LONG-TERM STORAGE OF SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE

František Huptych
ÚJV Řež, a. s., Division ENERGOPROJEKT PRAHA
Na Žertvách 2247/29, Praha, Czech Republic
frantisek.huptych@ujv.cz

Václava Havlová
ÚJV Řež, a. s., Division of RADIOACTIVE WASTES AND DECOMMISSIONING
Hlavní 130, Řež, Czech Republic
vaclava.havlova@ujv.cz

ABSTRACT

The contribution refers to activities related to the assurance of sufficient storage capacity for Spent Nuclear Fuel (SNF) at the NPP sites during their overall planned lifetime.

The Czech Republic is currently planning to operate NPPs for 60 years, with construction of up to 3 new units at the sites of existing NPPs. In addition, the Deep Geological Repository (DGP) is planned to be built and operational in 2065.

INTRODUCTION

Nowadays, only a dry storage method in containers in special storage facilities is used in the Czech Republic. In the case of construction of new NPPs (which are planned to be built at existing NPP sites), one of the options is to build a Central Spent Nuclear Fuel Storage Facility (CSNFSF) at Skalka site and to use this facility as an intermediate step ahead of the planned construction of deep geoloigical repository (DGR).

Furthermore, the project concerning assessment of options for long-term storage of SNF and Radioactive Waste (RAW), generated from NPPs (that are unacceptable for disposal in near-surface repository) it the CSNFSF Skalka is presented. The results of the study will be used for decision-making in the process of DGR development.

The analysis and evaluation of storage facilities was based on the predicted volumes of SNF and RAW generated from operation of NPP Dukovany, NPP Temelín and new NPPs (1 unit at Dukovany site, 2 units at Temelín site; https://www.cez.cz/en/energy-generation/nuclear-power-plants/new-nuclear-power-sources) with a performance of 3 x 1200 MW including predicted amounts of RAW from decommissioning. The lifetime of the existing NPPs and new NPPs is assumed to be 60 years.

One concept is to built a new storage facility. Another possible concept is to increase the existing storage capacity directly at the NPP sites until the DGR becomes operational (planned 2065). Currently, in the Czech Republic, DGR development is in the stage of siting procedure.

NNP Dukovany – extension of SNF storage capacity

The long-term concept of the NPP Dukovany (four reactors of the Russsian WWER 440/213) envisages the shutdown for reactor units 1 to 4 in the period 2045-2047. The current capacity of the SNF 2 storage is not sufficient for the operation of the EDUs during envisaged 60 years.

Concerning the fuel cycle analysis, it is estimated that there is a lack of capacity to store additional 41 containers, which, taking into account, sufficient margin represents a requirement for the creation of 60 new storage positions for the SNF containers.

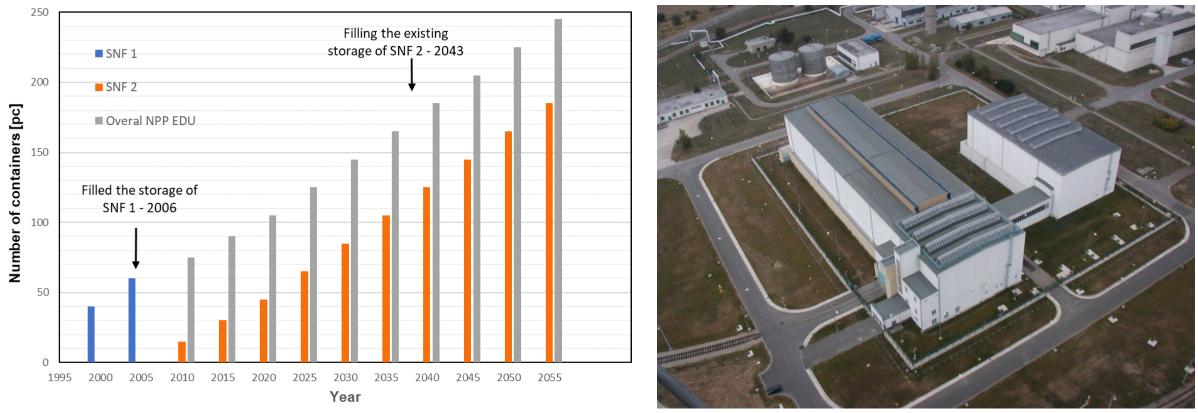

Figure 1: Number of containers with SNF for storage over 60 years of operation NPP Dukovany (left); an aerial view of the storages SNF 1 and SNF 2

