





Analysis of decommissioning options for V1 Nuclear Power Plant

CASE STUDY

KP-JAVYS-012

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Foreword

In 2021, the European Commission (EC) adopted a new proposal for a Council Regulation[1] establishing a dedicated financial programme for decommissioning nuclear facilities and managing radioactive waste. This instrument covers the co-funding of the decommissioning programmes of Bulgaria, Slovakia and the decommissioning of the Joint Research Centre (JRC). A separate Council Regulation[2] was adopted for the decommissioning programme of Lithuania.

The EC JRC is mandated to foster the spread of decommissioning knowledge across all the European Union Member States and facilitate knowledge sharing arising from implementing the above-mentioned decommissioning programmes, funded by the Nuclear Decommissioning Assistance Programme (NDAP).

The decommissioning operators from the NDAP (NDAP Operators) implemented and tested a knowledge management methodology in 2021 through Project ENER/D2/2020-273. Using this methodology, the NDAP Operators can develop knowledge products that are currently available to share with other European stakeholders. In addition, this methodology is being implemented by the JRC Nuclear Decommissioning and Waste Management Directorate (NDWMD), which has become a knowledge generator extracting the knowledge from the ongoing decommissioning activities across the JRC´s four different sites (Geel, Ispra, Karlsruhe and Petten).

The JRC´s NDWMD aims to become a Centre of Excellence in nuclear decommissioning knowledge management and to develop a decommissioning knowledge platform which allows exchanging information building on EU best practices through executing the multi-annual financial framework (2021 – 2027) strategy. The operational phase of the project started in 2024 with the objectives to: develop ties and exchanges among EU stakeholders, document explicit knowledge and make it available through multi-lateral knowledge transfers on decommissioning and waste management governance issues, managerial best practices, technological challenges, and decommissioning processes at both operational and organisational level, as well as to develop potential EU synergies.

This is a knowledge product prepared by the JAVYS for the Nuclear Decommissioning and Waste Management Directorate (NDWMD) – Directorate J of the Joint Research Centre.

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[1] Council Regulation (Euratom) 2021/100 of 25 January 2021 establishing a dedicated financial program for the decommissioning of nuclear facilities and the management of radioactive waste, and repealing Regulation (Euratom) No 1368/2013
[2] Council Regulation (EU) 2021/101 of 25 January 2021 establishing the nuclear decommissioning assistance programme of the Ignalina NPP in Lithuania and repealing Regulation (EU) No 1369/2013

PRODUCT DESCRIPTION

This knowledge product (KP) presents the approach used to analyse and compare decommissioning options for V1 Nuclear Power Plant. Drawing primarily on Project B6.1, the V1 NPP Conceptual Decommissioning Plan (CDP), it explains the technical, radiological, environmental, economic, scheduling and implementation criteria considered, the calculation model applied and the multi-criteria analysis used to identify the preferred option. It is intended to support organisations and practitioners involved in planning, assessing or reviewing nuclear facility decommissioning strategies.

ABSTRACT

This KP summarises the assessment of three decommissioning options for V1 Nuclear Power Plant: immediate decommissioning, safe enclosure under surveillance for 30 years and reactor safe enclosure for 30 years. It describes the technical, radiological, environmental, economic, scheduling and implementation criteria used to compare the options, together with the calculation model and expert judgements supporting the assessment.

The comparison showed that no option performed best against every criterion. Reactor safe enclosure had the lowest estimated total cost, safe enclosure under surveillance had the lowest estimated collective effective dose (CED) and immediate decommissioning provided the shortest decommissioning period and earliest site release. This demonstrated that reliance on a single criterion could produce a partial or potentially misleading basis for option selection.

Therefore, a weighted multi-criteria analysis was used to provide an integrated comparison. Within the assumptions, data and weighting framework applied, immediate decommissioning was identified as the preferred option. The assessment also demonstrated the importance of complete and well-structured input data, transparent expert judgement and early planning for radioactive waste (RAW) treatment, storage, transport and disposal capacity.

The multi-criteria analysis provided a decision-support recommendation rather than the formal decision or permission to implement. **JAVYS'** management subsequently selected immediate decommissioning as the strategy for V1 NPP. The CDP was then submitted to the relevant Slovak regulatory, public-health and governmental authorities for review. The subsequent Environmental Impact Assessment process permitted implementation of the selected strategy. Immediate decommissioning remains the strategy being implemented at V1 NPP.

OBJECTIVE

To record, convey and explain the knowledge gained during the assessment of various approaches to decommissioning a nuclear power plant, including the advantages and disadvantages of each option within the specific context of the V1 NPP.

APPROACH

This KP (knowledge product) was developed through a focused review and synthesis of the principal documentation prepared for Project B6.1 (the V1 NPP CDP), as a contribution to the JRC's **Nuclear Decommissioning Knowledge Management** (**NDKM**) **Initiative**. The main inputs included the: CDP, analysis of decommissioning options and comprehensive comparison of those options. The assessment drew on plant data, material and radiological inventories, activity-based and time-dependent cost calculations, RAW routes, scheduling assumptions and expert judgement.

The following **main points** are conveyed in this KP:

- descriptions of the immediate decommissioning, safe enclosure under surveillance, reactor safe enclosure and zero options,
- the principal input assumptions and the calculation model,
- comparisons of the options against technical, radiological, environmental, economic, scheduling and implementation criteria,
- explanations of the weighted multi-criteria analysis used to identify the preferred option,
- records of the transferable lessons and recommendations for future decommissioning option assessments.

RESULTS, FINDINGS AND INSIGHTS

Results

The comparison demonstrated that different options performed best against different individual criteria. RSE had the lowest estimated total cost, SES had the lowest estimated CED, and immediate decommissioning option (IDO) had the shortest duration and earliest site release. Within the assumptions, criteria, weights and input values applied, IDO achieved the lowest overall option value and was identified as the preferred option in the multi-criteria assessment.

Findings

No single criterion provided a sufficient basis for selecting a decommissioning strategy. The result depended on the input data, options scopes, criteria, weights and expert judgements applied. Although a common evaluation framework was used, the options differed in building scope, retained infrastructure, dismantling sequence and intermediate site configuration. The records did not permit the reported cost-sensitivity consideration to be reproduced and did not demonstrate the stability of the option ranking under alternative criterion weights, subjective scores, schedules or waste assumptions.

Insights

A defensible option-selection process requires transparent assumptions, traceable data and clearly documented weighting decisions. Input datasets should be structured consistently across all options, and any differences in option scope should be made explicit before comparison. Experience from other decommissioning programmes can support benchmarking and validation, but site-specific conditions must remain central to the assessment. The preferred result should be treated as a decision-support recommendation as well as tested through the applicable regulatory and stakeholder decision-making processes.

TARGET USERS

The principal target users are nuclear facility owners and operators, decommissioning organisations, programme and project managers, engineering and safety specialists, RAW management organisations, regulators and public authorities involved in decommissioning strategy development or review. The KP may also be useful to technical support organisations, researchers and academic institutions working in nuclear decommissioning and RAW management.

APPLICATION, VALUE AND USE

This KP can be used as a reference when scoping, structuring or independently reviewing an assessment of nuclear facility decommissioning options. It illustrates how technical, radiological, environmental, economic, scheduling and implementation considerations can be integrated within a transparent decision-support framework. Its value lies in helping users identify data requirements, understand trade-offs between competing objectives, document assumptions and expert judgements, and anticipate constraints associated with RAW management, infrastructure and site reuse. The approach should be adapted to the regulatory framework, facility characteristics and strategic objectives of the site concerned.

KEYWORDS

Conceptual decommissioning plan; decommissioning cost estimation; decommissioning option assessment; decommissioning strategy; immediate decommissioning; multi-criteria analysis; nuclear decommissioning; RAW management; reactor safe enclosure; safe enclosure under surveillance; site release; V1 Nuclear Power Plant; VVER-440; zero option.

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ACRONYMS & ABBREVIATIONS

AKOBOJE	Site-specific designation for the Bohunice area protection system
ALARA	As Low As Reasonably Achievable
BIDSF	Bohunice International Decommissioning Support Fund
CB	Civil Building
CDP	Conceptual Decommissioning Plan
CED	Collective effective dose
EWN	Energiewerke Nord GmbH, now EWN Entsorgungswerk für Nuklearanlagen GmbH (organisation associated with the Greifswald NPP decommissioning experience used in the assessment)
FCC	Fiber-concrete container
IDO	Immediate decommissioning option
ISFSF	Interim Spent Fuel Storage Facility
ISRAW/IS RAW	Interim storage of RAW
LLW	Low-Level Radioactive Waste
MSVP	Interim Spent Fuel Storage Facility (site-specific Slovak abbreviation)
NNF	National Nuclear Fund
NPP	Nuclear Power Plant
NRA SR	Nuclear Regulatory Authority of the Slovak Republic
NRWR/NSR	National Radioactive Waste Repository/Near surface repository in Mochovce
PDA	Preparatory decommissioning activity
PMU	Project Management Unit — manages, monitors, and reports progress of the decommissioning activities/projects
PMU BIDSF	Project Management Unit of Bohunice International Decommissioning Support Fund located in Trnava created to manage the implementation of the pre-decommissioning support projects of Bohunice V1
PSL	Proposed standardised list of items for decommissioning costing purposes
RAW	Radioactive Waste
REKO V1	Site designation for the building used to support the reconstruction of V1 NPP
RSE	Deferred decommissioning option with reactor safe enclosure (RSE) for thirty years

SE EBO	Bohunice NPP (branch of Slovenské elektrárne, a.s.), operator of V1 and V2 NPP
SE VYZ	Decommissioning of the Nuclear Installations, Radioactive Waste and Spent Fuel Management (branch of Slovenské elektrárne, a.s.)
SES	Deferred decommissioning option with safe enclosure under surveillance (SES) for thirty years
VLLW	Very Low-Level Radioactive Waste
VVER	Water-Water Power Reactor
ZO	Zero option

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1. INTRODUCTION

1.1. Background and context

The **Nuclear Decommissioning and Waste Management Directorate** (**NDWMD**) of the **JRC** is running the Nuclear Decommissioning and Waste Management (NDWM) Programme for the nuclear sites of the **European Commission** (**EC**), with the majority of the activities currently focused on dormant facilities situated on the Ispra site (located in northern Italy).

In 2020 the Council of the EU issued **Council Regulations 100** and **101** in which they provided co funding to the decommissioning programmes in three EU Member States (Slovakia, Bulgaria and Lithuania), and full funding to the EC's internal NDWM Programme, run by the JRC. This initiative is commonly known as the **Nuclear Decommissioning Assistance Programme** (**NDAP**).

The same regulations mandated the **JRC** to initiate a knowledge management project on NDWM, based on the experience and lessons learnt during the implementation of the **JRC's** and **NDAP Operators'** decommissioning programmes. The primary products of the KM project, referred to as KPs, will be disseminated to European stakeholders to support new operators entering NDWM activities, enabling them to benefit from knowledge gained through previous experience and programmes.

This builds on the progress made by the NDWM Programme in the past years, specifically as an extension to what has already been provided for by contributing to the programme's broader objective of supporting informed and well-structured evaluations of decommissioning approaches. It does so by examining the analysis of decommissioning options undertaken for V1 NPP under Project B6.1, "The V1 NPP CDP".



Figure 1. Aerial view of V1 NPP in Jaslovské Bohunice

1.2. Overview of the case study

The decommissioning of a nuclear facility presents significant challenges and requires thorough planning and careful consideration of numerous critical factors, including safety, environmental impact, schedule adherence and cost-effectiveness. The choice of the most suitable decommissioning option depends on many factors, such as the plant's specific characteristics, regulatory requirements, available technologies and societal considerations.

It is crucial to understand various approaches to decommissioning an NPP, including the advantages and disadvantages of the options within the specific context of the NPP. Choosing a wrong option may significantly hinder safety across a vast area and could impact the economic situation of the whole country. Capturing the findings in this format makes it easily accessible to said stakeholders.

This case study provides an overview of the NPP decommissioning options decision-making process applied at the beginning of the V1 NPP´s decommissioning in Jaslovské Bohunice, Slovakia. It focuses on the analysis results of decommissioning options, describing various stages (technical, financial, safety aspects, etc.), the comprehensive comparison of the options and the preferred option.

For this purpose, **Project B6.1 "The V1 NPP Conceptual Decommissioning Plan"** was launched in 2004. It aimed to provide a document entitled "Conceptual Decommissioning Plan (CDP)" which would help provide the answer to the question "Which decommissioning option is the best for V1 NPP?" The CDP was intended primarily to provide conceptual technical and financial information to support, together with other preparatory documentation developed on the basis of this CDP, the selection of the final decommissioning strategy for the V1 NPP.

The **core planning documents** defined the following four decommissioning options for assessment:

- Option 1: IDO; the immediate and continuous dismantling of equipment and facilities, demolition of buildings up to the bottom of the building pit and preparation of the site for a new nuclear power plant erection.
- Option 2: SES; the safe enclosure of the equipment of the primary circuit (30 years).
- Option 3: RSE; the safe enclosure of the reactor in the reactor shaft (30 years).
- Option 4: ZO; the status that would arise if no activity was realised.

The analysis was undertaken within a set of operating constraints and boundary conditions. The principal operating constraints considered were regulatory compliance, funding and site infrastructure. The boundary conditions considered included potential future commercial operations, changes in national policy and possible developments in the global fuel cycle, including spent-fuel reprocessing and deep geological disposal.

Areas of focus of this KP include the findings of the above-mentioned analysis and comparison of decommissioning strategies, which consider factors like manhours, costs, regulations and safety.

2. CASE STUDY

As mentioned previously, this case study is based on Project B6.1 “The V1 NPP Conceptual Decommissioning Plan”, which was one of four interrelated projects within the general project B6.

Project B6.1 represented a transition from earlier strategic studies to a structured evaluation of the feasible decommissioning pathways. By applying a consistent methodology to the three options taken forward for detailed analysis, the project aimed to provide a transparent basis for comparison, recommendation and subsequent stakeholder review.

The **other 3 interrelated projects** were:

- B6.2: “The Environmental Impact Assessment (EIA) Report of V1 NPP Decommissioning”
- B6.3: “The V1 NPP Decommissioning Stage Plan & Other Documentation”
- B6.4: “Decommissioning Database”

The main dependencies and interrelations of the above “B-projects” are illustrated in Figure 2 below.

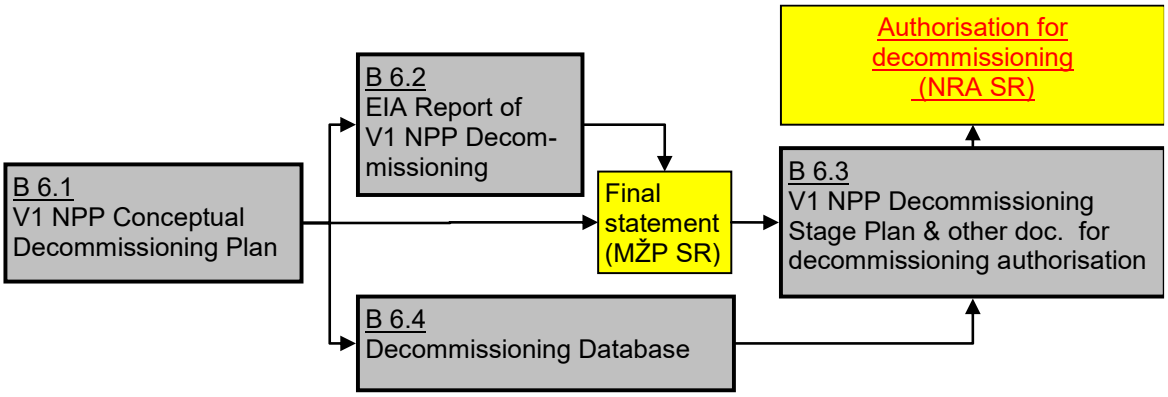


Figure 2. Main dependencies and interrelations of the BIDSF “B - projects”

It follows from the above that the CDP aimed at providing mainly conceptual technical and financial information to enable, in conjunction with other preparatory documentation developed based on the CDP, the selection of V1 NPP’s final decommissioning strategy.

To understand why these options were assessed and why the preferred strategy changed over time, the case study first reviews the principal studies, decisions and planning developments that preceded Project B6.1.

2.1. Historical context

Under the legal framework applicable to the planning period, decommissioning of V1 NPP could begin only after all spent nuclear fuel had been transferred to the Interim Spent Fuel Storage Facility (ISFSF; Slovak abbreviation: MSVP). The operating-licence holder was responsible for arranging this transfer. Only after its completion could the organisation responsible for decommissioning apply to the Nuclear Regulatory Authority of the Slovak Republic (NRA SR) for a decommissioning licence. Therefore, activities undertaken before that authorisation were classified as part of operation termination rather than decommissioning.

Context for international readers: This regulatory distinction influenced both programme planning and cost allocation because activities performed before the decommissioning licence was issued were legally treated as operational shutdown activities rather than decommissioning activities.

This means that activities before obtaining this permission did not fall within decommissioning activities but were a part of operation termination.

The V1 NPP reactor units 1 and 2 were shut down in 2006 and 2008 respectively. Projects related to V1 NPP's decommissioning were realised even years before. Since 2000, many **preliminary strategic documents** and a **decommissioning plan** were developed. They were **regularly updated due to** numerous reasons, such as:

- changes in RAW management specifications,
- changes in boundary conditions (increased price level, re-assessment of unit costs, consideration of pre-decommissioning activities);
- consideration of international experience from other NPPs with VVER-440 reactors decommissioning.

The first comprehensive studies which dealt with V1 NPP's decommissioning options were elaborated in 1991 and 1992. These studies evaluated technical/organisational, economic and safety aspects (i.e. to some degree also environmental impacts) of the **following five decommissioning options**:

1. IDO, i.e. continuous decommissioning immediately after operation termination up to the site release for unrestricted use,
2. option with safe enclosure of hermetic compartments of main production buildings for a period of about 70 years with subsequent dismantling and demolition of civil structures and equipment up to the site release for unrestricted use,
3. option with safe enclosure of reactors in the reactor cavities for a period of about 70 years with subsequent dismantling and demolition of civil structures and equipment up to the site release for unrestricted use,
4. option with safe enclosure of the reactor building for a period of about 70 years with subsequent dismantling and demolition of civil structures and equipment up to the site release for unrestricted use,
5. SES of civil buildings (CBs) containing equipment with induced activity or contaminated equipment for a period of about 70 years with subsequent dismantling and demolition of civil structures and equipment up to the site release for unrestricted use.

Those studies selected option 2 as the preferred strategy at that stage. However, the recommendation was not subsequently developed, reviewed or approved.

The first document which dealt with environmental impacts of V1 NPP's decommissioning (intention study) was elaborated in 1997. The document was based on the studies mentioned above and evaluated the impacts of options 1, 2 and 5. This document was also not submitted to appropriate regulatory bodies and was not reviewed and approved.

At the end of 1998 another document was elaborated based on previous ones.

Its objective was to find the optimal extent of equipment to be placed under the safe enclosure and an optimum duration of the safe enclosure. The study did not provide the answer to the optimal extent. However, it stated that the safe enclosure should be between 30 and 70 years, with 50 being the optimal choice.

In the end, it was decided that the minimum duration should be sufficient based on V1 NPP's circumstances.

The last document which considered V1 NPP's decommissioning ("Redevelopment of V1 NPP") was prepared in **2004**, required to ensure an analysis of economical utilisation of V1 NPP's civil structures and technological equipment and an analysis of use of the site after V1 NPP decommissioning.

It was recommended to decommission the plant as soon as possible (sooner than the IDO in the previous study). This **recommendation was justified**, according to the considerations of this study, **as follows**:

- effort to valorise the further utilisation potential of the site at the earliest time,
- the owner of the site can sell it to other investors or use it for personal investments sooner,
- decrease of the assets for repeated utilisation (constructions, technology, infrastructure) by time,
- continuity of the job opportunities in the affected municipalities,
- earlier utilisation of the site for new production (specifically new nuclear source) minimises impacts on the environment,
- more effective utilisation of the waste treatment and conditioning technologies,
- more effective utilisation of the Mochovce repository capacity,
- the recommended option was respectable to the National Nuclear Fund and minimised the risk of devaluation of the fund financial means by the negative real interest rate.



