National policy of spent fuel management for MVM Paks NPP reactors

Nuclear Engineering Department
MVM Paks Nuclear Power Plant Ltd.
Hungary
Four VVER-440/V213 units each with 500 MW electrical capacity


Planned operation till: 2033, 2034, 2036 and 2037

All units operated exclusively with VVER-440 fuel supplied by the Russian vendor
New-build project, Paks 5 and 6

- Intergovernmental agreement in 2014 by Russia and Hungary
- Two VVER-1200 type reactors at the Paks site (operation starts from 2026)
- Russian fuel supply for the first period of operation
- Possibility for cooperation in SF management (interim storage and/or reprocessing)
- Residual waste would be transferred back to Hungary
### Amount of spent fuel in Hungary

<table>
<thead>
<tr>
<th>Source of spent fuel</th>
<th>Generated amount of spent fuel</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>No. of Fuel assemblies</td>
</tr>
<tr>
<td>Paks 1-4 operation</td>
<td>17,716</td>
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<tr>
<td>Paks 5-6 operation</td>
<td>6,100</td>
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<tr>
<td><strong>Total:</strong></td>
<td></td>
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<tr>
<td>Training reactor operation</td>
<td>56</td>
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<tr>
<td>Budapest Research Reactor operation</td>
<td>1,092</td>
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<tr>
<td><strong>Total:</strong></td>
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Spent fuel policy

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

- Second step in the past (until 1998): 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

- 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 (first module 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)
Interim storage of the spent fuel

- ISFS design lifetime is 50 years (2047)
- The central reception building and the relating technology were commissioned together with the first three chambers in 1997
- The operation and maintenance is carried out by the NPPs staff
- Legislation in force requires with a frequency of 10 years the implementation of a Periodic Safety Review
- Based on the extension of the lifetime of the Paks NPP and in accordance with the planned date of commissioning (2065) of the deep geological repository
- The design lifetime of the facility must be extended with 25 years until 2072
- The license renewal is going to start after the full completion of the ISFS with 36 vaults (in 2035)
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
National Program - Management of spent fuel

- MVM Paks NPP is operating within the European Union
- 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 (1)

- 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
  - none of the VVER-440 units are licensed for MOX fuel
  - manufacturing Pu based fuel is still more expensive then using LEU
  - full recycling would not be possible based on four operating units (with less than 20 years of remaining life time)

- Feasibility of reprocessing should only be based on decreased interim storage and disposal costs
  - long term storage of separated Pu should be solved
  - interim storage of vitrified HLW is needed
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.

- Vitrified waste is more compact and stable
- Storage system could be simplified
- Reduced size of the underground chambers
- Cost of the repository is not linear with size

Decision points defined in the National Program

- Interim storage of SF from Paks-2 (in Hungary or in a foreign country);
- Use of reprocessed U and Pu on new units
- Decision on reprocessing (early, during decommissioning or never)

Processing option must be assessed with the help of a detailed comparative safety, technical and economic analysis, which also considers the plans for the closing stages of the fuel cycle of the new units.
Illustration of decision-making points for closing the nuclear fuel cycle
Financing

- Central Nuclear Financing Fund (KNPA)
  - Separated state fund
  - Under the supervision of Ministry for Innovation and Technology
- 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
Thank you for your attention!