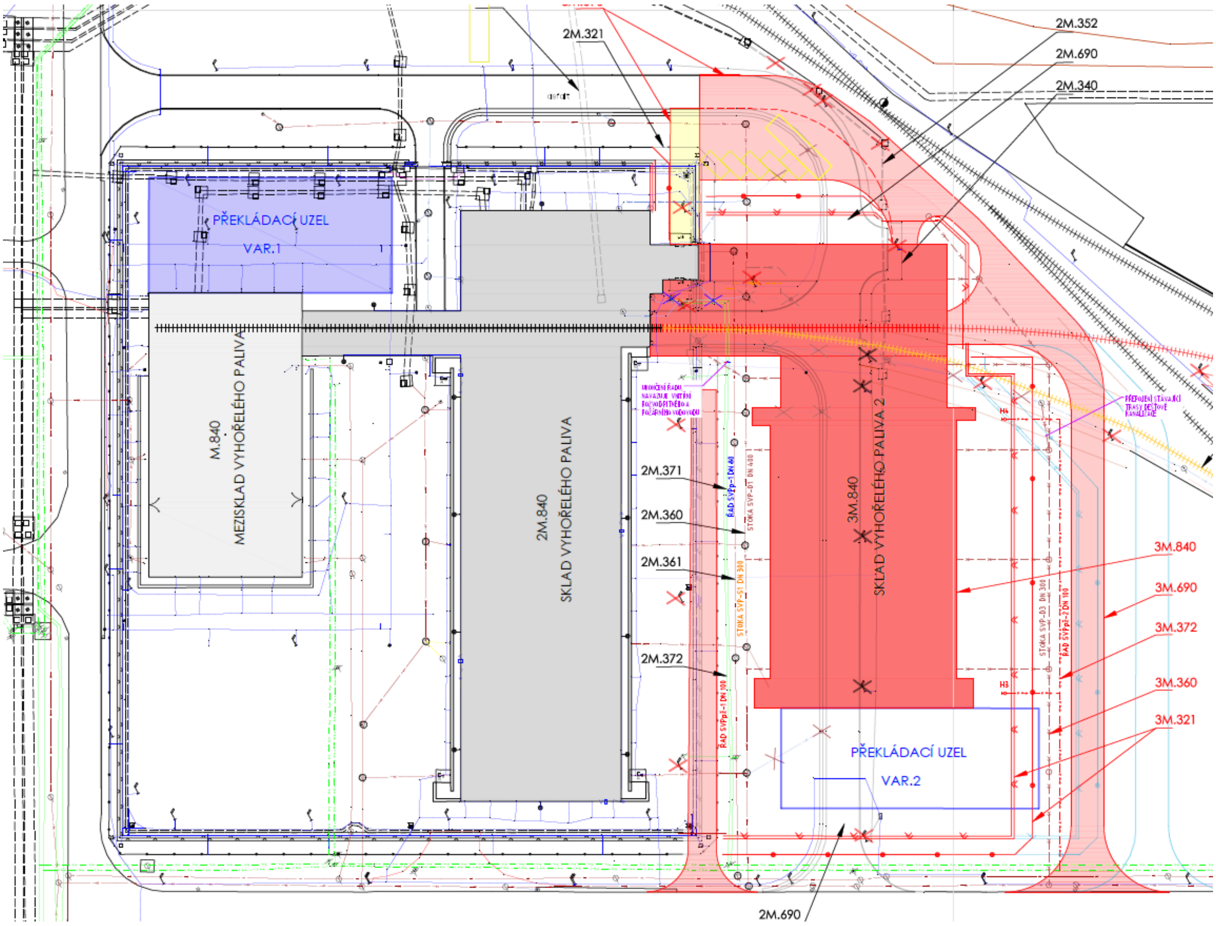

Figure 2: The selected option for the construction of a new SNF storage (red building)

NNP Temelín – increase of SNF storage capacity

The long-term concept of the NPP Temelín (two reactors of the WWER 1000/320V type) envisages the shutdown for the reactor units 1 and 2 in the period 2060 and 2062. A dry SNF storage facility with a capacity for the planned 30-year operation of the NPP was built at the Temelín site. It allows to receive, handling and storage of 152 pieces of containers. The current capacity of the SNF storage is not sufficient for the operation of the ETEs for 60 years. However, the current SNF storage design allows use of the receiving part of SNF for another SNF storage of the same capacity.