Transferable lesson: The intended post-decommissioning use of a site can strongly influence the preferred strategy. Decisions regarding immediate dismantling or deferred dismantling should be evaluated not only against decommissioning parameters but also against long-term economic, industrial and strategic objectives for the site.



These recommendations were taken into account in the choice of the recommended decommissioning option in the final CDP.

The evolution of the recommended strategies illustrates how decommissioning decisions can change as assumptions, cost information, waste-management arrangements, international experience and future site-utilisation objectives develop. In this case, the main drivers were changes in specification of RAW management and boundary conditions, such as increased overall price level, re-assessment of unit costs of envisaged activities and consideration of pre-decommissioning activities, as well as international experience, particularly the Greifswald NPP decommissioning experience associated with EWN.



Knowledge-transfer insight: decommissioning strategies should be reviewed periodically to ensure that they remain aligned with the available evidence and prevailing project conditions.

Against this evolving strategic background, Project B6.1 established a defined set of plant conditions, option assumptions and quantitative inputs as the basis for the updated assessment.

2.2. Input assumptions and data

This section contains a brief overview of three different areas of interest that were considered input information. The first area describes the expected initial status of V1 NPP systems and equipment at the beginning of decommissioning, i.e. in year 2012.

The **analysis used three principal categories of input information**.

The first category described the anticipated condition of V1 NPP systems and equipment at the planned start of decommissioning in 2012, including systems expected to remain operational, be modified or be taken out of service.

The second category comprised the assumptions used to define the options, including their scope and timing, the civil constructions and buildings included, as well as the dismantling, demolition and decontamination strategies, RAW-management arrangements, safety assumptions, calculation model and breakdown of activities.

The third category comprised the quantitative input data used by the model, including material inventories, radiological characterisation, prices, labour-unit factors and consumable-unit factors.

The **list of technological systems** of V1 NPP was developed by the Project Management Unit of Bohunice International Decommissioning Support Fund (PMU BIDSF) and documented in several reports. The systems are **categorised into**:

- systems belonging to unit 1 of V1 NPP,
- systems belonging to unit 2 of V1 NPP,
- systems common to both units.

These documents address only those systems that are important for the final shutdown of the V1 NPP or are affected by the final shutdown process.

For modelling purposes, the anticipated status of each relevant system at the start of decommissioning was classified using **the following designations**:

- D: systems disabled (not in operation),
- O: systems in operation,
- MO: systems in operation but that have been modified during or for the shut-down period.

Examples of the systems status based on the type and name of systems are presented in Table 1 below:

Table 1. Examples of initial status of systems

System type	System name	System status
Unit 1 and unit 2 systems: primary part	Main reactor cooling circuit	D
	Special drain water system	O
	Sampling system	MO
Unit 1 and unit 2 systems: secondary part	Turbine system	D
	Secondary side ventilation system	MO
Unit 1 and unit 2 systems: electrical part	Main generator system (including main and working transformer)	D
	Lighting systems	O
	6 kV secured system including diesel generators (II. category)	MO
Common systems: primary part	Reloading/Refuelling machine	D
	Ventilation systems	O

System type	System name	System status
	Compressed air system	MO
Common systems: secondary part	Demineralised water 1 MPa system	D
	Fire water system	O
	V1 NPP heat exchanger station	MO
Common systems: chemical part	Demineralised water preparation system	D
	Biological waste water purification system (BIOCLAR)	O
Common systems: electrical part	Switchyards 220 kV	D
	Common 0.4 kV distribution points supplied from both units	O
	Switchyard R-713	MO
Common systems: other systems	Diagnostic systems	D
	Dosimetry monitoring system	O
	Technological information system (TIS)	MO

Table 1 provides examples of the system status assumed at the start of decommissioning. Some systems were expected to be disabled, while others were expected to remain operational or to operate in a modified form. Changes to technological systems, including separation of their operational and non-operational parts, were subject to NRA SR approval.

☆ **Knowledge-transfer insight**: planning should distinguish clearly between systems that can be taken out of service and those that must remain operational or be modified to support shutdown and decommissioning. This status assessment provides an important basis for defining the sequence and dependencies of subsequent activities.

2.2.1. List of V1 NPP civil constructions and buildings to be decommissioned

A list of V1 NPP's civil constructions and buildings was developed for each decommissioning option (see section 2.3).

For option 1, the assessment assumed that a greater number of structures could be retained to support the possible development of a new NPP. For **options 2** and **3**, identical lists were used for the structures included in and excluded from decommissioning. These lists reflected the site-utilisation and infrastructure requirements assumed for each option.

The differences between the lists reflect differing assumptions regarding future site utilisation, infrastructure retention and decommissioning end-state objectives. As a result, the comparison of options considers not only different implementation schedules but, in some cases, differences in the extent of structures retained or removed.

Both lists considered the circumstances following decommissioning, which formed the basis for deciding which structures to exclude from the decommissioning process. Option 1 considered circumstances defined by the needs of Slovenské elektrárne – operator of V1 and V2 NPP branch (SE EBO) and the potential new NPP; options 2 and 3 considered only the needs of SE EBO.

The structures designated for decommissioning were divided into two groups: (a) those containing equipment with induced activity or contaminated equipment and (b) those without contamination. For more information, see Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned.

☆ **Knowledge-transfer insight**: the scope of a decommissioning option should be defined before its cost, schedule and waste implications are compared. Differences in retained structures, radiological condition and intended site end-state can materially affect the resulting parameters.

2.2.2. Summary data on the material inventory of V1 NPP

Inventories were compiled for all materials recovered during the disassembly of technological systems and the demolition of both CB units.

For a concise overview of the total quantities of contaminated and non-contaminated items across all evaluated options please see Appendix 5.

Regarding the material inventory, the **radioactive materials potentially present at V1 NPP were classified as follows**:

- materials with induced activity in the reactor core area (reactor pressure vessel, internal reactor components, shielding assemblies, absorbing and connecting parts of control rods, parts of in-core measurement, water biological protection (WBO), concrete of reactor shaft, etc.),
- materials contaminated with activated corrosion products of primary circuit materials and impurities in coolant,
- materials contaminated with fuel fission products.



Knowledge-transfer insight: the quality and completeness of inventory data directly influence the reliability of an option assessment. Material quantities, radiological characterisation and waste classifications provide key inputs for estimating costs, worker exposure, waste generation and project duration.



Transferable lesson: Irrespective of reactor type or national context, the quality of the material and radiological inventory is one of the principal determinants of assessment quality. Incomplete inventories increase uncertainty in cost estimates, waste forecasts, dose assessments and schedule development. Therefore, investment in early characterisation activities can significantly improve the reliability of strategic decision-making.

In addition to this, **four methods for obtaining data on the activity and isotopic composition** of these materials were established:

- theoretic calculation by means of dedicated computing codes for activation calculation, respectively for modelling contamination propagation in NPP facilities,
- activity measurement of surface contamination from samples extracted from internal and external surfaces of primary circuit equipment and structural elements,
- from analysis of decontamination solutions after primary circuit equipment decontamination,
- from recalculation of dose rates measurements received from equipment.

^{137}Cs and ^{60}Co were expected to be the predominant contaminants. Within the characterisation approach, ^{60}Co was treated principally as an indicator of activated corrosion products in the primary circuit, while ^{137}Cs was used as an indicator associated with fuel integrity.

^{60}Co represented corrosion products in the primary circuit, while ^{137}Cs provided information about fuel assemblies' tightness. An inventory of equipment requiring decontamination in key buildings (reactor building, auxiliary building, etc.) was compiled, including contamination levels and the selected decontamination method (chemical or semi-dry electrolytic).

Although the complete inventory contained thousands of individual entries, the following example illustrates the level of detail used to support the analysis and demonstrates how component-specific information was translated into decontamination and waste-management assumptions.

For example, the assessment assigned the combined primary sides of all 12 steam generators in the reactor building a calculated contamination level of 20 kBq/cm², a total mass of approximately 396 tonnes, a total surface area of approximately 30,000 m² and a total volume of approximately 148 m³. Chemical decontamination was selected as the assumed treatment method. These values were calculated estimates used for planning purposes rather than subsequently verified measurements.

Naturally, the overall data related to the material inventory are significantly more complex. However, presenting them here would be redundant, as processing and reviewing them would require substantial time.

What is particularly important to note is that, at this stage, the different types of RAW were also identified, including very low-level (VLLW) RAW, such as concrete debris, and operational RAW, such as sorbents and sludges. In addition to this, issues including room dose rates, technical procedures for carrying out decommissioning activities, transportation requirements and safety criteria (e.g. free release, occupational dose limits and transportation limits) were addressed.

2.3. Calculation model

To estimate the costs of the evaluated decommissioning options, a calculation model was created in Microsoft Excel. It implemented the breakdown of the items based on the Proposed Standardised List of Items for Costing Purposes (PSL) as recommended by the OECD. This provided a sufficient level of detail for conceptual planning.

The anticipated system conditions, option-specific building scopes, as well as material and radiological inventories described above, formed the principal technical basis for the calculation model. A structured model was then used to translate these inputs into comparable estimates of cost, duration, labour, waste and other decommissioning parameters.

Knowledge-transfer insight: applying common formulas and calculation structures improves traceability and helps ensure that differences in results arise from the strategy assumptions and inputs rather than from inconsistent calculation methods.

The computing algorithms were designed so that the cell formulas remained standard for each decommissioning option, while differences between individual options were introduced by modifying the inputs or by including or excluding specific computing rows. The **development and use of the calculation model were divided into three steps**:

1. development of the template procedures,
2. assignment of the template procedures,
3. determination of the starting dates for individual items (rows), ensuring a logical sequence of activities.

Through these steps, the model generated estimated item costs, durations, cost components and other decommissioning parameters for each option, with the results distributed by year.

2.3.1. Template procedures

All template procedures used a unified implementation to ensure consistent calculation of key parameters. Three types of algorithms were applied in the calculation model: activity-dependent costs, time-dependent costs and fixed costs.

Activity-dependent costs
The Activity-Based Costing (ABC) principle was applied; i.e., the required labour hours were derived from the inputs. Specific attention was paid to increase factors such as non-productive time inside and outside the controlled area and work difficulty. The resulting number of labour hours was then multiplied by the average labour cost. Other cost components were determined by mutual agreement.

Time-dependent costs
When costs depended on the duration of the task rather than the required labour hours, the model used simpler procedures as described below. Manpower was then handled in the same way as above.

Fixed costs
These could be included in any procedure. Fixed costs were distributed over time according to the duration of their associated tasks.

2.3.2. Unit factors, prices and other input data

General input data on working time

The calculation model used the working-time assumptions shown in Table 2. These values formed part of the historical input basis for the assessment and should not be interpreted as current operating parameters.

Table 2. General input data on working time

Item	Amount
Number of paid working days per year	261
Number of working hours per day	8
Average non-productive working time percentage in controlled area	20% of normal working time
Average non-productive working time percentage outside controlled area	9% of normal working time

Working time increase factor dependence on dose rate					
Dose rate [μGy.h^{-1}]	< 2	2 – 20	20 - 200	200 – 2000	> 2000
Increase factor	1.0	1.6	1.6	1.6	2.4

Source-verification note: The dose-rate unit, ranges and increase factors in Table 2 are reproduced as stated in the historical source documentation used for the CDP. They have been checked for correspondence with that source but have not been independently validated for this KP. Therefore, they should be interpreted as historical model inputs rather than as current operating values or independently verified radiological data.

Cost components of the PSL items / group

Table 3 presents the labour rates, expense rates, contingency allowances and other financial assumptions applied in the calculation model.

The values in Table 2 and Table 3 formed part of the historic input basis used to develop the CDP. They represented agreed planning assumptions rather than current operating or contractual rates. The labour-cost estimates were based principally on the salary information available at the time. The original supporting documents are not currently available for independent verification. Therefore, the values are reproduced as documented inputs to the historic assessment.

For each item / group of the PSL, four cost components (labour costs, investments, expenses and contingency) were defined. To calculate the PSL item costs, the following input data were fixed:

Table 3. PSL calculation input data

Item	Amount			
Workers				
Worker category	**Average labour costs**		**Average expenses**	
	(SKK/hour)	**(EUR/hour)***	**(SKK/hour)**	**(EUR/hour)***
Auxiliary worker	175.00	5.81	100	3.32
Classified worker	320.00	10.62	130	4.32
Technician	370.00	12.28	140	4.65
Clerk	180.00	5.97	100	3.32
Engineer	490.00	16.27	170	5.64
Senior engineer	550.00	18.26	200	6.64
Top management level	930.00	30.87	400	13.28
Total average worker	400.00	13.28	180	5.97

Item	Amount
Average investment cost component percentage	12% from calculated sum (labour costs + expenses)
Labour costs contingency	10%
Expenses contingency	10%
Investment contingency	10%
VAT %	19% (if any)
Risk rate %	2% (if any)

* Exchange rate 1 EUR = 30.126 SKK

Selected prices and unit factors
See Appendix 6. Selected prices and unit factors.

2.3.3. Calculation model

Each item (calculation row) had its total costs broken down into labour costs, investment costs, expenses and contingency (in accordance with the PSL). Formulas corresponding to each cost category are depicted in Table 4.

Table 4. Calculation model formulas

Cost category	Formula
Labour costs	calculated manpower * average labour costs (per worker category)
Investment costs	fixed investment costs per item + (labour costs + expenses) x average investment percentage
Expenses	calculated manpower x average expenses (per worker category) + calculated process expenses + fixed expenses per item
Contingency	labour costs x labour costs contingency percentage + expenses x expenses contingency percentage + investment costs x investment costs contingency percentage

The **presented formulas consisted of multiple components**, including the following calculations:

a. calculated manpower for activity-dependent costs (e.g. dismantling) = calculated process manpower * (1 + average non-productive working time percentage) * increase factors,

b. calculated manpower for time-dependent costs (e.g. engineering services) = calculated process manpower,

c. average non-productive working time percentage = average non-productive working time percentage in controlled area + average non-productive working time percentage outside controlled area,

d. increase factor = factors increasing the calculated manpower due to work in areas with ionising radiation and other types of work difficulties.

Average labour cost per worker included all payments to the employee, including contributions and charges. These consisted of being basic and additional payments, allowances, social security, insurance, social charges. Expenses from processes were calculated separately.

Dismantling template procedure
The material inventory served as an input. To determine the amount of labour hours, the weights of each type of material were multiplied by the labour-unit factors for dismantling, applying the relevant increase factor for higher dose rates. Material types were broken down according to the material-routes distribution table, which changed over time as it reflected the radioactive decay of waste disposed of in the National Radioactive Waste Repository (NRWR) or free-released.

Decontamination
Three types of decontamination were modelled: pre-dismantling decontamination for dose reduction, post-dismantling decontamination of metals and final decontamination of building surfaces.

Pre-dismantling decontamination
Used autonomous circuits, with circuit number, volume and contamination as inputs. A contamination limit of <1 kBq/cm² and average decontamination factor of 10 were applied. Labour hours and agent consumption were based on the number of circuits, repetitions and circuit volume.

Post-dismantling decontamination of metals
Was calculated like waste treatment: a defined share of dismantled metal was multiplied by labour-unit and consumption-unit factors.

Final decontamination
Used floor and wall areas as inputs. Labour hours were obtained by applying labour-unit factors to the portions treated chemically or mechanically.

Radiation survey
The total areas of floors, walls and external areas served as an input. The areas were multiplied by the labour-unit factors for the radiation survey to determine labour hours. Other types of the radiation survey were calculated as time-dependent activities (see below).

Demolition
The balance of materials served as an input. Weights of individual material types were multiplied by the labour-unit factors for demolition to determine labour hours.

Waste treatment and conditioning
The sums of individual waste routes from the dismantling, demolition and decontamination activities served as an input. Weights or volumes of individual waste routes were multiplied by the labour-unit factors for each waste-treatment and conditioning method to determine labour hours.

Packaging
The sums of individual processed waste routes from the waste treatment and conditioning served as an input. The numbers of containers for the interim RAW storage facility or near surface repository were derived from the waste volumes. The numbers of each container type were multiplied by the labour unit factors for packaging to determine labour hours. The same applied to ISO containers which were used to place the VLLW metallic waste in the interim storage of RAW (IS RAW).

Storage
The number of containers, their type, storage type and duration of storage served as an input to determine the amount of labour hours needed.

Transport
The number of containers, their type, type of transport means and the distance from repository, communal disposal site or recycling plant served as an input to determine the amount of labour hours needed. Transport destinations included conventional waste dumps, salvage (only uncontaminated waste which was not planned for backfilling), NRWR and IS RAW. For material routes of selected materials, see Appendix 7. Material routes.

Disposal
The number of containers to be disposed of served as an input to determine the amount of labour hours needed.

Assets recovery
The weights of the metals to be sold to the recycling companies or residual prices of the usable equipment served as an input to determine the amount of labour hours needed for the management of the sale. Sales income was deducted from the total costs.

Time-dependent activities
In this template procedure, the duration of the activity and the number of workers needed on various working posts served as an input. The amount of labour hours needed was a scalar product of the number of workers per category and their corresponding labour costs multiplied by the duration of the activity. This procedure was also used for the fixed costs activities.

In addition to the physical dismantling and waste-management activities represented in the model, the assessment also needed to account for the organisational, technical and infrastructure preparations required before licensed decommissioning could begin. These requirements were addressed through the preparatory decommissioning activities (PDA) described below.

2.4. Preparatory decommissioning activities

The pre-decommissioning stage was the final period of the plant operation under the operation licence (for schematic phasing of the V1 NPP decommissioning process, see Figures 3 to 5) that included V1 NPP preparation for the final shutdown, final shutdown and establishing the optimum conditions for its subsequent decommissioning.

The CDP identified a set of **PDAs** required before decommissioning could begin. These activities included:

- separation of V1 NPP from the other SE EBO facilities that remained in operation,
- preparation and execution of V1 NPP final shut down and termination of operation,
- assessment of V1 NPP status at the beginning of decommissioning,
- assurance of the availability of qualified personnel for decommissioning,
- development of V1 NPP decommissioning documentation,
- provision of new and / or modified infrastructure for V1 NPP decommissioning,
- other tasks, such as assessment of legal, technical and other preconditions and requirements for handover of the V1 NPP for decommissioning.

The purpose of the planned PDAs was to establish the technical, organisational and financial conditions required to begin decommissioning and to support strategic planning for the overall programme.

Knowledge-transfer insight: preparation for decommissioning extends beyond final shutdown and fuel removal. Organisational arrangements, qualified personnel, documentation, infrastructure and the separation of shared services should be addressed early enough to support the transition from operation to decommissioning.

An overview of PDAs is provided in Appendix 8. Overview of preparatory decommissioning activities.

With the preparatory requirements and analytical baseline established, the assessment proceeded to define the option-specific dismantling sequences, schedules and end states.

2.5. Analysis of decommissioning options

The objective of this section is to present the analysis of the decommissioning options which was conducted on a conceptional level. Three options were analysed and the inadequacy of the fourth option was justified.

The **three decommissioning options analysed**, along with the justification for dismissing the fourth option, were:

- Option 1: IDO
  - The immediate and continuous equipment and facilities dismantling, demolition of buildings up to the bottom of building pit and preparation of the site for a new nuclear power plant erection.
- Option 2: SES
  - The safe enclosure of the equipment of the primary circuit (30 years).
- Option 3: RSE
  - The safe enclosure of the reactor in the reactor shaft (30 years).
- Option 4: ZO
  - The status that would arise if no activity was realised.

The key parameters (labour hours, CED, etc.) were presented in the PSL for each of the options. The **calculation model** used in this analysis **recognised two main types of activities**:

- mass-related (e.g. decontamination),
- time-dependent (e.g. planning).

For the calculation of mass-related activities, data such as CBs to be decommissioned, material inventory and material routes were used. For time-dependent activities, duration and personnel needed were estimated and these estimations were subsequently applied in the calculations. Some activities, such as labour hours or dose loads, were estimated based on identified PDAs.

PDAs included tasks such as separation of V1 NPP from the other SE EBO facilities remaining in operation, development of V1 NPP decommissioning documentation or provision of new and/or modified infrastructure for V1 NPP decommissioning (see sections 2.3 and 2.4).

The results of the analysis and calculation included various parameters, such as labour, volumes and categories of decommissioning materials and wastes produced, consumables and dose estimations for the individual PSL items. The following subsections describe how these common inputs and calculation principles were applied to each option, beginning with immediate decommissioning.

