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Thank you for your attention!