The existing SNF storage facility was commissioned in 2010, and new SNF storage capacity would be needed approximately in 2040.

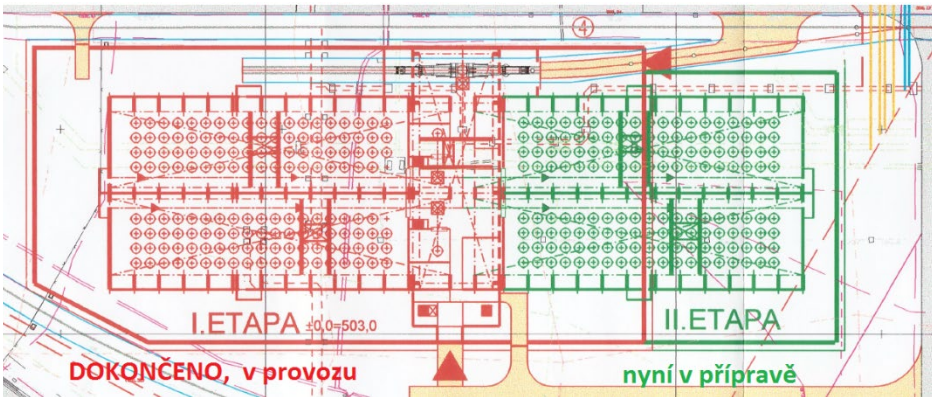

Figure 3: The existing SNF storage (red) and planned new SNF storage capacity (green)

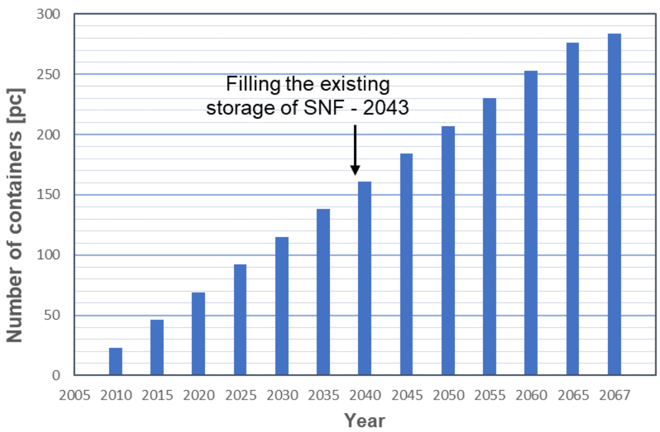

Figure 4: Amount of SNF (in containers) for storage over 60 years of operation NPP Temelín

FEASIBILLITY STUDY - Central Spent Nuclear Fuel Storage Facility Skalka

The aim of the Study was to evaluate the potential of existing storage facilities and to analyse the needs of the Czech Republic with regard to the planned lifetime of operating NPPs and planned new NPP units. The analysis and evaluation of storage facilities was based on the predicted amounts of SNF and RAW generated from operation of NPP Dukovany, NPP Temelín and new NPPs (1 unit at Dukovany site, 2 units at Temelín site) with a performance of 3 x 1200 MW including predicted amounts of RAW from decommissioning. The lifetime of the existing NPPs and new NPPs is assumed for 60 years.

The basic input data included information on legislation concerning NPPs and SNF storage, properties of the Skalka site, storage containers, expected volume of SNF from operation of NPP Dukovany, NPP

Temelín and new NPPs (see Figure 5). The existing storage capacities for storage of SNF and RAW in the Czech Republic were also described.

The Study proposed technical modifications of the existing Skalka building, including its extension by a hot chamber for the transfer of SNF, if necessary, to the new storage containers (see Figure 6). The activities of the future operator were described and the use of Central Spent Nuclear Fuel Storage Facility (CSNFSF) Skalka for long-term storage was evaluated.