2.5.1. Option 1: Immediate decommissioning option

The main characteristic of this option is the immediate and continuous dismantling of equipment and facilities, the demolition of buildings, primarily down to the bottom of the building pit, and the preparation of the site for industrial reuse.

A simplified scheme illustrating the time schedule from final shutdown of V1 NPP to the completion of decommissioning can be seen in Figure 3 below.

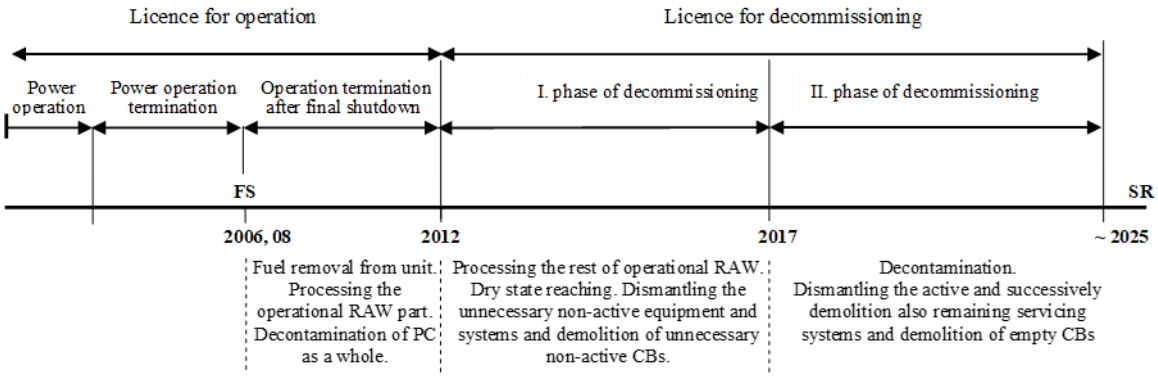


Figure 3. Option 1: simplified scheme

For a detailed decommissioning scheme (without timeline), see Appendix 1. Option 1 scheme.

The CBs (see Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned) were grouped into seven groups to illustrate the general order of decommissioning. The sequence was based on the point at which individual CBs became unnecessary, and the order of CBs to be decommissioned was proposed for each group.

The grouping and sequencing of structures were based on two principal considerations: when individual facilities became unnecessary for continued site operations and how their removal supported the overall end-state objectives of the strategy. Under IDO, redundant non-contaminated facilities were scheduled for removal at an early stage, before dismantling progressed to radiologically significant structures.

The IDO strategy offered the earliest completion of decommissioning and site release among the options assessed. It also supported continuity of manpower and the utilisation of RAW-processing facilities, both of which were subsequently considered in the multi-criteria analysis.

Transferable lesson: Workforce continuity should be considered as a strategic factor during option selection. Long deferral periods can increase the risk of knowledge loss, retraining requirements and reduced organisational continuity, while immediate implementation may allow expertise developed during operation and shutdown to be transferred more effectively into decommissioning activities.

The following grouping presents the planned sequence of structures under the IDO strategy. A consolidated inventory of the structures considered under each option is provided in Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned. The CDP assumed the following principal phases and sequencing for IDO.

Decommissioning phase I (2012–2014)
In this phase, only non-contaminated equipment and CBs were planned for decommissioning.

1. CBs which were already shutdown in the time of V1 NPP power operation;
2. CBs/systems shut down during/just after unit shut down;
3. CBs/systems shut down after replacement/obsoleteness at the beginning of decommissioning phase I;
4. CBs/systems shut down after replacement/obsoleteness in the course of decommissioning phase I.

Decommissioning phase II (2015–2025)

5. CBs with radioactive contamination;
6. Non-contaminated CBs which served for decommissioning;
7. Underground canals, channels, drinkable water piping, drainage.

Input data for mass-related activities
Input data was based on data provided in appendices 5–7. This data formed the basis for the analysis of mass-related activities in the PSL structure.

Input data for time-dependent activities
There was a limited amount of input data for time-dependent activities provided in appendices 5–7. Therefore, the Contractor's experience was used to select and evaluate the respective PSL items. That included mainly the assessment of the overall duration of the PSL items and the assignment of a certain number of workers of various categories to these PSL items as a basis for further calculation.

Main general investments for IDO
The main general investments are presented in Appendix 9. Main general investments. This list was based on PDA and items presented in Appendix 8. Overview of preparatory decommissioning activities.

2.5.2. Option 2: Deferred decommissioning option with safe enclosure under surveillance for 30 years

In contrast to IDO, SES deferred the dismantling of selected primary-circuit equipment through a 30-year safe-enclosure period. Before the operation is terminated, the spent fuel is removed from each unit and part of the operational RAW is processed. After expiration of the term of SES, the facilities are dismantled, by taking into account the radiation that could be decreased because of natural decay of isotopes. So this option could be characterised as an interrupted decommissioning process.

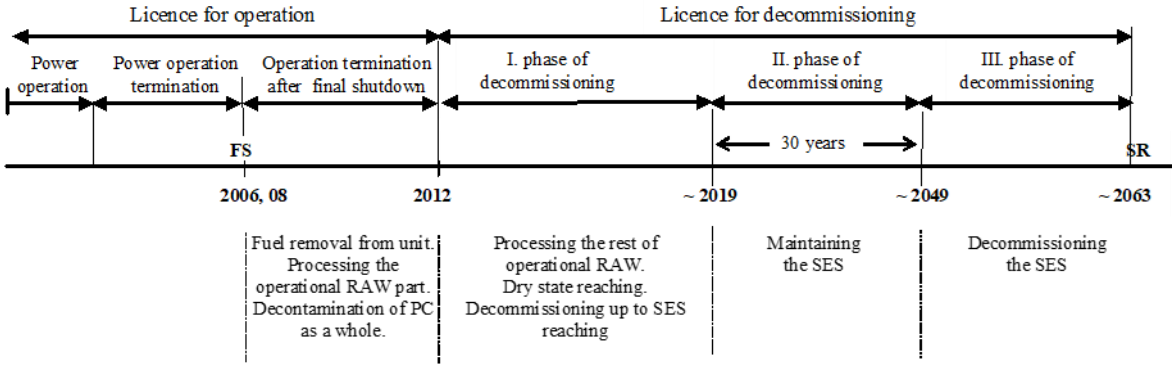


Figure 4. Option 2: simplified scheme

The principal rationale for SES was to defer the dismantling of selected radiologically significant equipment so that natural radioactive decay could reduce radiation levels before final dismantling. Under the SES assumptions, structures no longer required would be removed during the earlier stages, while facilities needed to maintain the safe enclosure and support surveillance would remain in service.

For a detailed scheme, see Appendix 2. Option 2 scheme.

The CBs (see Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned) were grouped into eleven groups to illustrate the general order of decommissioning. The sequence was based on the point at which individual CBs became unnecessary and the order of CBs to be decommissioned was proposed for each group.

The following grouping illustrates the progressive reduction of site infrastructure during the active stages of the SES strategy. The CDP assumed the following phased sequence for SES. The dates represent the indicative schedule used in the option assessment.

Decommissioning phase I (2012–2019)
In this phase, only non-contaminated equipment and CBs were planned for decommissioning.

1. CBs which were already shutdown in the time of V1 NPP power operation;
2. CBs / systems shut down during/just after unit shut down;
3. CBs / systems shut down after replacement/obsoleteness at the beginning of decommissioning phase I - CBs ensuring emergency power supply;
4. CBs / systems shut down after replacement/obsoleteness at the beginning of decommissioning phase I - CBs of circulating cooling water, except for the central pumping station of circulating cooling water – building 583 and two cooling towers;
5. CBs / systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Systems which deliver compressed air, cooled water, hydrogen, nitrogen, oils, charging water from Pečeňady;
6. CBs / systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Chemical water treatment and demineralised water except for building 802;
7. CBs / systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Substations, lines, transformers.
8. CBs / systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Turbine hall and cross/longwise side electrical buildings (after proving classification as inactive constructions).

Decommissioning phase II (2020–2049)
This phase comprised the 30-year safe-enclosure period. Plant items containing radioactive materials and the associated equipment were to remain in a closed and controlled condition, with the required protection barriers maintained throughout the enclosure period. The assumed activities included site security and surveillance, inspection and maintenance of retained buildings and systems, general site upkeep, provision of energy and water, as well as periodic radiological and environmental surveys.

For **cost-modelling** purposes, the historic assessment assumed an annual labour requirement of approximately 33,000 labour hours during the **SES enclosure period**. This figure was a planning input used to estimate time-dependent costs and should not be interpreted as a subsequently verified staffing level or as a current operational requirement.

Decommissioning phase III (2049–2063)

9. CBs with radioactive contamination;
10. Other CBs which served for decommissioning;
11. Underground canals, channels, drinkable water piping, drainage.

Input data for mass-related activities
Input data were based on data provided in Appendices 5–7. These data formed the basis for the analysis of mass-related activities in the PSL structure.

Input data for time-dependent activities
There was a limited amount of input data for time-dependent activities provided in Appendices 5–7. Therefore, the Contractor's experience was used to select and evaluate the respective PSL items. That included mainly the assessment of the overall duration of the PSL items and the assignment of a certain number of workers of various categories to these PSL items as a basis for further calculation.

Main general investments for SES
The main general investments are presented in Table 5. The list was based on PDA and items presented in Appendix 8 and is relevant also for this option.

2.5.3. Option 3: Deferred decommissioning option with reactor safe enclosure for 30 years

RSE used a more concentrated form of deferred dismantling, with safe enclosure limited principally to the reactors and reactor shafts. Before the operation is terminated, the spent fuel is removed from the unit, part of the operational RAW is processed and decontamination of the primary circuit as a whole is performed. During the time of reactor safe enclosure, two independent buildings remain in the site area: the reactor shafts with the reactors and some other service CBs.

Unlike SES, RSE concentrated the safe enclosure around the reactors and reactor shafts. This represented an intermediate approach in which a larger proportion of the surrounding facility could be dismantled during the earlier stage, while dismantling of the most radiologically significant reactor components was deferred to allow for radioactive decay.

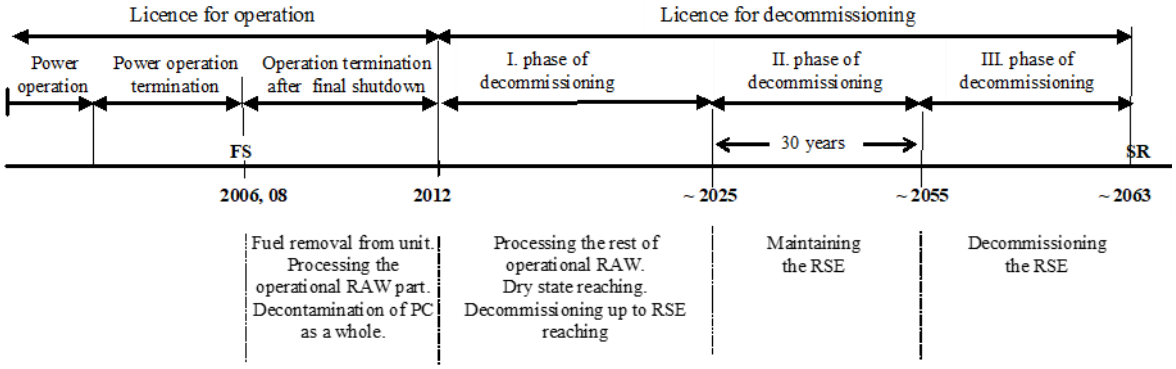


Figure 5. Option 3: simplified scheme

For a detailed scheme, see Appendix 3. Option 3 scheme.

The CBs (see Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned) were grouped into thirteen groups to illustrate the general order of decommissioning. The sequence was based on the point at which individual CBs became unnecessary, and the order of CBs to be decommissioned was proposed for each group.

The sequence below shows how dismantling of the surrounding facility was planned while preserving the reactor enclosure for deferred dismantling. The CDP assumed the following staged sequence for RSE; the dates represent the indicative schedule used in the option assessment.

Decommissioning phase I (2012–2024)

1. CBs which were already shutdown in the time of V1 NPP power operation;
2. CBs shutdown during / just after unit shutdown;
3. CBs / systems shut down after replacement/obsoleteness at the beginning of decommissioning phase I - CBs ensuring emergency power supply;
4. CBs / systems shut down after replacement/obsoleteness at the beginning of decommissioning phase I - CBs of circulating cooling water, except for the central pumping station of circulating cooling water – building 583 and two cooling towers;
5. CBs/systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Systems which deliver compressed air, cooled water, hydrogen, nitrogen, oils, charging water from Pečeňady;
6. CBs/systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Chemical water treatment and demineralised water except for building 802;
7. CBs/systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Substations, lines, transformers;
8. CBs/systems shut down after replacement/obsoleteness in the course of decommissioning phase I - Turbine hall and cross/longwise side electrical buildings (after proving classification as inactive constructions);
9. CBs with radioactive contamination;
10. Non contaminated CBs which served for decommissioning;
11. Platforms, roads, rails lighting AKOBOJE;
12. Underground canals, channels, drinkable water piping, drainage.

Decommissioning phase II (RSE)

This phase comprised the 30-year reactor safe-enclosure period. The reactors were to remain enclosed within closed buildings, with the required protection barriers maintained and monitored. The assumed activities included site security and surveillance, inspection and maintenance of retained buildings and operating systems, general site upkeep, provision of energy and water, as well as periodic radiological and environmental surveys.

For **cost-modelling** purposes, the historic assessment assumed an annual labour requirement of approximately 6,000 labour hours during the **RSE enclosure period**. This figure was a planning input used to estimate time-dependent costs and should not be interpreted as a subsequently verified staffing level or as a current operational requirement.

Decommissioning phase III (2055–2063)
13. Reactor shaft.

Input data for mass-related activities
Input data were based on data provided in Appendices 5–7. These data formed the basis for the analysis of mass-related activities in the PSL structure.

Input data for time-dependent activities
There was a limited amount of input data for time-dependent activities provided in Appendices 5–7. Therefore, the Contractor's experience was used to select and evaluate the respective PSL items. That included mainly the assessment of the overall duration of the PSL items and the assignment of a certain number of workers of various categories to these PSL items as a basis for further calculation.

Main general investments for RSE
The main general investments are presented in Table 5. The list was based on PDA and items presented in Appendix 8. Overview of preparatory decommissioning activities and is relevant also for this option.

Taken together, the three options illustrate that the timing and extent of dismantling determine how the potential benefits of radioactive decay are balanced against programme duration, site release, infrastructure retention and continuity of implementation resources.

2.5.4. Zero (no action) option

For the purposes of the assessment, the zero option represented the baseline condition in which no active decommissioning programme would be implemented. It did not mean the complete absence of activity, because monitoring, maintenance, safety functions and supporting services would still be required.

During decommissioning, regulations did not allow the traditional ZO approach. Instead, the ZO meant continued operation of the radioactive civil structures and process equipment (including the reactor), with ongoing radiation monitoring, barrier-integrity maintenance, as well as provision of energy and operational media.

Some non-active civil structures also had to remain in operation to support active systems and provide basic employee facilities.

Under the ZO:

- no liquid RAW was stored in the V1 NPP structures,
- activity remained as surface contamination on internal equipment and building surfaces, as well as induced activity in reactor materials, internals and other components.

Under the ZO assumptions, the following auxiliary systems would remain in service:

- ventilation systems,
- special drainage,
- radiation monitoring,
- automated information system,
- fire indication system,
- electrical distribution systems,
- media piping,
- underground water monitoring system,
- accesses to controlled area, shower bathrooms and operator rooms.

The zero option was included in the CDP and the wider EIA process as a comparison case but was excluded from detailed evaluation alongside IDO, SES and RSE. It represented an indefinite continuation of monitored shutdown conditions rather than a practicable decommissioning strategy. The stated reasons for exclusion were its unlimited duration, postponement of future site use, the prolonged potential for releases of radioactive substances to the environment and the indefinite costs of maintaining the shutdown condition.

2.5.5. Safety

Safety was treated as a fundamental requirement for every option. The assessment assumed that the applicable legislative requirements and the As-Low-As-Reasonably-Achievable (ALARA) principle would govern radiation protection and that measures such as limiting exposure time, providing shielding and monitoring radiological conditions would be applied as appropriate.

Because each option was required to satisfy the applicable safety framework, the comparative assessment also considered the extent to which the options differed across radiological, environmental, economic, implementation and RAW-management criteria.

2.6. Complex comparison of decommissioning options

The objective of this section is to provide a comparison of multi-criteria analysis results of the three decommissioning options. This method compared the options by considering a large set of criteria and by taking into account the rate of their importance. The final quality of the analysis was determined by two conditions: correctly defined criteria and a reasonable scaling of importance (criterion weight)

Basis and limitations of option comparability

The three options were evaluated using the same criteria, weights and calculation methodology. Their intended end state was understood to be the same but the routes and timescales for reaching that end state differed. The options did not include identical building scopes, retained infrastructure, intermediate site configurations or dismantling schedules. Therefore, applying a common evaluation framework ensured methodological consistency but did not fully normalise the effects of these scope and timing differences.

The comparative results should be interpreted with these limitations in mind.

2.6.1. Summary characteristics of evaluating decommissioning options

The summary data for evaluating the three options is provided below. This data resulted from the analyses discussed in the previous section.

The output parameters describing V1 NPP's decommissioning were selected with reference to similar projects worldwide. Most were economic indicators of required finances, manpower and time; these values, excluding historical RAW management, are provided in Table 5.

Table 5 presents the principal values calculated or estimated for the three options using the assumptions and input data described in the preceding sections. The figures represent the outputs of the conceptual assessment and not final implementation outcomes.

The table also includes nuclear-specific parameters such as worker dose load, environmental impacts, waste generation, processing and disposal. V1 NPP decommissioning required a complex set of technical and time-intensive activities. Preparing, evaluating and comparing several decommissioning options, as well as selecting the most suitable one from legislative, safety, economic, technical, time, and social perspectives, was an essential prerequisite to starting the process.

Table 5. List of main characteristic parameters for evaluating the analysed three options of V1 NPP decommissioning (without historical RAW management)

No.	Characteristic parameter of decommissioning	Unit	Value of parameter for option		
			IDO	SES	RSE
1	Total costs*	M Sk MEUR est.**	20,890.32 693.43	18,737.90 621.98	18,293.14 607.22
2	Collective effective dose	man Sv	13.8778	8.1734	13.2333
3	Duration of the decommissioning process under decommissioning licence	year	14	52	52
4	Labour hours needed	10^3 hours	15,026.5	13,498.4	12,891.1
5	Amount of liquid RAW (before processing at salinity 200 g/dm^3)	m^3	1,930	1,774	1,931
6	Radioactivity of gaseous effluents	Bq	3.22E+06	2.04E+06	3.27E+06
7	Radioactivity of liquid effluents	Bq	7.94E+07	5.04E+07	8.08E+07
8	Amount of released metals	t	55,996	61,004	59,867
9	Amount of recyclable building waste	t	418,125	318,734	318,599
10	Amount of conventional waste	t	3,331	7,855	7,883
11	Number of FCC for NSR	FCC	1 038	886	1,050
12	Number of FCC for ISRAW	FCC	44	30	30
13	Time load of site by radioactivity	year	13.7	51	51

*The cost estimates used input unit prices and factors dated June 2005 within the CDP developed in 2006. Neither inflation nor discounting was applied. This approach was adopted to compare the options on a common constant-price basis without introducing assumptions concerning future inflation, discount rates, technology development or productivity improvements over the substantially different option durations. The resulting figures are historic conceptual estimates and should not be interpreted as current implementation costs.

**Exchange rate 1 EUR = 30.126 SKK

Comparability note: the three options were assessed using the same calculation framework and the same definitions of the principal output parameters. However, the set of buildings, structures and retained infrastructure included within the IDO scope differed in part from those included within the SES and RSE scopes. The options also reached the intended final end state through different intermediate configurations and timescales. These differences contributed to variations in cost, waste quantities, labour requirements and schedule. They were considered when interpreting the results but could not be fully normalised within the multi-criteria calculation.