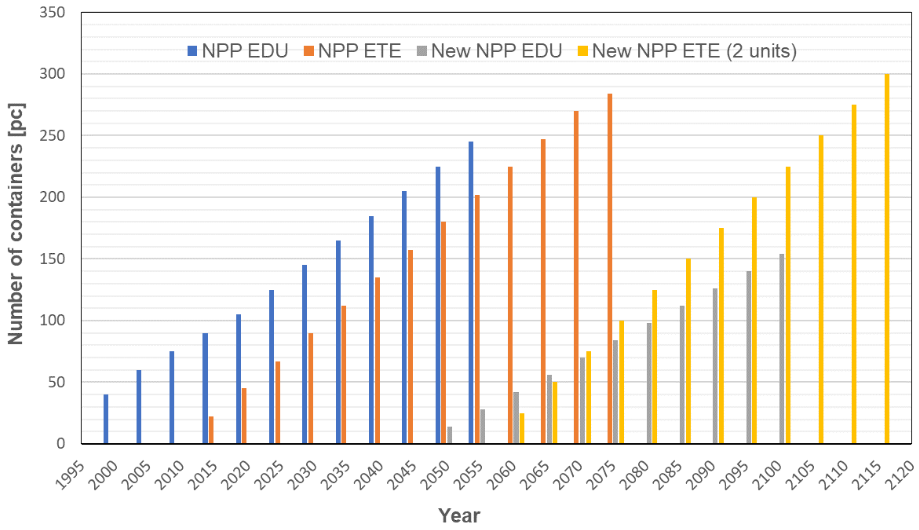

Figure 5: Number of containers for storage from NPPs in the Czech Rep. (including 3 new NPPs)

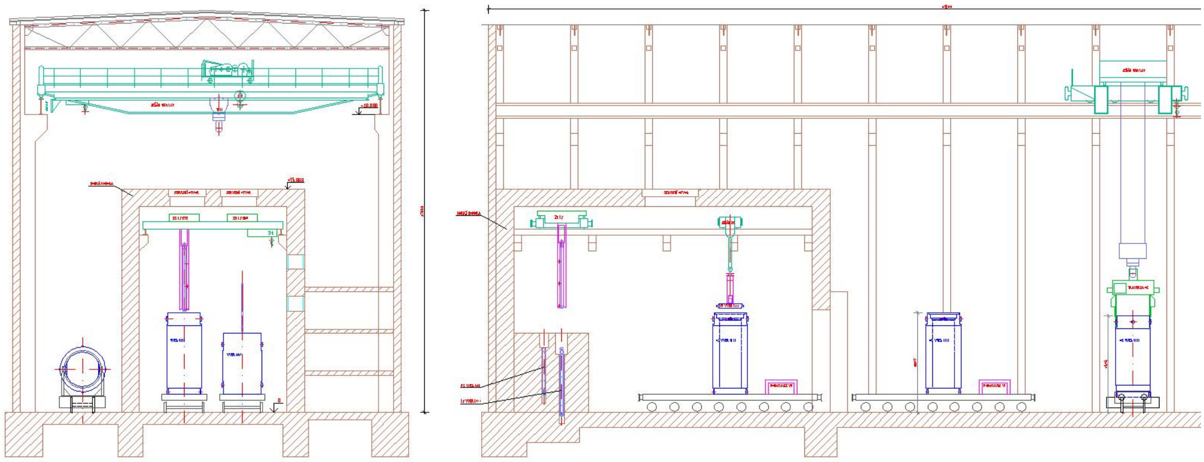

Figure 6: Sections of the hall for reception and reloading of containers with SNF and RAW

The Study analyzed and evaluated the impacts of the prolongation of SNF storage on the construction and technical design of the DGR, including quantification of the possible reduction of costs of the DGR depending on the time of extension of SNF storage. In the Study, the schedule of the proposed life cycle of CSNFSF Skalka was described and the impact of SNF storage in CSNFSF Skalka on the technical solution and life cycle schedule of DGR was assessed, including evaluation of CAPEX/OPEX. Moreover, the study also included their comparison with CAPEX/OPEX of DGR without SNF storage in CSNFSF Skalka.

The results of the technical design of CSNFSF Skalka were used as basic input data, where the potential of the existing storage facilities and the analysis of the needs of the Czech Republic with regard to the planned period of operation of existing NPPs and planned new NPPs were evaluated.

The Study compared the costs of operation of CSNFSF Skalka according to the proposed schedule, the impact of long-term storage of SNF on the size of the underground area of the DGR, being enabled due to reductionof the SNF residual heat output. The study compared the existing DGR design with the option of long-term storage of SNF and RAW and subsequent disposal in a modified DGR. The economic comparison of both approaches showed the economic advantage of the construction of CSNFSF Skalka.

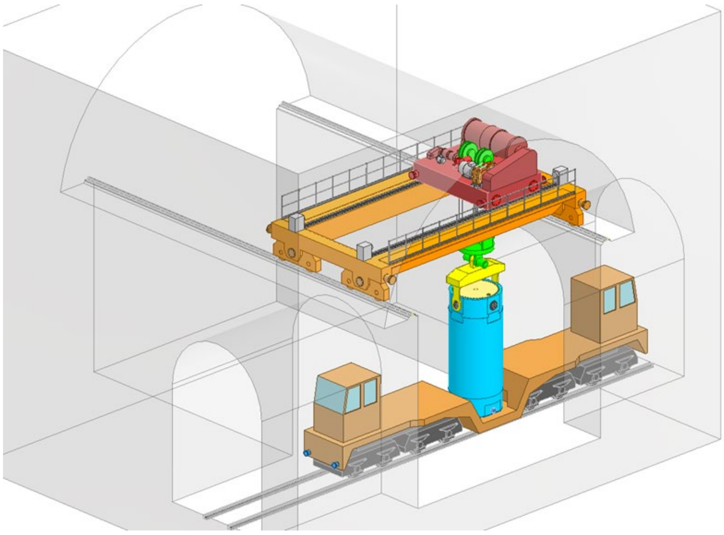

Figure 7: Model of the container with SNF from VVER 1000 in vertical position on a transport railcar

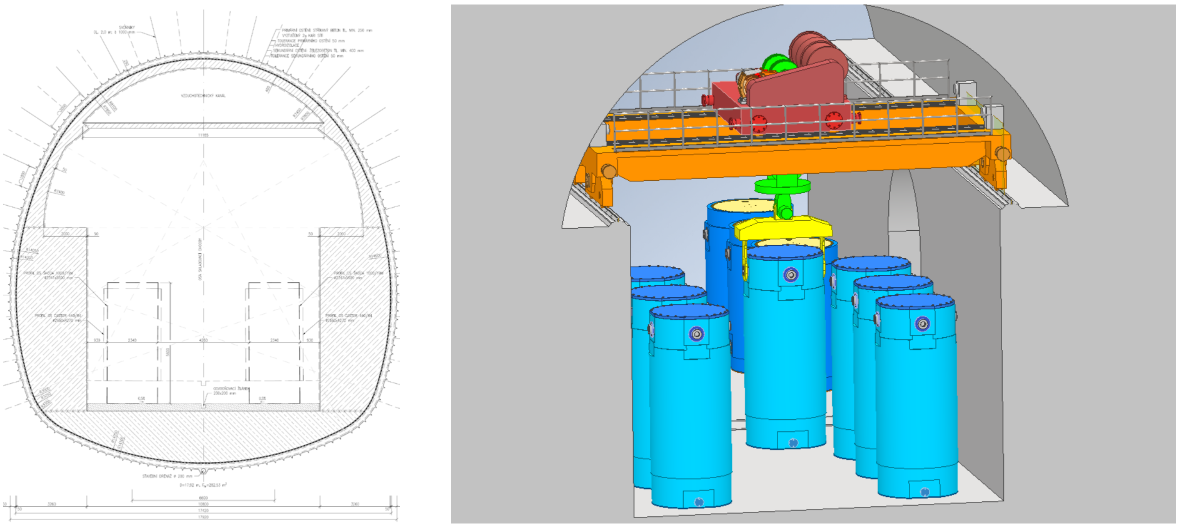

Figure 8: Positioning of the container with SNF from VVER 1000 on the storage position