For the reasons mentioned above, Table 5 should be read as a comparison of complete option concepts under their respective planning assumptions, rather than as a comparison of identical physical scopes

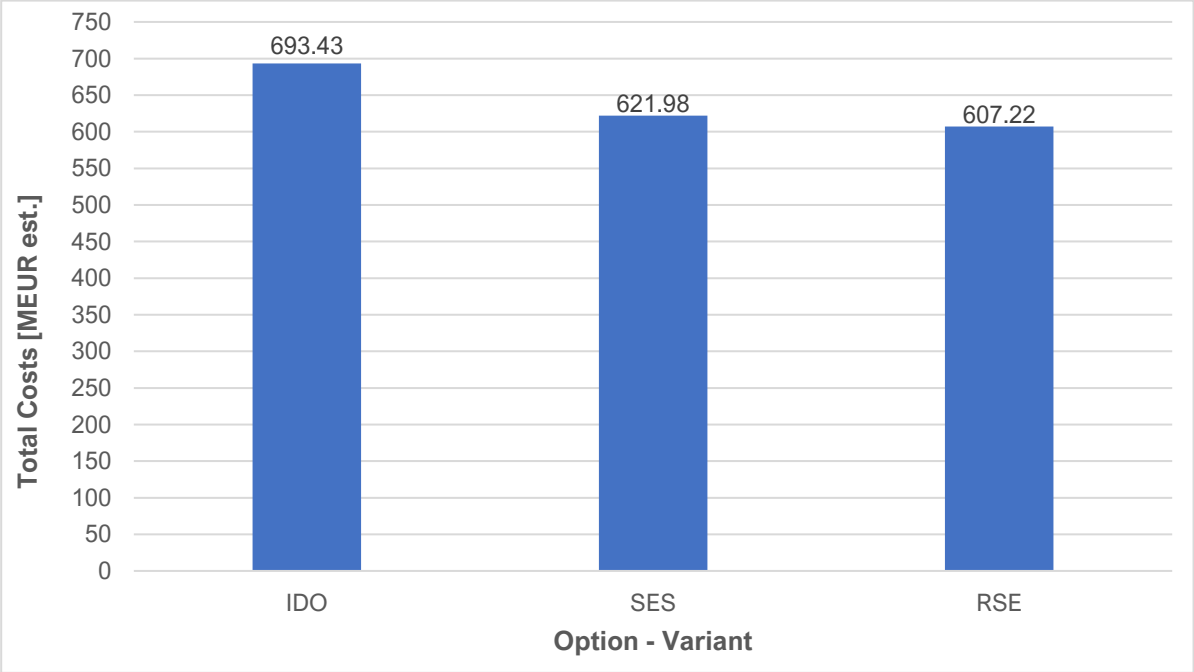


Figure 6. Total costs of analysed decommissioning options

Although RSE had the lowest estimated undiscounted total cost, the preferred strategy could not be determined from cost alone. Therefore, the economic results required consideration alongside the radiological, environmental, implementation and RAW-management criteria.

The collective-dose comparison illustrates the potential radiological benefit of deferred dismantling under the assumptions applied. However, this advantage was considered alongside programme duration, cost, implementation and other criteria in the overall option assessment.

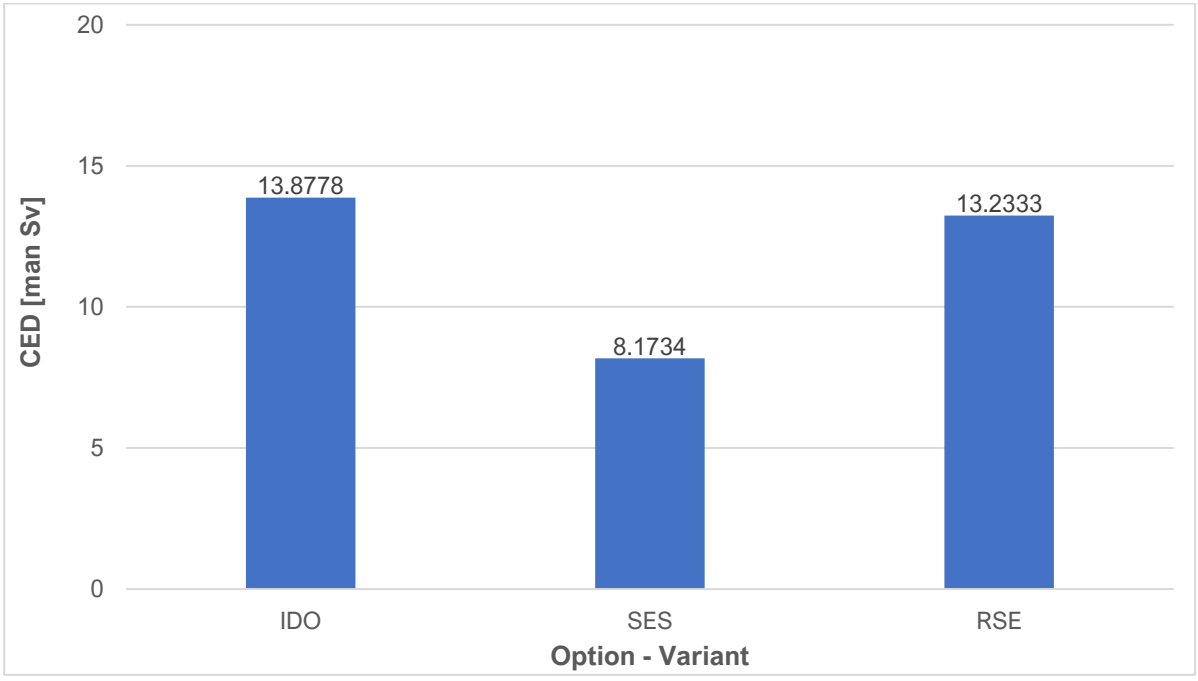


Figure 7. Collective effective dose of analysed decommissioning options

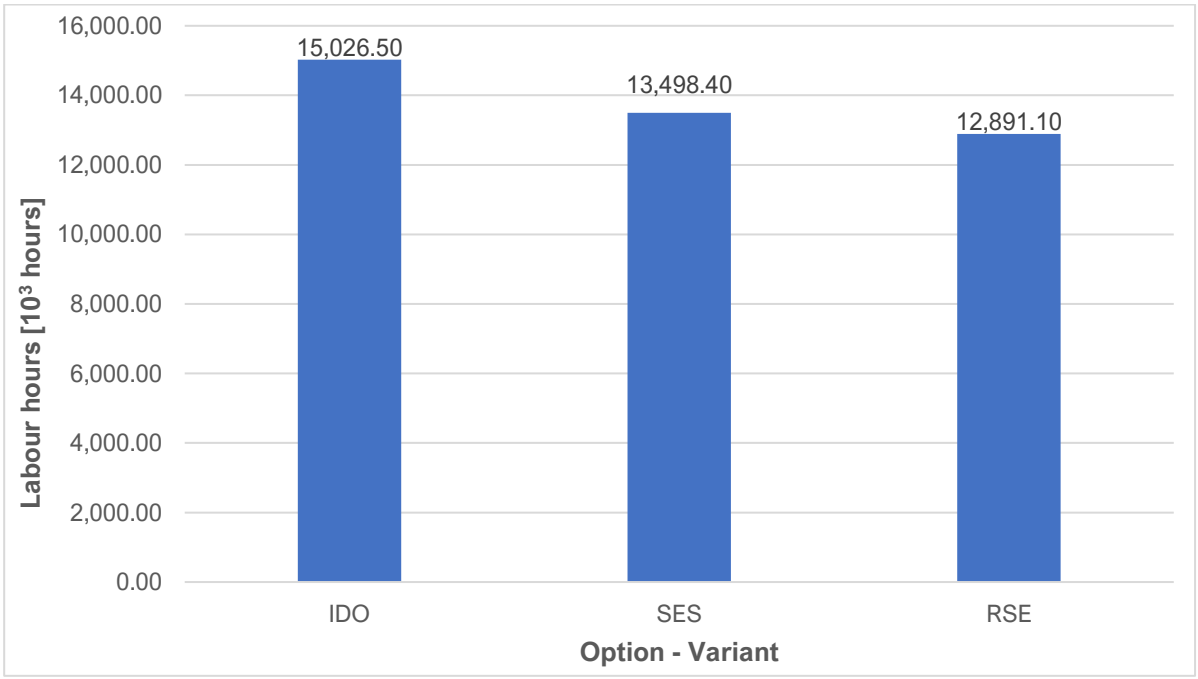


Figure 8. Total labour hours needed for the analysed decommissioning options

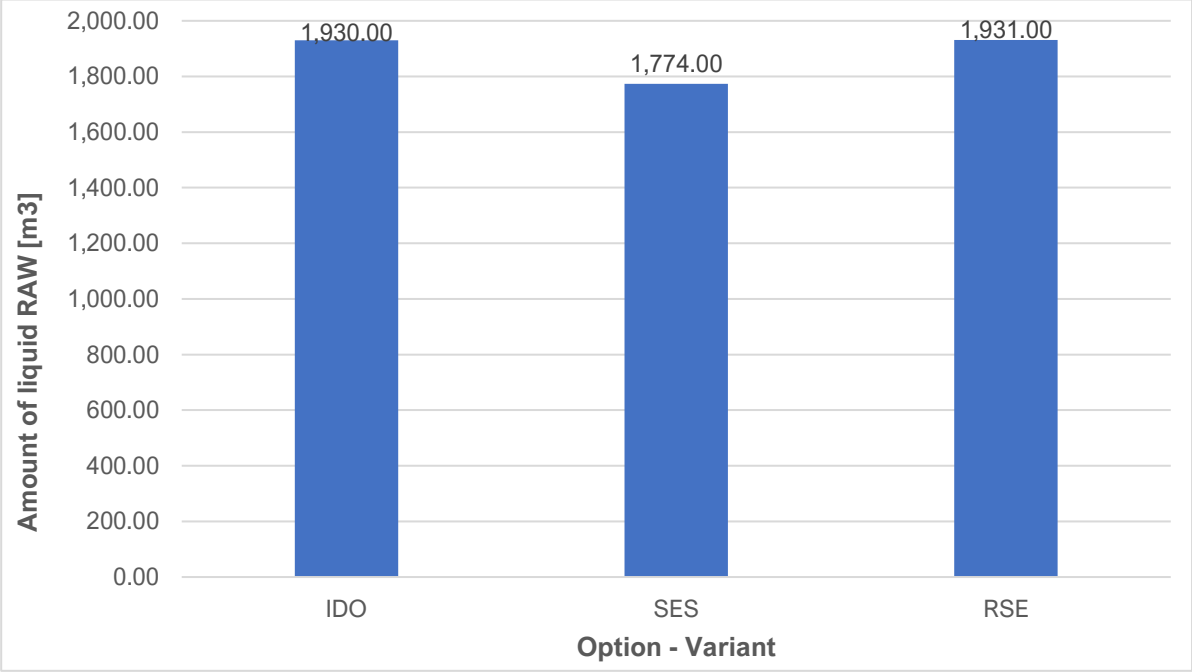


Figure 9. Amount of liquid RAW (before processing at salinity 200 g/dm3)

☆ **Knowledge-transfer insight**: individual performance indicators can favour different options. Therefore, comparative results should be interpreted collectively and in the context of differences in option scope, assumptions and strategic objectives, rather than used independently to determine the preferred strategy.

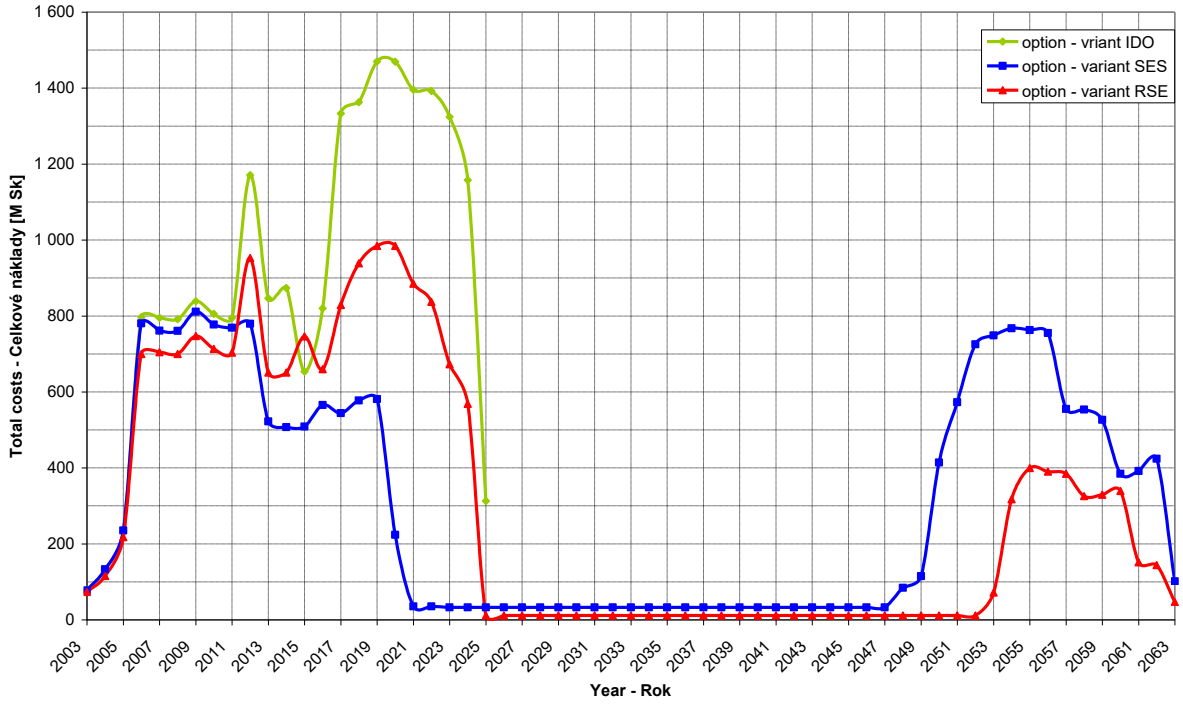


Figure 10. Time dependence of annual total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)

For a figure with greater visibility than Figure 10 (with MEUR estimate), please see Appendix 10. Time dependence of annual total costs of V1 NPP decommissioning options (including VAT and without historical RAW management).

Notes on Figure 10: the main activities contributing to the annual costs in individual time periods are listed below in order of their importance.

Option 1	
2006 - 2014	Preparatory activities and investments for decommissioning and for RAW management Dismantling and demolition of non-contaminated CBs Decommissioning management and support
2015 - 2025	Demolition of CBs Decommissioning management and support RAW management Decontamination of building surfaces Dismantling in the contaminated CBs Pre-dismantling and post-dismantling decontamination

Option 2	
2006 - 2019	Preparatory activities and investments for decommissioning and for RAW management Dismantling and demolition of non-contaminated CBs Decommissioning management and support
2020 - 2049	The SES enclosure period was modelled using an annual labour requirement of approximately 33,000 labour hours. This contributed to higher annual enclosure-period costs than under RSE. The model included security and surveillance, inspection and maintenance, site upkeep, utilities, and periodic radiological and environmental surveys. Preparatory activities for the third decommissioning phase were assumed to increase towards the end of the enclosure period.
2050 - 2063	Decommissioning management and support Dismantling and demolition of contaminated CBs RAW management Predismantling and postdismantling decontamination Decontamination of building surfaces

Option 3	
2006 - 2024	Preparatory activities and investments for decommissioning and for RAW management RAW management Decommissioning management and support Dismantling and demolition of CBs
2025 - 2054	The RSE enclosure period was modelled using an annual labour requirement of approximately 6,000 labour hours. The more limited extent of retained facilities contributed to lower annual enclosure-period costs than under SES. The model included security and surveillance, inspection and maintenance, site upkeep, utilities, and periodic radiological and environmental surveys. Preparatory activities for the third decommissioning phase were assumed to increase towards the end of the enclosure period.
2055 - 2063	RAW management Demolition Dismantling the reactors

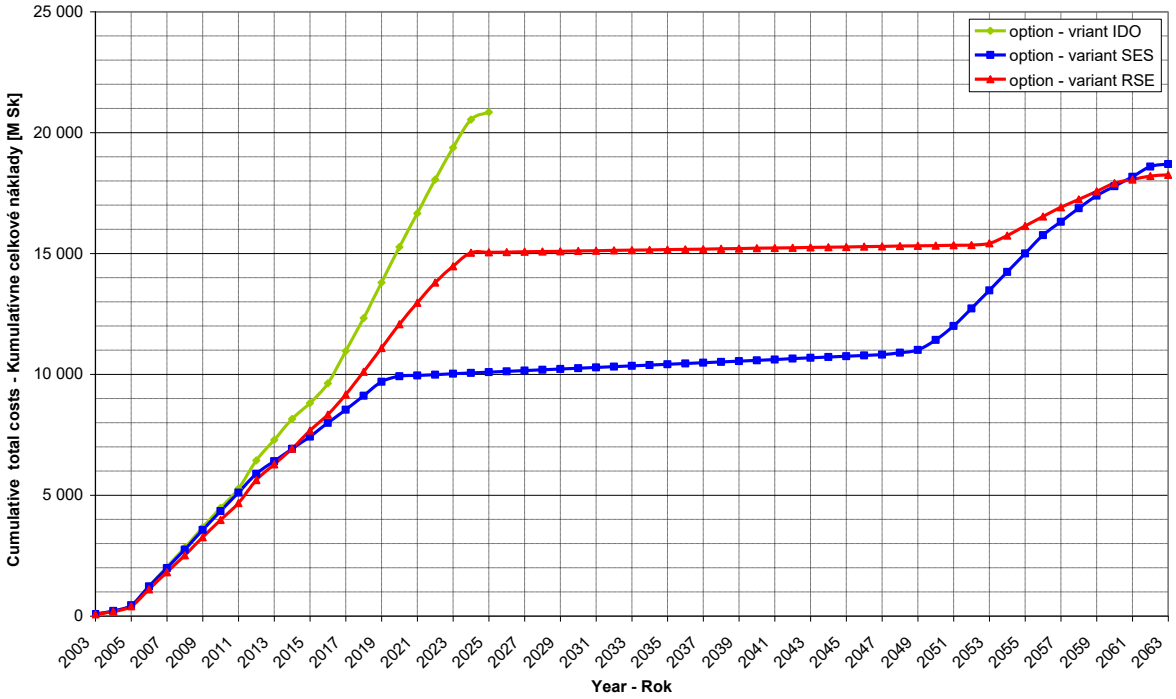


Figure 11. Time dependence of cumulative total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)

For better visibility of Figure 11 (with MEUR estimate), please see Appendix 11. Time dependence of cumulative total costs of V1 NPP decommissioning options (including VAT and without historical RAW management).

2.6.2. Multi-criteria analysis of the evaluated decommissioning options

A concise overview of the key aspects for selecting the most suitable decommissioning option is provided in this subsection. It outlines the multi-criteria analysis (MCA) used to evaluate the analysed options, the classes of criteria based on their importance and the proposed methodology for assessing and selecting the preferred option. cost, occupational exposure, waste generation, implementation complexity and long-term site objectives. The preceding evaluation showed that different indicators favoured different options, so no single indicator was sufficient to capture all relevant advantages and disadvantages of the alternatives.

Rationale for applying multi-criteria analysis
A decision based solely on economic or radiological criteria could overlook other factors that are important for successful implementation. Therefore, no single individual criterion provided a sufficient basis for identifying the preferred decommissioning strategy. For this reason, the MCA approach was adopted to integrate the quantitative and qualitative considerations within a single decision-support framework, allowing the relative strengths and limitations of each option to be assessed in a balanced manner.

The **basic multi-criteria analysis steps were**:

- defining the set of criteria,
- dividing criteria into objective and subjective classes and assigning weights,
- determining criterion values for each option,
- evaluating options mathematically according to the methodology,
- recommending the most suitable V1 NPP decommissioning option based on the comparison results.