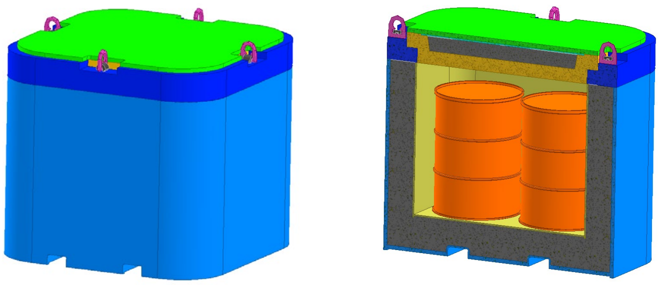

Figure 9: Concrete container (BK) for storage of RAW from decommissioning of NPPs

DGR DEVELOPMENT IN THE CZECH REPUBLIC

The future deep geological repository for radioactive waste in the Czech Republic will be constructed in a suitable crystalline rock mass around 500 metres below the earth's surface. The commencement of operation is planned for 2065. The current DGR development phase is devoted principally to the determination of the optimum disposal concept and the selection of the most suitable site. A total of nine potential sites have been assessed with the aim of reducing their number to four (2018 – 2020).

The data set subjected to assessment included site descriptions from the geological point of view (3D geological and hydrogeological model), and long-term site stability (seismotectonic, climate and erosion) and geomechanical data (Vondrovic et al. 2021). A further assessed dataset included information on construction issues and on the evaluation of both environmental characteristics and the presence of groundwater resources. All the assessed characteristics were derived from surface-based exploration without the need for borehole drilling.

The key criteria reflected the three main areas of concern i.e. long-term and operational safety (including geological and hydrogeological indicators), technical feasibility and environmental impacts. The assessment of the sites was performed in two stages. The first stage involved the assessment of the probability of fulfilling the exclusion criteria (total 26), while the second stage involved the mutual comparison of the sites in terms of the defined key criteria (total of 13, divided into 38 indicators). The second stage involved the determination of weightings for the various criteria and indicators via the application of the SAATY method for the expert comparison of the significance of criteria. This method distinguished between relatively strongly weighted and less weighted criteria. The sites were graded with respect to the value estimation of the criteria; moreover, the grading of the sites considered various types of data (Vondrovic et al. 2021).

On 21 December, 2020 the Czech government approved the selection of four sites (from a total of nine sites) recommended for the location of the country's DGR – Březový potok, Horka, Hrádek and Janoch (https://www.surao.cz/en/public/deep-geological-repository/safety-of-dgr/).

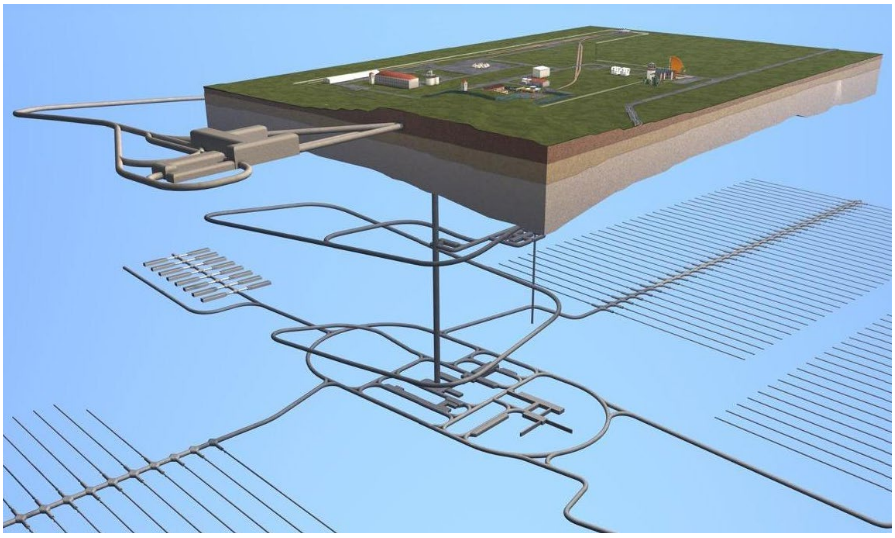

Figure 10: The Czech DGR concept

References:

Vondrovic, L., Augusta, J., Vokal, A., Konopacova, K., Popelova, E., and Urik, J.: Multi-criteria site assessment process for candidate deep geological repository sites: Case study from the Czech Republic, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-16491, https://doi.org/10.5194/egusphere-egu21-16491, 2021.