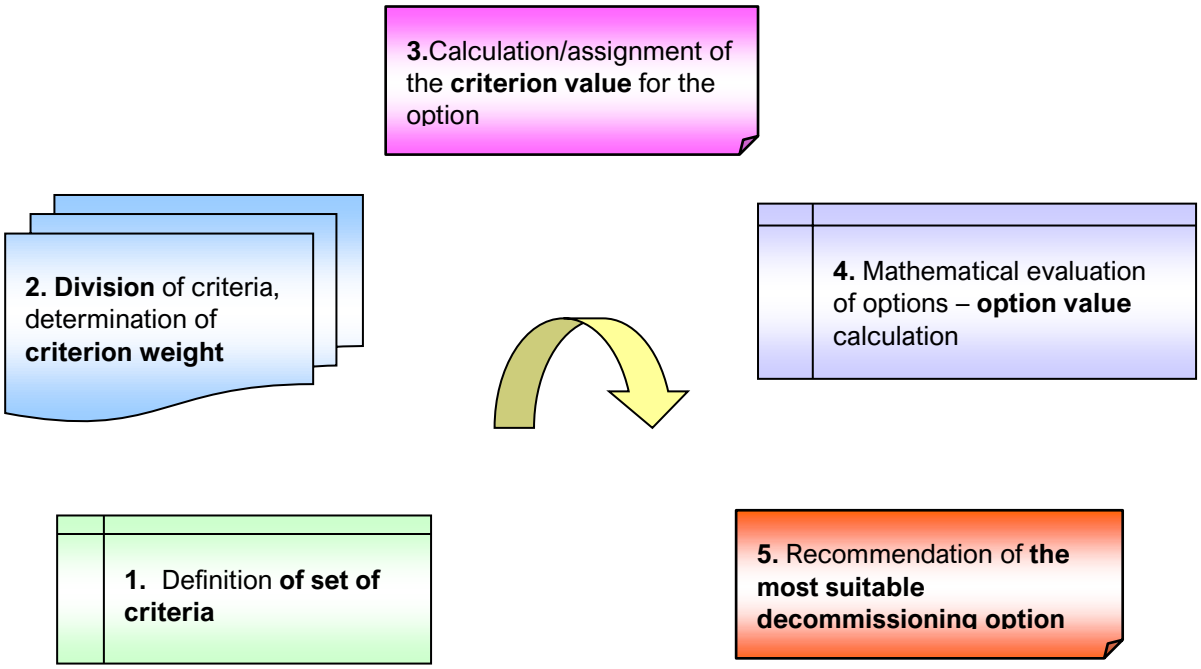


Figure 12. Scheme of the multi-criteria analysis

Evaluation criteria: grouping, classification and weight assignment

Thirteen criteria were defined and divided into five groups: safety, environmental, economic, implementation, demands for repositories of RAW. Criteria groups were important to ensure all important areas are considered. Additionally, the criteria were divided into two classes: objective and subjective.

Objective
Criteria for which the criterion value could be calculated.

Subjective
Criteria were those for which no calculated value existed and the criterion value was assigned by experts.

☆ **Knowledge-transfer insight**: the credibility of a multi-criteria assessment depends not only on the calculation method but also on transparent criterion definitions, documented weighting decisions and a clear distinction between calculated values and expert judgement.

Each evaluation criterion was assigned a weight to reflect its importance, using a common scale from 1 to 10. Experts ordered the criteria by significance and assigned weights accordingly, with the top criterion receiving 10 and others decreasing as agreed. Criteria of equal importance could share the same weight. This method provided a common numerical framework for comparing the criteria, although the resulting weights remained dependent on expert judgement and the decision priorities adopted at the time. Final weights, determined through team evaluation, are shown in Table 6.

Table 6. Criteria grouping and weighting

No.	Description	Criterion weight	Criterion class
	Safety criteria		
1	Total CED	10	Objective
	Environmental criteria		
2	Radiation consequences of gaseous effluents to environment	5	Objective
3	Radiation consequences of liquid effluents to environment	5	Objective
4	Time load of site by radioactivity	6	Objective
5	Amount of conventional waste	2	Objective
	Economic criteria		
6	Total costs	8	Objective
7	Time distribution of costs	8	Subjective
8	Labour hours needed	5	Objective
	Implementation criteria		
9	Continuity of manpower and RAW processing facilities utilisation	8	Subjective
10	Time of final site release	7	Objective
11	Preparedness of site for further utilisation	3	Subjective
	Criteria of demands for RAW repositories		
12	Total number of FCC into NSR	8	Objective
13	Total number of FCC into ISRAW	8	Objective

The weighting and subjective scoring were established through mutual agreement informed by informal consultations with relevant teams, experience associated with Greifswald NPP and international and authority recommendations. No formal consensus method or complete official record of the weighting and scoring discussions has been identified. Therefore, the published weights and scores are traceable to the final assessment tables but the underlying deliberative process cannot be independently reconstructed from the records currently available.

Assignment of criterion value for the option
Criterion values were assigned to each of the thirteen criteria for every decommissioning option. Values for the objective criteria were derived from the analyses and calculations. Values for the subjective criteria were assigned by the expert group using its review of the preceding analyses, professional judgement and experience. For the subjective criteria, a scale from 1 to 100 was applied, with lower values representing more favourable performance.

All criteria values for the decommissioning options are presented in Table 7.

Table 7. Criterion values assigned to the decommissioning options

No.	Description	Criterion value		
		IDO	SES	RSE
	Safety criteria			
1	Total CED	13.8778	8.1734	13.2333
	Environmental criteria			
2	Radiation consequences of gaseous effluents to environment	3.22E+06	2.04E+06	3.27E+06
3	Radiation consequences of liquid effluents to environment	7.94E+07	5.04E+07	8.08E+07
4	Time load of site by radioactivity	13.7	51	51
5	Amount of conventional waste	3,331	7,855	7,883
	Economic criteria			
6	Total costs (MSKK) MEUR estimate*	20,890.32 693.43	18,737.90 621.98	18,293.14 607.22
7	Time distribution of costs	30	80	70
8	Labour hours needed	15,026.5	13,498.4	12,891.1
	Implementation criteria			
9	Continuity of manpower and RAW processing facilities utilisation	30	80	60
10	Time of final site release	14	52	52
11	Preparedness of site for further utilisation	20	80	80
	Criteria of demands for RAW repositories			
12	Total number of FCC into NSR	1,038	886	1,050
13	Total number of FCC into ISRAW	44	30	30

*Exchange rate 1 EUR = 30.126 SKK

The inclusion of multiple criteria reflects the fact that decommissioning decisions require balancing competing objectives. For example, an option that performs favourably from a cost perspective may not necessarily minimise waste generation or optimise workforce utilisation. Therefore selected criteria represent different dimensions of decision-making that together provide a more comprehensive assessment of overall option performance.

Methodology and procedure of options evaluation
The next step was to calculate the option value for each decommissioning option. These values were then compared across all options. The principle applied was simple: the lower the option value, the more suitable the option.

The **following inputs were used in the multi-criteria analysis for evaluating**:

- criterion values for the first option X11, X12, ... X1n,
- criterion values for the second option X21, X22, ... X2n,
- criterion values for the k-th option Xk1, Xk2, ... Xkn,
- criterion weight assigned to each criterion W1, W2, ... Wn, which is common for all the considered options.

where:

- n is the number of criteria,
- k is the number of analysed decommissioning options,
- X_{ji} is the criterion value for the i-th criterion of the option j,
- W_i is the criterion weight of the i-th criterion.

For all options j = 1, 2,…k the **option value** S_j is calculated as the sum of products of criterion weight W_i and criterion value X_{ji}, divided by the arithmetic average of criterion values of the i-th criterion. The respective formula can be expressed as:

$$S_j = \sum_{i=1}^{n} \frac{(W_i \times X_{ji})}{\overline{X}_i}$$

where:

- i is criterion serial number, i = 1, 2, ...n,
- j is option serial number, j = 1, 2, ...k,
- S_j is **option value** of the j-th option,
- $\overline{X}_i$ is the arithmetic average of the criterion values of i-th criterion for all the options j = 1, 2,….k, calculated by the formula.

$$\overline{X}_i = \frac{\sum_{j=1}^{k} X_{ji}}{k}$$

The selection of the most suitable option is finally made by selecting the option with the least option value:

$$S_{tmso} = \min(S_1, S_2, \ldots S_k)$$

The weighting factors represent the relative importance assigned to each criterion within the decision framework. Therefore, they influence the final ranking of the options. While the technical performance of the alternatives remains unchanged, different weighting assumptions may lead to different overall preferences. The weighting process should be viewed as an explicit representation of decision priorities rather than a purely mathematical exercise.

Table 8 presents the contribution of each criterion to the resulting option value of all potential decommissioning options. The source work reports that sensitivity consideration relating to costs was undertaken. However, the records available for this KP do not provide sufficient information to reproduce the method, variables, tested ranges or results. No documented sensitivity analysis of criterion weights, subjective scores, schedules or waste assumptions has been identified. Consequently, the robustness of the final ranking under alternative assumptions cannot be demonstrated from the available records.

Table 8. Final results of multi-criteria analysis

No.	Description	Contribution of criterion to option value		
		IDO	SES	RSE
	Safety criteria			
1	Total CED	11.799	6.949	11.251
	Environmental criteria			
2	Radiation consequences of gaseous effluents to environment	5.662	3.587	5.750
3	Radiation consequences of liquid effluents to environment	5.655	3.590	5.755
4	Time load of site by radioactivity	2.131	7.934	7.934
5	Amount of conventional waste	1.048	2.472	2.480
	Economic criteria			
6	Total costs	8.656	7.764	7.580
7	Time distribution of costs	4.000	10.667	9.333
8	Labour hours needed	5.442	4.889	4.669
	Implementation criteria			
9	Continuity of manpower and RAW processing facilities utilisation	4.235	11.294	8.471
10	Time of final site release	2.492	9.254	9.254
11	Preparedness of site for further utilisation	1.000	4.000	4.000
	Criteria of demands for RAW repositories			
12	Total number of FCC into NSR	8.377	7.150	8.473
13	Total number of FCC into ISRAW	10.154	6.923	6.923
	Option value — S_j	**70.652**	**86.473**	**91.875**

Results of multi-criteria analysis
Within the criteria, weights, input values and calculation method applied, IDO obtained the lowest option value, 70.652, and was consequently identified as the preferred option in the multi-criteria assessment.

This result was relative to the input conditions and assumptions and was partly influenced by the expert group's weighting and assignment of subjective criterion values. As a result, the assessment provided a recommendation rather than a binding decision. The MCA results should be interpreted as a decision-support tool rather than an absolute measure of superiority. The results indicate which option provides the most balanced overall outcome under the adopted assumptions, criteria and weighting framework. The value of the MCA process lies not only in identifying a preferred option but also in making the basis of the decision transparent and traceable.

Consequently, a different weighting scheme reflecting different stakeholder priorities could potentially change the relative ranking of the options. This is why the MCA should be regarded as a structured decision-support tool rather than an absolute determination of the preferred strategy.



Transferable lesson: Complex decommissioning decisions rarely have a single objectively correct answer. Structured multi-criteria approaches provide a transparent mechanism for balancing competing technical, radiological, economic and strategic considerations while making the basis of the recommendation visible to stakeholders and regulators.

Within the adopted assumptions, criteria and weighting framework, the MCA identified IDO as the preferred option. The MCA constituted a decision-support recommendation rather than the formal decision. JAVYS management subsequently selected IDO for V1 NPP decommissioning. The CDP was then submitted to the relevant Slovak regulatory, public-health and governmental authorities for review. The subsequent EIA process permitted implementation of the selected strategy. IDO remains the strategy being implemented at V1 NPP.

The comparative option values are presented in Figure 13.

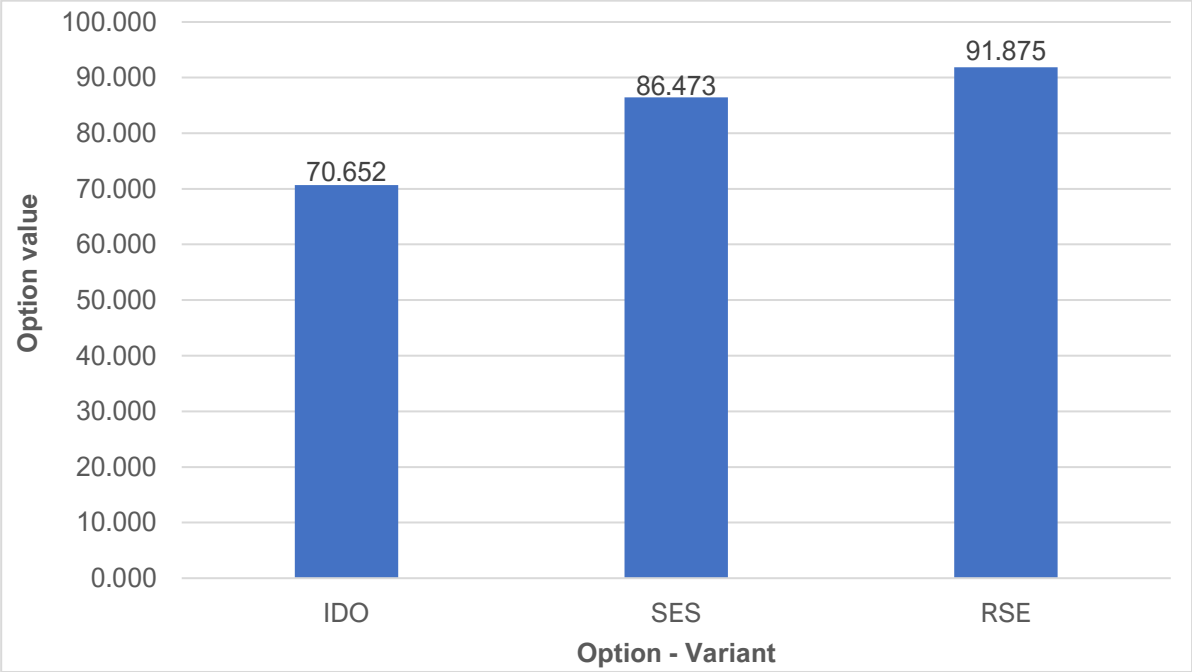


Figure 13. Results of the multi-criteria analysis of V1 NPP's decommissioning options

Knowledge-transfer insight: a limitation of any weighted multi-criteria approach is that results depend, to some extent, on the selected weighting scheme. With this in mind, the rankings presented here should be interpreted within the context of the adopted assumptions and stakeholder priorities.

2.7. Conceptual decommissioning plan

Having identified IDO as the preferred option within the multi-criteria assessment, this concluding section brings together the principal planning assumptions, scope boundaries, analytical inputs and scheduling considerations documented in the CDP.

Before the beginning of decommissioning, it was necessary to carry out some **preparatory activities**. These were:

- separation of V1 NPP from the other SE EBO facilities that remained in operation,
- preparation and execution of V1 NPP final shut down and termination of operation,
- assessment of V1 NPP status at the beginning of decommissioning,
- assurance of the availability of qualified personnel for decommissioning,
- development of V1 NPP decommissioning documentation,
- provision of new and / or modified infrastructure for V1 NPP decommissioning,
- other tasks, such as an assessment of legal, technical and other preconditions as well as requirements for handover of V1 NPP for decommissioning.

For an overview of the PDAs, please see Appendix 8. Overview of preparatory decommissioning activities.

Option 1 involved immediate dismantling of selected V1 NPP civil structures and demolition down to the building pit to prepare the site for a new plant. In options 2 and 3 a broader set of structures was planned to be decommissioned for unrestricted site release, with demolition to –1 m.

The CDP divided decommissioning into two stages for IDO and three stages for SES and RSE. It used planned final-shutdown dates of 2006 and 2008 and assumed an operation-termination period extending to 2012. During that period, the plan provided for fuel removal, primary-circuit decontamination and drainage, processing of remaining operational RAW, preparatory activities and completion of the documentation required for the first decommissioning stage.

The CDP assumed that decommissioning would begin after the necessary authorisation had been granted and that no operational event would materially alter the plant condition used as the analytical baseline. Spent-fuel management following transfer to the ISFS was outside the scope of the CDP. RAW that did not meet the NRWR acceptance criteria was assumed to be stored in IS RAW, while deep geological disposal was outside the plan's scope.

Safety aspects were analysed, including ALARA implementation, radiation protection and monitoring, physical security, industrial safety, fire protection, emergency arrangements, and assessment of potential incidents and radiological impacts.

The analysis of V1 NPP decommissioning options was based on project documentation, operational data on equipment, contamination, releases, RAW, available RAW-management technologies, release criteria, staffing and technology availability, resource adequacy, legislative requirements, and agreed unit prices and factors (June 2005). Additional data came from V1 NPP operation, analogous studies (Paks, Bohunice V2, Dukovany), EWN's Greifswald experience, and literature.

These PSL results were then distributed over time to obtain annual parameter profiles. PSL items were also mapped into schedule items to create an indicative time schedule reflecting key activity links. The calculation model was implemented in Microsoft Excel.

Table 9 and Table 10 on the next page present the data from Table 5 and Table 8 with highlighted values. Green indicates the lowest values, while red marks the highest values. The principal lesson from the comparison is that the preferred option emerged from the combined effect of its performance across multiple criteria, rather than from superiority in every individual parameter. Table 9 and Table 10 illustrate these different strengths and trade-offs.

Table 9. List of main characteristic parameters: the highest and lowest values

No.	Characteristic parameter of decommissioning	Unit	Value of parameter for option		
			IDO	SES	RSE
1	Total costs*	M Sk MEUR est.**	20,890.32 693.43	18,737.90 621.98	18,293.14 607.22
2	Collective effective dose	man Sv	13.8778	8.1734	13.2333
3	Duration of the decommissioning process under decommissioning licence	year	14	52	52
4	Labour hours needed	10^3 hours	15,026.5	13,498.4	12,891.1
5	Amount of liquid RAW (before processing at salinity 200 g/dm^3)	m^3	1,930	1,774	1,931
6	Radioactivity of gaseous effluents	Bq	3.22E+06	2.04E+06	3.27E+06
7	Radioactivity of liquid effluents	Bq	7.94E+07	5.04E+07	8.08E+07
8	Amount of released metals	t	55,996	61,004	59,867
9	Amount of recyclable building waste	t	418,125	318,734	318,599
10	Amount of conventional waste	t	3,331	7,855	7,883
11	Number of FCC for NSR	FCC	1 038	886	1,050
12	Number of FCC for ISRAW	FCC	44	30	30
13	Time load of site by radioactivity	year	13.7	51	51

Table 10. Final results of multi-criteria analysis: the highest and lowest values

No.	Description	Contribution of criterion to option value		
		IDO	SES	RSE
	Safety criteria			
1	Total CED	11.799	6.949	11.251
	Environmental criteria			
2	Radiation consequences of gaseous effluents to environment	5.662	3.587	5.750
3	Radiation consequences of liquid effluents to environment	5.655	3.590	5.755
4	Time load of site by radioactivity	2.131	7.934	7.934
5	Amount of conventional waste	1.048	2.472	2.480
	Economic criteria			
6	Total costs	8.656	7.764	7.580
7	Time distribution of costs	4.000	10.667	9.333
8	Labour hours needed	5.442	4.889	4.669
	Implementation criteria			
9	Continuity of manpower and RAW processing facilities utilisation	4.235	11.294	8.471
10	Time of final site release	2.492	9.254	9.254
11	Preparedness of site for further utilisation	1.000	4.000	4.000
	Criteria of demands for RAW repositories			
12	Total number of FCC into NSR	8.377	7.150	8.473
13	Total number of FCC into ISRAW	10.154	6.923	6.923
	Option value — S_j	**70.652**	**86.473**	**91.875**

The conclusions and trade-offs summarised above provide the basis for the lessons learnt and recommendations presented in the following section.

Retrospective implementation perspective
IDO was subsequently selected and remains the strategy being implemented for V1 NPP. From the author's retrospective perspective, implementation has supported several considerations that contributed to the original preference for IDO, particularly the shorter decommissioning duration, earlier reduction in the period for which the site remains affected by radioactivity and continuity of experienced personnel. This retrospective assessment is qualitative and does not constitute a new numerical evaluation of the original options.

3. KEY TAKEAWAYS

The key takeaways from the assessment and selection of the preferred V1 NPP decommissioning option are recorded below. The following lessons learnt capture the principal knowledge gained from the analysis and comparison of V1 NPP's decommissioning options. They explain how option scope, input-data quality, radioactive waste-management capacity, workforce continuity, site-reuse objectives and expert judgement influenced the assessment. They also demonstrate why a multi-criteria analysis should be treated as a transparent decision-support mechanism rather than as a substitute for statutory or organisational decision-making.

3.1. Lessons Learnt

#LL-1. The preferred option emerged from the balance of competing criteria

Within the assumptions, scope, criteria, weights and input values applied, IDO achieved the lowest overall option value and was identified as the preferred option in the MCA. It did not perform best against every individual criterion. The result reflected the combined effect of the adopted evaluation framework and should not be interpreted as an absolute measure of superiority.

#LL-2. No individual criterion was sufficient to determine the preferred strategy

The options exhibited different strengths when assessed against individual criteria. RSE had the lowest estimated total cost, SES had the lowest estimated CED and IDO had the shortest decommissioning duration as well as earliest site release. This demonstrated that a decision based on cost, dose, duration or another single measure would provide only a partial view of overall option performance.

#LL-3. Radioactive waste-management infrastructure can determine strategy feasibility

All assessed options depended on adequate capacity for radioactive waste characterisation, treatment, conditioning, packaging, transport, interim storage and disposal. These requirements affected cost, schedule and implementation feasibility. Therefore, radioactive waste-management capacity should be treated as an integral input to strategy development rather than as a downstream consequence of dismantling.

#LL-4. Expert judgement materially influences a weighted multi-criteria assessment

Expert judgement influenced both the relative weights assigned to the criteria and the values assigned to the subjective criteria. The resulting ranking reflected the adopted decision priorities as well as the calculated technical outputs. Transparent documentation of the experts who were involved, the basis for their judgements and the method used to reach agreement is essential for traceability and confidence in the recommendation. Because the underlying weighting deliberations and the reported cost-sensitivity consideration could not be reconstructed from the available records, the stability of the ranking under alternative assumptions could not be independently demonstrated.

#LL-5. Multi-criteria analysis supports, but does not replace, formal decision-making

The MCA identified IDO as the preferred option within the adopted assumptions, criteria and weighting framework, but it did not constitute the formal decision or permission to implement. JAVYS management subsequently selected IDO. The CDP was then submitted to the relevant Slovak regulatory, public-health and governmental authorities for review, after which the EIA process permitted implementation of the selected strategy. The case demonstrates the importance of distinguishing analytical recommendation, organisational selection, authority review and permission to implement.

#LL-6. Option comparisons must distinguish scope and timing differences from final end-state objectives

The options were intended ultimately to reach the same final end state, but they did not follow identical routes or timescales. The included building scope, retained infrastructure, dismantling sequence and intermediate site configurations differed between the options. These differences affected calculated costs, waste quantities, schedules and other performance indicators. Applying common criteria, weights and calculation methods ensured a consistent evaluation framework, but did not eliminate the effect of the different option scopes. Due to this, a credible comparison should identify scope and timing effects separately from the inherent advantages and disadvantages of each decommissioning strategy.

#LL-7. Inventory quality establishes the reliability ceiling of the assessment

Material quantities, radiological characterisation, waste classifications and plant-system status underpin estimates of cost, worker exposure, waste generation and programme duration. Gaps or inconsistencies in these inputs propagate through the calculation model and limit confidence in the resulting comparison. Therefore, early characterisation and systematic inventory validation are prerequisites for a credible option assessment.

#LL-8. Deferral creates knowledge-retention and organisational-continuity risks

A deferred strategy may benefit from radioactive decay but a long enclosure period can also increase the risk of losing plant knowledge, experienced personnel and organisational continuity. Immediate implementation may allow operational knowledge and shutdown experience to be transferred more directly into decommissioning. Therefore, workforce continuity should be assessed as a strategic consideration, not solely as a labour-cost parameter.

#LL-9. Decommissioning strategy should remain aligned with the intended future use of the site

The intended post-decommissioning use of the site influenced assumptions about timing, infrastructure retention and the preferred end state. A strategy that appears favourable when assessed only as a dismantling programme may be less suitable when site-release timing, asset reuse and future industrial or nuclear development are considered. Therefore, site-reuse objectives should be defined early and incorporated explicitly into the option assessment.

3.2. Recommendations

Nine (9) recommendations have been developed from JAVYS' experience gained during the analysis and comparison of V1 NPP's decommissioning options. They address multi-criteria decision support, input-data quality, option comparability, RAW-management capacity, external benchmarking, expert judgement, workforce continuity, site-reuse objectives and periodic reassessment. However, they should not be interpreted as activities demonstrated to have been completed in full during the historical V1 NPP assessment.



#R-1. Use multi-criteria analysis to support option selection rather than relying on a single criterion

Define a balanced set of technical, radiological, environmental, economic, scheduling, implementation, waste-management and strategic criteria. Use the multi-criteria analysis to make trade-offs and decision priorities explicit, while retaining statutory, regulatory and organisational decision-making as separate processes.



#R-2. Establish a common, traceable and quality-controlled input-data baseline

Before comparing options, compile and validate a consistent baseline covering plant configuration, system status, material and radiological inventories, waste routes, unit factors, costs, labour assumptions, schedules and end-state requirements. Record the source, date, status and uncertainty of each input, and distinguish measured or recorded data from estimates, projections and expert assumptions. Apply common definitions and calculation structures across all options.



#R-3. Define and reconcile option scope before comparing results

Document the structures, systems, activities, retained infrastructure, exclusions, schedule boundaries and intended end state applicable to each option. Where scopes differ, explain the effect on cost, waste, dose and duration, and consider presenting normalised or supplementary comparisons so that scope effects are not mistaken for strategy performance.



#R-4. Integrate radioactive waste-management capacity into strategy development

Assess anticipated waste streams against available and planned capacity for characterisation, treatment, conditioning, packaging, transport, interim storage and disposal. Identify capacity constraints, acceptance requirements, interfaces and timing dependencies early, and incorporate any necessary infrastructure or service development into the option cost and schedule.



#R-5. Use external experience for benchmarking, not direct substitution

Draw on comparable decommissioning programmes to test assumptions, identify proven methods and benchmark unit factors, schedules, waste routes and implementation risks. Document why each comparator is relevant and adapt the resulting evidence to the facility's design, radiological condition, regulatory framework, infrastructure and strategic objectives.



#R-6. Document expert judgement and test the effect of weighting choices

For future assessments, record the composition and relevant expertise of the assessment group, the rationale for criterion selection and weighting, the basis for subjective scores and the method used to resolve differing views. Where practicable, test alternative weighting and scoring scenarios to determine whether the preferred ranking changes under plausible stakeholder priorities or uncertainties.

#R-7. Plan workforce and knowledge continuity for the full strategy period

Identify the knowledge, competences and roles required during shutdown, transition, active dismantling, surveillance and final dismantling. For deferred strategies, establish arrangements for knowledge capture, configuration control, records preservation, competence maintenance and eventual workforce regeneration. Include these provisions in the option cost, schedule and risk assessment.

#R-8. Define site-reuse and end-state objectives before finalising the assessment

Agree the intended site end state, release objectives, infrastructure-retention assumptions and potential future uses early enough to inform option scope. Evaluate the consequences of each strategy for site availability, asset reuse and future development and revisit the assessment if these strategic objectives change.

#R-9. Establish review points and update the assessment when key assumptions change

Treat the option assessment as a controlled decision basis rather than a one-off calculation. Define review points linked to regulatory developments, improved characterisation, cost-base changes, waste-facility availability, funding conditions, implementation experience and changes in future site use. Record whether updates alter the preferred recommendation and why.

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[10] *Act of the Slovak National Council No. 541/2004 Coll. on the peaceful use of nuclear energy (Atomic law)..*

[11] *NC SR Act No. 290/1996 Coll., which amends NC SR Act No. 272/1994 and NC SR Act No. 222/1996 Coll. on population health protection..*

[12] *Decree No. 12/2001 Coll. of Ministry of health of the SR (replaced by Act No. 126/2006)..*

[13] *Decree No. 58/2006 Coll. of NRA SR..*

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APPENDICES

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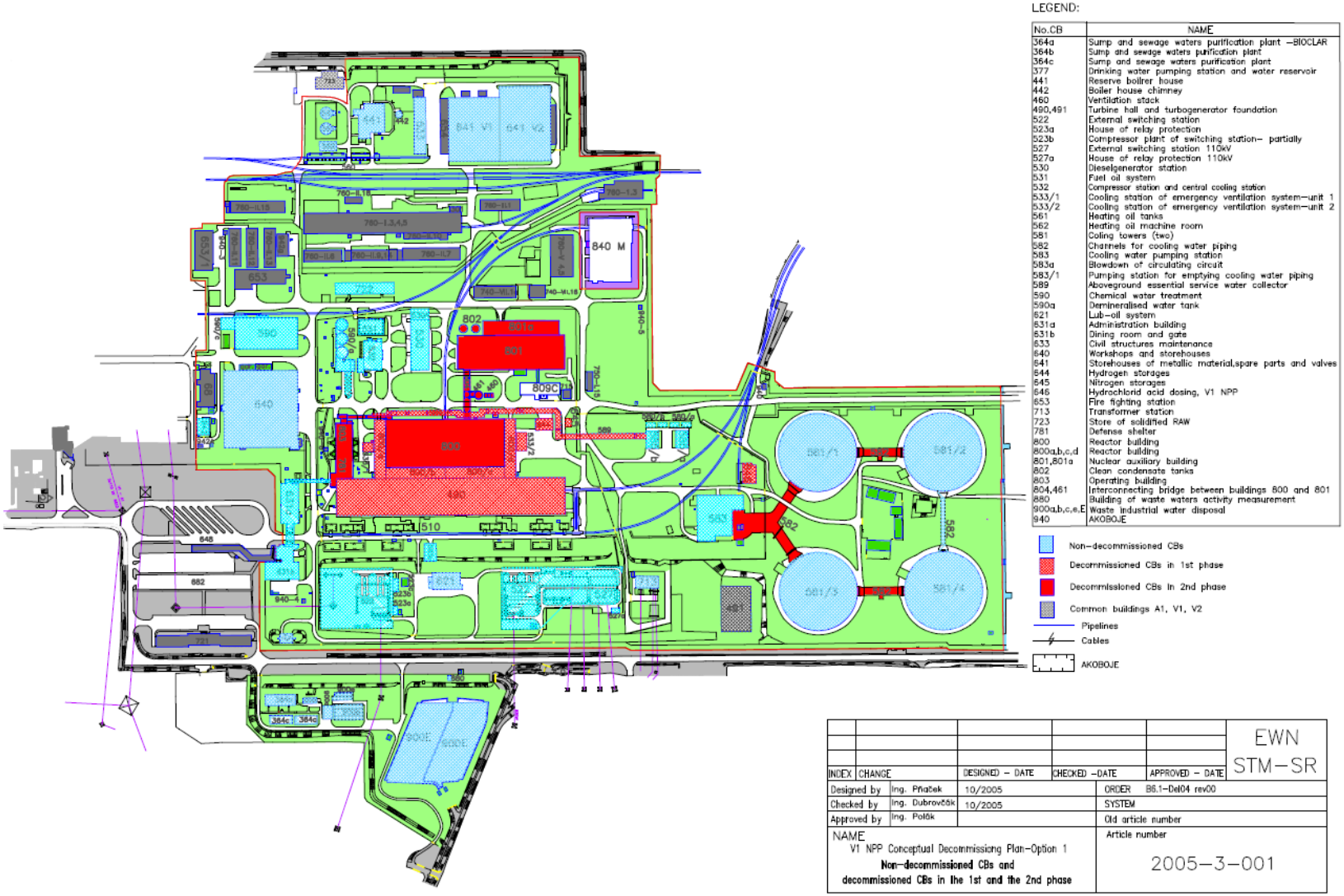
Appendix 10. Time dependence of annual total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)

Appendix 11. Time dependence of cumulative total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)

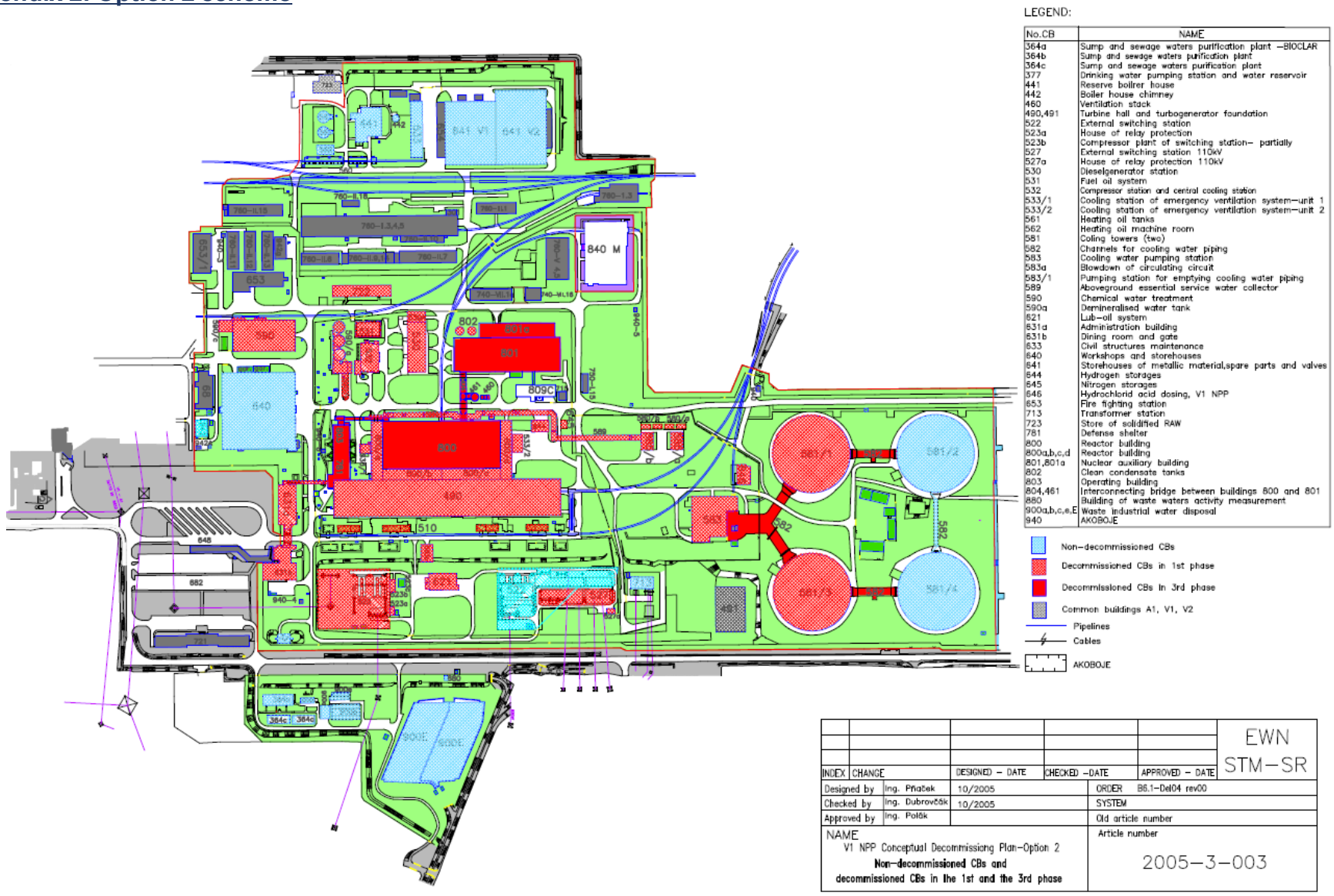
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Appendices

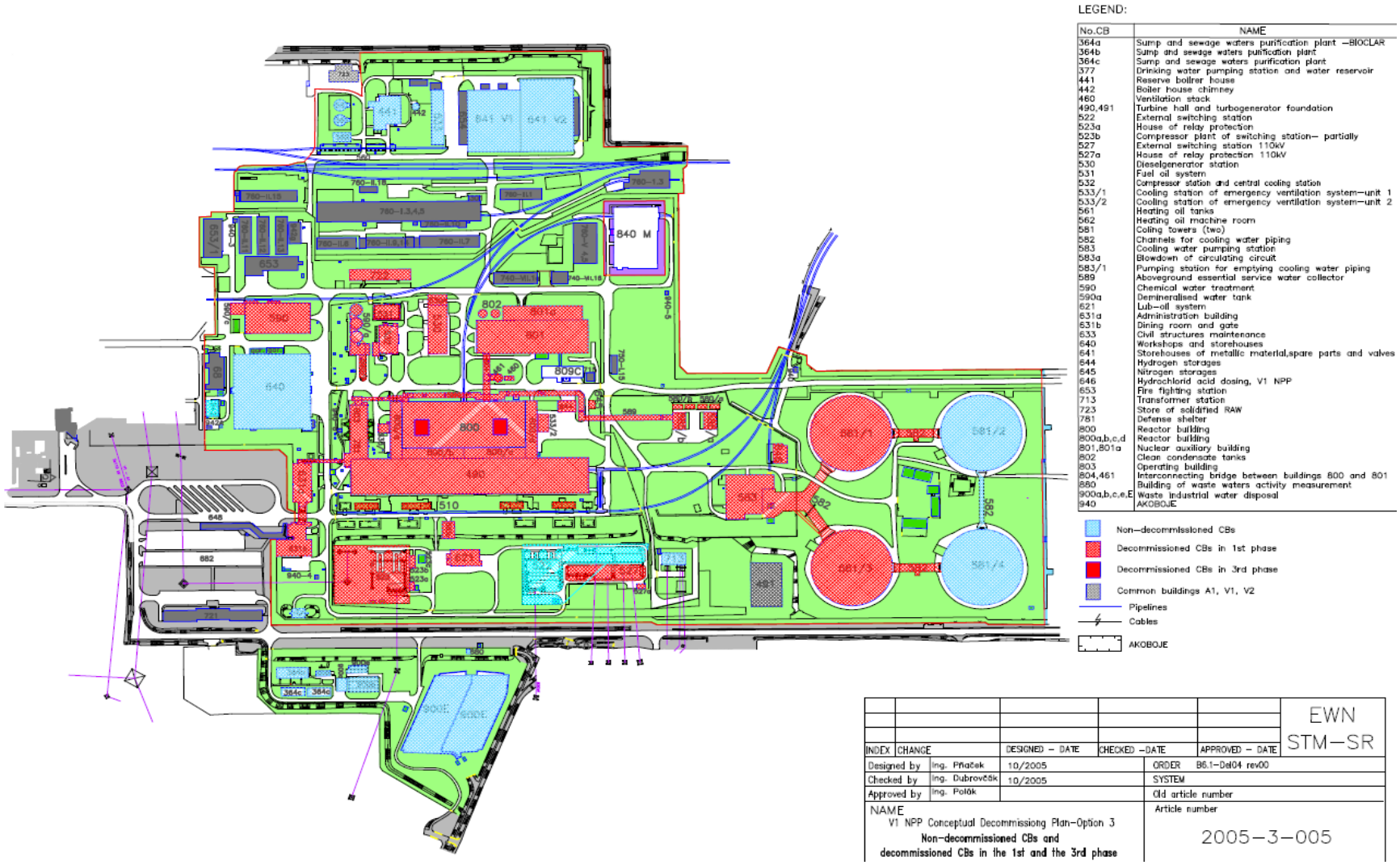
Appendix 1. Option 1 scheme



Appendix 2. Option 2 scheme



Appendix 3. Option 3 scheme



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Appendix 4. List of V1 NPP civil constructions and buildings to be decommissioned

Note on extent values: An extent of 50% denotes a historic rough-average planning estimate that only part of the relevant element would be dismantled within the option scope. The remaining part was expected either to remain in use temporarily or to be completed under Project D4.7.01, "Decontamination and Demolition of V1 NPP Buildings and Site Restoration". The percentage is an approximate scope allocation rather than a measured physical-completion value.

OPTION 1		
Excluded from decommissioning		
CB No.	**CB name**	**Extent of decommissioning**
321	Fence of industrial waste waters disposal area	
340	External lighting	
341	External lighting of waste waters disposal area	
351	Lighting trenches and channels, including cabling	50%
352+MSVP	Low voltage trenches and channels, including cabling	50%
360	Rain sewerage	50%
P360	Final sewage collector from V1 NPP into Socoman	
361	Sewage drainage	50%
362	Industrial drainage	50%
364 a,b,c	Sump and sewage waters purification plant	
367	Drainage channels	
368	Station of waste water activity measurement	
370	Drinking water inlet line	
371	Drinking water piping	50%
372	Fire fighting and service water piping	50%
377	Drinking water pumping station and water reservoir	
400	Piping trenches	
400 a	Raw water piping Ø 1200 A1 NPP - V1 NPP	
401	Essential service water channels	50%
441	Reserve boiler house	
442	Boiler house chimney	
510	Transformers foundations, including oil tank	
522	External switching station 220 kV,110 kV	
523a	House of relay protections.	
523b	Compressor plant of switching station – partially	
526	Safety fence of switching station	

OPTION 1

Excluded from decommissioning

CB No.	CB name	Extent of decommissioning
527	110 kV switching station	
527a	House of relay protections 110 kV	
530,530 A	Diesel generator station with additional building DG 5	
531	Fuel oil system	
532	Compressor station and central cooling station	
560	Chemicals discharging building	
561	Heating oil tanks	
562	Heating oil machine room	
563	Channel for heating oil piping	
571	Fence of Pečeňady pumping station	
573	Pumping and filtering station Pečeňady	
574	Inlet channel Ø 1400 from Dudvah river	
575	Traffic roads at Pečeňady pumping and filtering station	
578	Discharge line Ø 800 Pečeňady - V1 NPP	
579	Structures in the path of Pečeňady discharge line - V1 NPP	
580 a	Essential service water cooling towers – unit 1	
580 b	Essential service water cooling towers – unit 2	
581	Cooling towers (two of four)	
582	Channels for cooling water piping	50%
583	Cooling water pumping station	
583/1	Pumping station for emptying cooling water piping	
583 a	Blowdown of circulating circuit	
585 a	Essential service water pumping station – unit 1	
585 b	Essential service water pumping station – unit 2	
590	Chemical water treatment	
590a	Demineralised water tank	
590/b	Building of emergency feedwater pumps	
590 B	Building of demineralised water tanks	
590c	H_2SO_4 dosing station at V1 NPP	
621	Lub-oil system	
631a, 780	Administration building and civil defence shelter	
631b, c	Dining room and gate	

OPTION 1

Excluded from decommissioning

CB No.	CB name	Extent of decommissioning
633	Civil structures maintenance	
640	Workshops and storehouses of electrical and connecting material	
641	Storehouses of metallic material, spare parts and valves	
653	Fire fighting station	
656	Unloading ramp	
660	Outside railway siding	
663	Securing and announcing devices at outside railways siding	
670	Internal railway siding, including all tracks	
680	External traffic roads under SE-EBO administration	
682	Parking lot, bus platform	
683	Road connection of industrial waste water disposal	
690	Internal roads, including courts and courtyards	
701	Garages	
703	Diesel oil and petrol station	
713	Transformer station	
722	REKO V1 site establishment building, used to support reconstruction of V1 NPP	
792	Fire fighting equipment of buildings	
880	Building of waste waters activity measurement	
881	Intermediate spent fuel storage - Probes for monitoring common waters	
900 a,b,c,e,E	Waste industrial water disposal	
920	110 kV line Madunice – V1 NPP	
921	110 kV line Malženice – V1 NPP	
922	220 kV line A1 NPP – V1 NPP	
924	Extension of 110 kV switching station HC Madunice	
940	AKOBOJE civil structures	
942	V1 NPP guard-room 1	

OPTION 1		
To be decommissioned		
CB No.	**CB name**	**Extent of decommissioning**
1st group		
460	Ventilation stack	
800	Reactor building	
801, 801a	Nuclear auxiliary building, including extension, additional building and penthouse	
803, 781	Operating building and civil defence shelter	
804, 461	Interconnecting bridge between buildings 800 and 801 + air ducts of ventilation stack	
2nd group		
350+MSVP	Power cables trenches and channels	
351	Lighting trenches and channels, including cabling	50%
352+MSVP	Low voltage trenches and channels, including cabling	50%
353+MSVP	Grounding trenches	
360	Rain sewerage	50%
361	Sewage drainage	50%
362	Industrial drainage	50%
371	Drinking water piping	50%
372	Fire fighting and service water piping	50%
401	Essential service water channels	50%
401 M/1	Clean piping channel, turbine hall - interim spent fuel storage	
490, 491	Turbine hall and turbogenerator foundations	
533/1	Cooling station of emergency ventilation system – unit 1	
533/2	Cooling station of emergency ventilation system – unit 2	
573-2	Water reservoirs of washing water at Pečeňady pumping and filtering station	
573-3/1	Discharge line for washing water reservoirs	
573-3/2	Waste from washing water reservoirs	
582	Channels for cooling water piping	50%
589	Aboveground essential service water collector	
644	Hydrogen storages	
645	Nitrogen storage	
646	Hydrochloric acid dosing, V1 NPP	

OPTION 1		
To be decommissioned		
CB No.	**CB name**	**Extent of decommissioning**
800 a	Cross side electrical building – unit 1	
800 b	Longwise side electrical building – unit 1	
800 c	Longwise side electrical building – unit 2	
800 d	Cross side electrical building – unit 2	
802	Clean condensate tanks	

OPTIONS 2, 3		
Excluded from decommissioning		
CB No.	**CB name**	**Extent of decommissioning**
321	Fence of industrial waste waters disposal area	
341	External lighting of waste waters disposal area	
351	Lighting trenches and channels, including cabling	50%
352+MSVP	Low voltage trenches and channels, including cabling	50%
353+MSVP	Grounding trenches	50%
360	Rain sewerage	50%
P360	Final sewage collector from V1 NPP into Socoman	
361	Sewage drainage	50%
362	Industrial drainage	50%
364 a,b,c	Sump and sewage waters purification plant	
367	Drainage channels	
368	Station of waste water activity measurement	
370	Drinking water inlet line	
371	Drinking water piping	50%
372	Fire fighting and service water piping	50%
377	Drinking water pumping station and water reservoir	
400	Piping trenches	50%
400 a	Raw water piping Ø 1200 A1 NPP - V1 NPP	
441	Reserve boiler house	
442	Boiler house chimney	
560	Chemicals discharging building	
561	Heating oil tanks	
562	Heating oil machine room	
563	Channel for heating oil piping	
571	Fence of Pečeňady pumping station	
574	Inlet channel Ø 1400 from Dudváh river	
575	Traffic roads at Pečeňady pumping and filtering station	
633	Civil structures maintenance	
640	Workshops and storehouses of electrical and connecting material	
641	Storehouses of metallic material, spare parts and valves	
653	Fire fighting station	
656	Unloading ramp	

OPTIONS 2, 3		
Excluded from decommissioning		
CB No.	**CB name**	**Extent of decommissioning**
660	Outside railway siding	
663	Securing and announcing devices at outside railways siding	
670	Internal railway siding, including all tracks	50%
680	External traffic roads under SE EBO administration	
682	Parking lot, bus platform	
683	Road connection of industrial waste water disposal	
690	Internal roads, including courts and courtyards	50%
701	Garages	
703	Diesel oil and petrol station	
713	Transformer station	
792	Fire fighting equipment of buildings	
880	Building of waste waters activity measurement	
881	Intermediate spent fuel storage - Probes for monitoring common waters	
900 a,b,c,e,E	Waste industrial water disposal	
920	110 kV line Madunice – V1 NPP	
921	110 kV line Malženice – V1 NPP	
924	Extension of 110 kV switching station HC Madunice	
940	AKOBOJE civil structures	50%
942	V1 NPP guard-room 1	

OPTIONS 2, 3		
To be decommissioned		
CB No.	**CB name**	**Extent of decommissioning**
1st group		
460	Ventilation stack	
800	Reactor building	
801, 801a	Nuclear auxiliary building, including extension, additional building and penthouse	
803, 781	Operating building and civil defence shelter	
804, 461	Interconnecting bridge between buildings 800 and 801 + air ducts of ventilation stack	
2nd group		
340	External lighting	
350+MSVP	Power cables trenches and channels	
351	Lighting trenches and channels, including cabling	50%
352+MSVP	Low voltage trenches and channels, including cabling	50%
353+MSVP	Grounding trenches	50%
360	Rain sewerage	50%
361	Sewage drainage	50%
362	Industrial drainage	50%
371	Drinking water piping	50%
372	Fire fighting and service water piping	50%
400	Piping trenches	50%
401	Essential service water channels	
401 M/1	Clean piping channel, turbine hall - interim spent fuel storage	
490, 491	Turbine hall and turbogenerator foundations	
510	Transformers foundations, including oil tank	
522	External switching station 220 kV, 110 kV	
523a	House of relay protections.	
523b	Compressor plant of switching station – partially	
526	Safety fence of switching station	
527	110 kV switching station	
527a	House of relay protection 110 kV	
530,530 A	Diesel generator station with additional building DG 5	
531	Fuel oil system	
532	Compressor station and central cooling station	

OPTIONS 2, 3		
To be decommissioned		
CB No.	**CB name**	**Extent of decommissioning**
533/1	Cooling station of emergency ventilation system - unit 1	
533/2	Cooling station of emergency ventilation system - unit 2	
573	Pumping and filtering station Pečeňady	
573-2	Water reservoirs of washing water at Pečeňady pumping and filtering station	
573-3/1	Discharge line for washing water reservoirs	
573-3/2	Waste from washing water reservoirs	
578	Discharge line Ø 800 Pečeňady - V1 NPP	
579	Structures in the path of Pečeňady discharge line - V1 NPP	
580 a	Essential service water cooling towers – unit 1	
580 b	Essential service water cooling towers – unit 2	
581	Cooling towers (two) [18, page 19/196]	
582	Channels for cooling water piping	
583	Cooling water pumping station	
583/1	Pumping station for emptying cooling water piping	
583 a	Blowdown of circulating circuit	
585 a	Essential service water pumping station – unit 1	
585 b	Essential service water pumping station – unit 2	
589	Aboveground essential service water collector	
590	Chemical water treatment	
590a	Demineralised water tank	
590b	Building of emergency feedwater pumps	
590 B	Building of demineralised water tanks	
590c	H_2SO_4 dosing station at V1 NPP	
621	Lub-oil system	
631a, 780	Administration building and civil defence shelter	
631b,c	Dining room and gate	
644	Hydrogen storages	
645	Nitrogen storage	
646	Hydrochloric acid dosing, V1 NPP	
670	Internal railway siding, including all tracks	50%
690	Internal roads, including courts and courtyards	50%

OPTIONS 2, 3		
To be decommissioned		
CB No.	**CB name**	**Extent of decommissioning**
722	REKO V1 - site establishing (building used for V1 NPP reconstruction)	
800 a	Cross side electrical building – unit 1	
800 b	Longwise side electrical building – unit 1	
800 c	Longwise side electrical building – unit 2	
800 d	Cross side electrical building – unit 2	
802	Clean condensate tanks	
922	220 kV line A1 NPP – V1 NPP	
940	AKOBOJE civil structures	50%

Appendix 5. Summary data on the material inventory

OPTION 1					
Materials gained at the disassembly of technology (both units)					
CB No.	**Stainless steel [t]**	**Carbon steel [t]**	**Non-ferrous metals [t]**	**Other [t]**	**Note**
Contaminated structures					
460		4.0		1.0	
800 without reactors	3 993.5	3 991.0	196.0	226.12	
800 reactors	349.5	580.0		186.88	
801,801a	730.0	416.0	79.0	69.0	
803,781	90.0	253.0	30.0	25.0	
804,461	5.0			5.0	
Total contaminated structures	**5 168.0**	**5 244.0**	**305.0**	**513.0**	
Non contaminated structures					
350+MSVP		41.0	852.0	576.0	
351 (50%)			5.0	6.0	
352+MSVP (50%)			6.0	8.0	
353+MSVP					
360 (50%)					
361 (50%)					
362 (50%)					
371 (50%)					
372 (50%)					
401 (50%)		160.5	1.0	2.5	
401M/1		20.0		2.0	
490,491	10.0	12 165.0	475.0	430.0	
533/1		7.0	1.0	1.0	
533/2		7.0	1.0	1.0	
573-2,573-3/1,573-3/2		4.0			
582 (50%)					
589		389.0	4.0	3.0	
644	51.0	2.0	7.0	2.0	
645	50.0	20.0	3.0	1.0	
646	2.0	26.0	10.0	25.0	
800a,b,c,d	2.0	2 790.0	380.0	435.0	
802		51.0	1.0	10.0	
Total non-contaminated structures	**115.0**	**15 682.5**	**1 746.0**	**1 502.5**	
Total	**5 283.0**	**20 926.5**	**2 051.0**	**2 015.5**	

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OPTION 1

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabricates	Masonry	Peripheral walls		Lining		Hermetic and protective doors	Special canalisation	Non-ferrous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Together	Below -1 m	Above-1 m	Together	Below -1 m	Above-1 m	Together				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
Contaminated structures																				
460	767	85	852	450	627	1 077	38	54	92	23		30						1		2
800 whole	1 926		1 926	27 000	25 316	52 316	4 026	3 774	7 800	1 438	3 000	7 000	3 800	0	15 865	6 666	850	40	69	380
out of that the reactor shaft	126		126	3 300	1 100	4 400	1 310	440	1 750						1 400					
801, 801a	2 810		2 810	5 200	9 097	14 297	449	800	1 249	264	1 135	1 026	2 530		7 372	646	70	13	11	61
803, 781	630	339	969	2 000	2 148	4 148	200	200	400	1 319	1 040	683	3 600	8 000				8	3	223
804, 461	195		195	50	2 270	2 320	6	294	300	250		30	720							6
Contaminated structures	**6 328**	**424**	**6 752**	**34 700**	**39 458**	**74 158**	**4 719**	**5 122**	**9 841**	**3 294**	**5 175**	**8 769**	**10 650**	**8 000**	**23 237**	**7 312**	**920**	**62**	**83**	**672**
Non-contaminated structures																				
350+MSVP	210	466	676							119	8625									98
351 (50%)										14	4									139
352+MSVP (50%)	11	20.5	31.5							9	90									
353+MSVP	3	1	4							162	78									
360 (50%)				20	10	30	1	0.5	1.5	1.5										
361 (50%)				20	10	30	1	0.5	1.5	1.5										

OPTION 1

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabri-cates	Ma-son-ry	Peripheral walls		Lining		Her-metic and protec-tive doors	Special canali-sation	Non-fer-rous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
362 (50%)				20	10	30	1	0.5	1.5	1.5										
371 (50%)	20	5	25							6										
372 (50%)	20	5	25							7.5										
401 (50%)	20	11.5	31.5	250	308	558	29	36	65	21		4								4
401M/1	360	280	640							10										
490, 491	4 920		4 920	34 385	10 660	45 045	2 300	714	3 014	6 450	2 100	1 200	15 755						7	450
533/1				111	138	249	6	8	14	9										1
533/2				181	221	402	10	13	23	8										1
573-2, 573-3/1, 573-3/2				82	192	274	5	18	23	8	9	60								1
582 (50%)	50	6.5	56.5	700	62.5	762,5	14	1.5	15.5											5
589	50	510	560	70	1 101	1 171	9	134	143	425			2 550							3
644	55	50	105		20	20		2	2	7		124								4
645		35	35		20	20		2	2	2	4	22								4
646	65	65	130		240	240		20	20	20	400	150							1	24
800a,b,c,d	680	1 538	2 218	1 830	14 668	16 498	264	2 116	2 380	1 790		1 376	11 620						8	200
802	14		14	6	170	176	1	11	12	1	14	15								1
Non-conta-minated structures	**6 478**	**2 994**	**9 472**	**37 675**	**27 831**	**65 506**	**2 641**	**3 077**	**5 718**	**9 073**	**11 324**	**2 951**	**29 925**	**0**	**0**	**0**	**0**	**0**	**16**	**935**

OPTION 1

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabricates	Masonry	Peripheral walls		Lining		Hermetic and protective doors	Special canalisation	Non-ferrous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Together	Below -1 m	Above-1 m	Together	Below -1 m	Above-1 m	Together				Panels	Feal	S	C				
	m^3	m^3	m^3	m^3	m^3	m^3	t	t	t	t	t	m^3	m^2	m^2	m^2	m^2	t	t	t	t
Total	12 806	3 418	16 224	72 375	67 289	139 664	7 360	8 199	15 559	12 367	16 499	11 720	40 575	8 000	23 237	7 312	920	62	99	1 607

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OPTIONS 2, 3

Materials gained at the disassembly of technology (both units)

CB No.	Stainless steel [t]	Carbon steel [t]	Non-ferrous metals [t]	Other [t]	Note
Contaminated structures					
460		4.0		1.0	
800 without reactors	3 993.5	3 991.0	196.0	226.12	
800 reactors	349.5	580.0		186.88	
801, 801a	730.0	416.0	79.0	69.0	
803, 781	90.0	253.0	30.0	25.0	
804, 461	5.0			5.0	
Total contaminated structures	**5 168.0**	**5 244.0**	**305.0**	**513.0**	
Non contaminated structures					
340					
350+MSVP		41.0	852.0	576.0	
351 (50%)			5.0	6.0	
352+MSVP (50%)			6.0	8.0	
353+MSVP					
360 (50%)					
361 (50%)					
362 (50%)					
371 (50%)					
372 (50%)					
400 (50%)					
401		321.0	2.0	5.0	
401M/1		20.0		2.0	
490, 491	10.0	12 165.0	475.0	430.0	
510		606.0	632.0	16.0	
522, 527		108.0	16.0	44.0	
523a, b, 527a		21.0	5.0	6.0	
526					
530, 530A, 531		609.0	50.0	31.0	
532		139.0	5.0	6.0	
533/1		7.0	1.0	1.0	
533/2		7.0	1.0	1.0	
573		464.0	7.0	6.0	
573-2,573-3/1,573-3/2		4.0			
578, 579		5.0			
580a, b		138.0	6.0	11.0	
581		58.0	3.0	24.0	
582					
583		1 093.0	5.0	7.0	
583a		1.0			
583/1		3.0			
585a, b		99.0	10.0	1.0	
589		389.0	4.0	3.0	
590, 590a, 590B,/b	3.0	706.0	51.0	33.0	
590c	20.0	40.0	1.0	5.0	

OPTIONS 2, 3

Materials gained at the disassembly of technology (both units)

CB No.	Stainless steel [t]	Carbon steel [t]	Non-ferrous metals [t]	Other [t]	Note
621		32.0	2.0	2.0	
631a, 780		42.0	15.0	8.0	
631b, c		10.0	2.0	8.0	
644	51.0	2.0	7.0	2.0	
645	50.0	20.0	3.0	1.0	
646	2.0	26.0	10.0	25.0	
670 (50%)					
690 (50%)					
800a,b,c,d	2.0	2 790.0	380.0	435.0	
802		51.0	1.0	10.0	
922					
940 (50%)		15.5		1.0	
722		2.0		1.0	
Total non-contaminated structures	**138.0**	**20 034.5**	**2 557.0**	**1 715.0**	
Total	**5 306.0**	**25 278.5**	**2 862.0**	**2 228.0**	

OPTIONS 2, 3

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabri-cates	Ma-son-ry	Peripheral walls		Lining		Herme-tic and protect-tive doors	Special canali-sation	Non-fer-rous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
Contaminated structures																				
460	767	85	852	450	627	1 077	38	54	92	23		30						1		2
800 whole	1 926		1 926	27 000	25 316	52 316	4 026	3 774	7 800	1 438	3 000	7 000	3 800	0	15 865	6 666	850	40	69	380
out of that the reactor shaft	126		126	3 300	1 100	4 400	1 310	440	1 750						1 400					
801, 801a	2 810		2 810	5 200	9 097	14 297	449	800	1 249	264	1 135	1 026	2 530		7 372	646	70	13	11	61
803, 781	630	339	969	2 000	2 148	4 148	200	200	400	1 319	1 040	683	3 600	8 000				8	3	223
804, 461	195		195	50	2 270	2 320	6	294	300	250		30	720							6
Contamina-ted structures	**6 328**	**424**	**6 752**	**34 700**	**39 458**	**74 158**	**4 719**	**5 122**	**9 841**	**3 294**	**5 175**	**8 769**	**10 650**	**8 000**	**23 237**	**7 312**	**920**	**62**	**83**	**672**
Non-contaminated structures																				
340	310	550	860							180	20									4
350+MSVP	210	466	676							119	8625									98
351 (50%)										14	4									139
352+MSVP (50%)	11	20.5	31.5							9	90									
353+MSVP (50%)	1.5	0.5	2							81	39									

OPTIONS 2, 3

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabri-cates	Ma-son-ry	Peripheral walls		Lining		Herme-tic and protect-tive doors	Special canali-sation	Non-fer-rous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
360 (50%)				20	10	30	1	0.5	1.5	1.5										
361 (50%)				20	10	30	1	0.5	1.5	1.5										
362 (50%)				20	10	30	1	0.5	1.5	1.5										
371 (50%)	20	5	25							6										
372 (50%)	20	5	25							7.5										
400 (50%)																				50
401	40	23	63	500	616	1 116	58	72	130	42		8								8
401M/1	360	280	640							10										
490, 491	4 920		4 920	34 385	10 660	45 045	2 300	714	3 014	6 450	2 100	1 200	15 755						7	450
510	140	145	285	400	850	1 250	34	72	106	5	50								1	2
522, 527	595	500	1 095	200	698	898	13	46	59	168	143	35							5	10
523a,b, 527a	118		118	20	62	82	2	4	6	3		76	336						2	6
526		30	30		6	6		1	1	8	20									0
530, 530A, 531	320	173	493	950	1 135	2 085	113	136	249	481	150	1 247	1 905			18			8	231
532	291	200	491	192	200	392	16	17	33	10	20	792							1	15
533/1				111	138	249	6	8	14	9										1
533/2				181	221	402	10	13	23	8										1
573		29	29	1 051	3 238	4 289	63	194	257	148	914	20								9
573-2, 573-3/1, 573-3/2				82	192	274	5	18	23	8	9	60								1

OPTIONS 2, 3

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabri-cates	Ma-son-ry	Peripheral walls		Lining		Herme-tic and protect-tive doors	Special canali-sation	Non-fer-rous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
578, 579	80	80	160		3	3		1	1		5	28								
580a, b	402		402	400	322	722	30	24	54	35	198	20								10
581	1 800	4 400	6 200	20 050	15 810	35 860	1300	2 160	3 460	288	25 200								2	5 600
582	100	13	113	1400	125	1525	28	3	31											10
583	3 200	680	3 880	5 000	2 050	7 050	425	175	600	501	782	1 900							1	26
583a	25	50	75		2	2				10			75							4
583/1	8	1	9	60	3	63	5		5	4										2
585a, b	580		580	1 398	507	1 905	105	38	143	19		110	1 060							2
589	50	510	560	70	1 101	1 171	9	134	143	425			2 550							3
590, 590a, 590B,/b	2 000	544	2 544	2 000	1 003	3 003	165	83	248	117	709	598							1	148
590c	26	100	126		320	320		20	20	6		110								45
621	129		129	40	56	96	1	1	2	16	165	280	289							5
631a, 780	520	90	610	260	800	1 060	22	68	90	40	39	773		6 000					20	50
631b, c	139		139	252	480	732	22	41	63	363	1 800	170	159	600					20	50
644	55	50	105		20	20		2	2	7		124								4
645		35	35		20	20		2	2	2	4	22								4
646	65	65	130		240	240		20	20	20	400	150							1	24
670 (50%)		15	15							187.5	395									5
690 (50%)		3650	3650								950									600

OPTIONS 2, 3

Building materials gained during the demolition of CBs (both units)

CB No.	Concrete			Reinforced concrete						Steel	Pre-fabri-cates	Ma-son-ry	Peripheral walls		Lining		Herme-tic and protect-tive doors	Special canali-sation	Non-fer-rous metal	Other
				Total concrete + steel			Steel part from that													
	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther	Below -1 m	Above-1 m	Toge-ther				Panels	Feal	S	C				
	m³	m³	m³	m³	m³	m³	t	t	t	t	t	m³	m²	m²	m²	m²	t	t	t	t
800a,b,c,d	680	1 538	2 218	1 830	14 668	16 498	264	2 116	2 380	1 790		1 376	11 620						8	200
802	14		14	6	170	176	1	11	12	1	14	15								1
922	68	43	111							27									1	2
940 (50%)	10	115	125							60	180	16.5							1	2
722	20	136	156		7	7		1	1	8		39								512
Non-conta-minated structures	**17 328**	**14 542**	**31 870**	**70 898**	**55 753**	**126 651**	**5 000**	**6 197**	**11 197**	**11 698**	**43 025**	**9 170**	**33 749**	**6 600**	**0**	**18**	**0**	**0**	**79**	**8 334**
Total	**23 656**	**14 966**	**38 622**	**105 598**	**95 211**	**200 809**	**9 719**	**11 319**	**21 038**	**14 992**	**48 200**	**17 939**	**44 399**	**14 600**	**23 237**	**7 330**	**920**	**62**	**162**	**9 006**

Appendix 6. Selected prices and unit factors

General Data			
Name	**Unit**	**Value**	**Value (€)***
Price of compressed air	Sk/Nm^3	10.00	0.33
Price of electrical energy	Sk/kWh	2.00	0.07
Oxygen price	Sk/Nm^3	70.00	2.32
Acetylene price	Sk/Nm^3	240.00	7.97
Diesel oil price	Sk/t	40,000.00	1,327.76
Price of electrolyte for semi-dry decontamination	Sk/m^3	10,000.00	331.94
Detergent price	Sk/m^3	30,000.00	995.82
Demineralised water price	Sk/m^3	100.00	3.32
Price of electrolyte for electrolytical decontamination of S-steel	Sk/m^3	3,000.00	99.58
Steam price	Sk/t	800.00	26.56
Price of solution of HNO_3 + $KMnO_4$	Sk/m^3	600.00	19.92
Price of solution of citric acid+ oxalic acid + $EDTANa_4$	Sk/m^3	3,500.00	116.18
Price of solution for C-steel post-dismantling decontamination	Sk/m^3	4,600.00	152.69
Cooling water price	Sk/m^3	30.00	1.00
200 dm^3 drum price	Sk/pc	1,500.00	49.79
FCC container of volume 3.1 m^3 price	Sk/pc	185,000.00	6,140.87
Special steel container for IRAWSF price	Sk/pc	6,000,000.00	199,163.51
Price for disposal in IRAWSF	Sk/FCC	500,000.00	16,596.96
Price for disposal in NSR	Sk/m^3	250,000.00	8,298.48
Price for disposal in communal dump	Sk/t	1050	34.85
Price of transport to communal dump	Sk/km	75.00	2.49
Price of transport to NSR	Sk/km	130.00	4.32
Storage of recycled material price	Sk/t	400.00	13.28
SUF of concrete recycling	h/t	0.10	-
SUF of masonry recycling	h/t	0.08	-
SUF of reinforced concrete recycling	h/t	0.15	-
SUF of other material recycling	h/t	0.10	-
Bitumen price	Sk/t	20,000.00	663.88
Cement price	Sk/t	4,000.00	132.78
Additives price	Sk/t	4,000.00	132.78
Sale price of C-steel	Sk/t	3,500.00	116.18
Sale price of S-steel	Sk/t	25,000.00	829.85
Sale price of non-ferrous metals	Sk/t	50,000.00	1,659.70
Price of site internal transport	Sk/t	400.00	13.28
Distance from V1 NPP to NSR	km	74.00	-
Distance from V1 NPP to IRAWSF	km	2.00	-
Distance from V1 NPP to communal dump	km	15.00	-
SUF of transport to communal dump	h/km	0.13	-
V1 NPP site area	m^2	374,825.00	-
SUF of labour hours needed for site landscaping	h/m^2	0.37	-
Diesel oil consumption for site landscaping	t/m^2	0.00	-
Volume of PC	m^3	200.00	-

Dismantling

Name	Unit	Value
Average SUF of labour hours needed for C-steel dismantling	h/t	32
Average SUF of labour hours needed for S-steel dismantling	h/t	36
Average SUF of labour hours needed for CM metals dismantling	h/t	35
Average SUF of labour hours needed for other materials dismantling	h/t	20
Average SUF of labour hours needed for thermal insulating material dismantling	h/t	7
SUF of oxygen consumption for C-steel dismantling	Nm^3/t	25
SUF of acetylene consumption for C-steel dismantling	Nm^3/t	1.6
SUF of electricity consumption for S-steel and CM dismantling	kWh/t	51.5
SUF of electricity consumption for C-steel and other material dismantling	Nm^3/t	5
SUF of air consumption for plasma cutting of S-steel and CM	Nm^3/t	26.4
Thickness of S-lining	m	0.004
Thickness of C-lining	m	0.006
Weight ratio of C-steel in PREFA from total weight		0.04444
Weight ratio of C-steel in FEAL from total weight		0.25
Weight ratio of CM in FEAL from total weight		0.25
Weight of $1m^2$ of FEAL	t/m^2	0.01655
Weight ratio of insulation in FEAL from total weight		0.5
Ratio of liquid RAW conditioned by bituminisation		0.3
Ratio of liquid RAW conditioned by cementation		0.7

Demolition

Name	Unit	Value
Average SUF of labour hours needed for concrete demolition	h/m^3	6
Average SUF of labour hours needed for concrete demolition under -1m level	h/m^3	10
Average SUF of labour hours needed for RC demolition up to 400 mm thickness	h/m^3	8
Average SUF of labour hours needed for RC demolition of 400 to 700 mm thickness	h/m^3	12
Average SUF of labour hours needed for RC demolition over 700mm thickness	h/m^3	80
Average SUF of labour hours needed for BSS and lining demolition	h/t	33
Average SUF of labour hours needed for PREFA demolition	h/t	4
Average SUF of labour hours needed for masonry demolition	h/m^3	2
Average SUF of labour hours needed for peripheral panels demolition	h/m^3	2
Average SUF of labour hours needed for FEAL demolition	h/m^2	0.5
Average SUF of labour hours needed for other material demolition	h/t	20
Average SUF of labour hours needed for HMD demolition	h/t	20
Average SUF of labour hours needed for special drainage demolition	h/t	45
Capacity of high pressure water jet cutting	m^2/h	0.25
Electricity consumption for RC cutting by HPWJ	kWh/m^2	600
Diesel oil consumption for demolition	t/m^3	0.005
Diesel oil consumption for recycling	t/h	0.07
Diesel oil consumption for communal waste transport	l/km	0.4
Diesel oil consumption for recycled material transport	l/t	0.2
Diesel oil consumption for RAW transport	l/km	0.45
Electricity consumption for HMD dismantling	kWh/t	2.5
Oxygen consumption for HMD dismantling	m^3/t	2.5
Acetylene consumption for HMD dismantling	m^3/t	0.16

Decontamination of CB surfaces				
Name	Unit	Value		
		Surface with stainless steel liner	Surface with carbon steel liner	Surface with epoxy coating
Electrolyte consumption for semi-dry electrolytic decontamination	l/m^2	1		
Demineralised water consumption for rinsing after semi-dry electrolytic decontamination	l/m^2	10		
Detergent consumption	l/m^2		0.25	0.25
Electricity consumption for semi-dry electrolytic decontamination	kWh/m^2	13		
Electricity consumption for HP sprinkling	kWh/m^2		5.5	
Electricity consumption for foam exhausting	kWh/m^2			5.5
SUF of labour hours needed for building surface decontamination	h/m^2	2.6	0.52	0.68
Demineralised water consumption for HP sprinkling	l/m^2		200	200
Diesel oil consumption for building surface decontamination	kg/m^2		0.9	0.9
SUF of labour hours needed for mechanical decontamination by scarifying of 2 mm and 4 mm thickness	h/m^2			0.5 and 1
SUF of labour hours needed for decontamination by sprinkling	h/m^2		0.5	0.5
Electricity consumption for scarifying of thickness 2 and 4 mm	kWh/m^2			2.5 and 5

Decontamination of equipment		
Name	Unit	Value
DF for semi-dry electrolytic decontamination		Up to 100
DF for HP sprinkling decontamination		Up to 5
DF for grinding		Up to 100
SUF of labour hours needed for cutting-off of bushings	h/pc	2
Rise of solid RAW for semi-dry electrolytic decontamination	kg/m^2	0.001
Solution consumption for postdismantling decontamination of C-steel	kg/kg	1.6
Solution consumption for postdismantling decontamination of S-steel	kg/kg	0.46
Demineralised water consumption for S-steel decontamination	kg/kg	0.4
Demineralised water consumption for C-steel decontamination	kg/kg	2.7
SUF of labour hours needed for postdismantling decontamination of C-steel	h/t	44
SUF of labour hours needed for postdismantling decontamination of S-steel	h/t	16
Electricity consumption for postdismantling decontamination of S-steel	kWh/t	80
Detergent consumption for postdismantling decontamination	kg/kg	0.001
Rise of secondary liquid RAW	kg/h	0.001
Salinity of liquid RAW from predismantling decontamination	g/l	5
Salinity of liquid RAW from postdismantling decontamination	g/l	16.5
Salinity of liquid RAW from personnel hatch	g/l	0.5
Salinity of liquid RAW from reactor fragmentation	g/l	2.5
Salinity of liquid RAW in auxiliary building	g/l	200
Amount of liquid RAW from both reactors fragmentation	m^3	1 000

Decontamination of equipment		
Name	**Unit**	**Value**
SUF of labour hours needed for contam.checking of building surfaces before demolition	h/m^2	0.02
Electricity consumption for PC decontamination after final shutdown	kWh/h	700
Electricity consumption for cutting-off of bushings	kWh/h	2

*Exchange rate 1 EUR = 30.126 SKK

Appendix 7. Material routes

Material routes for materials from technological part of CB 800 without reactor			
Stainless steel	clearance: 48%		
	decontamination :44%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 2%		
	HPC - cementation in FCC - NSR: 6%		
Carbon steel	clearance: 48%		
	decontamination – 44%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 2%		
	HPC - cementation in FCC - NSR: 6%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 10%	
		decontamination by insulation stripping: 90%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 70%	
		HPC - cementation in FCC – NSR: 30%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 10%	
		directly to backfill/communal landfill: 65%	
		LPC – HPC - NSR: 25%	

Material routes for materials from building accessories which are part of CB 800			
Stainless steel	clearance: 48%		
	decontamination :43%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 3%		
	HPC - cementation in FCC - NSR: 6%		
Carbon steel	clearance: 48%		
	decontamination – 43%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 3%		
	HPC - cementation in FCC - NSR: 6%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 10%	
		decontamination by insulation stripping: 90%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 70%	
		HPC - cementation in FCC – NSR: 30%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 10%	
		directly to backfill/communal landfill: 65%	
		LPC – HPC - NSR: 25%	

Material routes for materials from technological part of CB 801 and 801a			
Stainless steel	clearance: 50%		
	decontamination :46%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 2%		
	HPC - cementation in FCC - NSR: 2%		
Carbon steel	clearance: 60%		
	decontamination – 34%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 3%		
	HPC - cementation in FCC - NSR: 3%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 10%	
		decontamination by insulation stripping: 90%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 70%	
		HPC - cementation in FCC – NSR: 30%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 10%	
		directly to backfill/communal landfill: 65%	
		LPC – HPC - NSR: 25%	

Material routes for materials from building accessories which are part of CB 801 and 801a			
Stainless steel	clearance: 60%		
	decontamination :33%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 4%		
	HPC - cementation in FCC - NSR: 3%		
Carbon steel	clearance: 60%		
	decontamination – 34%	clearance: 90%	
		packaging in ISO container – VLLW disposal facility: 10%	
	segmentation - cementation in FCC - NSR: 4%		
	HPC - cementation in FCC - NSR: 2%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 10%	
		decontamination by insulation stripping: 90%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 70%	
		HPC - cementation in FCC – NSR: 30%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 10%	
		directly to backfill/communal landfill: 65%	
		LPC – HPC - NSR: 25%	

Material routes for materials from technological part of CBs 803 and 781			
Stainless steel	clearance: 70%		
	decontamination :26%	clearance: 75%	
		packaging in ISO container – VLLW disposal facility: 25%	
	segmentation - cementation in FCC - NSR: 2%		
	HPC - cementation in FCC - NSR: 2%		
Carbon steel	clearance: 95%		
	decontamination – 5%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 100%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 70%	
		HPC - cementation in FCC – NSR: 30%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 4%	
		directly to backfill/communal landfill: 80%	
		LPC – HPC - NSR: 16%	

Material routes for materials from building accessories which are part of CBs 803 and 781			
Stainless steel	clearance: 70%		
	decontamination :26%	clearance: 72%	
		packaging in ISO container – VLLW disposal facility: 28%	
	segmentation - cementation in FCC - NSR: 2%		
	HPC - cementation in FCC - NSR: 2%		
Carbon steel	clearance: 98%		
	decontamination – 1.5%	clearance: 90%	
		packaging in ISO container – VLLW disposal facility: 10%	
	segmentation - cementation in FCC - NSR: 0.5%		
	HPC - cementation in FCC - NSR: 0%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 100%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 95%	
		HPC - cementation in FCC – NSR: 5%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 20%	
		directly to backfill/communal landfill: 78%	
		LPC – HPC - NSR: 2%	

Material routes for materials from technological part of CBs 804 and 461			
Stainless steel	clearance: 20%		
	decontamination :75%	clearance: 85%	
		packaging in ISO container – VLLW disposal facility: 15%	
	segmentation - cementation in FCC - NSR: 3%		
	HPC - cementation in FCC - NSR: 2%		
Carbon steel	clearance: 20%		
	decontamination – 73%	clearance: 85%	
		packaging in ISO container – VLLW disposal facility: 15%	
	segmentation - cementation in FCC - NSR: 4%		
	HPC - cementation in FCC - NSR: 3%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 100%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 95%	
		HPC - cementation in FCC – NSR: 5%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance:10%	
		directly to backfill/communal landfill: 80%	
		LPC – HPC - NSR: 10%	

Material routes for materials from building accessories which are part of CBs 804 and 461			
Stainless steel	clearance: 0%		
	decontamination :0%	clearance: 0%	
		packaging in ISO container – VLLW disposal facility: 0%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Carbon steel	clearance: 95%		
	decontamination – 5%	clearance: 80%	
		packaging in ISO container – VLLW disposal facility: 20%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 100%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 95%	
		HPC - cementation in FCC – NSR: 5%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 20%	
		directly to backfill/communal landfill: 78%	
		LPC – HPC - NSR: 2%	

Material routes for materials from technological part of CB 460			
Stainless steel	clearance: 0%		
	decontamination :0%	clearance: 0%	
		packaging in ISO container – VLLW disposal facility: 0%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Carbon steel	clearance: 100%		
	decontamination – 0%	clearance: 0%	
		packaging in ISO container – VLLW disposal facility: 0%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Non ferrous metals	electrical cables: 0%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 0%	stripped contaminated insulation – VLLW: 0%
			stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
	other non ferrous metals: 0%	clearance: 0%	
		HPC - cementation in FCC – NSR: 0%	
Other	dangerous (asbestos): 0%	special treatment: 0 %	
	non-dangerous: 0%	clearance: 0%	
		directly to backfill/communal landfill: 100%	
		LPC – HPC - NSR: 0%	

Material routes for materials from building accessories which are part of CB 460			
Stainless steel	clearance: 100%		
	decontamination :0%	clearance: 0%	
		packaging in ISO container – VLLW disposal facility: 0%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Carbon steel	clearance: 100%		
	decontamination – 0%	clearance: 0%	
		packaging in ISO container – VLLW disposal facility: 0%	
	segmentation - cementation in FCC - NSR: 0%		
	HPC - cementation in FCC - NSR: 0%		
Non ferrous metals	electrical cables: 70%	direct clearance: 0%	stripped clean insulation – communal landfill: 0%
			metal cable for clearance: 0%
		HPC - cementation in FCC – NSR: 0%	
		decontamination by insulation stripping: 100%	stripped contaminated insulation – VLLW: 5%
			stripped clean insulation – communal landfill: 35%
			metal cable for clearance: 60%
	other non ferrous metals: 30%	clearance: 95%	
		HPC - cementation in FCC – NSR: 5%	
Other	dangerous (asbestos): 1%	special treatment: 100 %	
	non-dangerous: 99%	clearance: 0%	
		directly to backfill/communal landfill: 100%	
		LPC – HPC - NSR: 0%	

Material routes for building materials for all contaminated CBs	
Activated reinforced concrete from reactor cavity and activated serpentinite rubble from biological shield)	Cementation in FCC – NSR: 100%
Contaminated building material from mechanical decontamination	Cementation in FCC – NSR: 100%
Concrete not contaminated	Clearance: 100%
Reinforced concrete not contaminated	Clearance: 100%
Reinforcing bars	carbon steel for clearance: 100%
Prefabricates	Concrete for clearance: 95.5%
	Carbon steel for clearance: 4.5%
Masonry	Clearance: 100%
Peripheral wall panels	Clearance: 100%
FEAL wall panels	Carbon steel for clearance: 25%
	Non-ferrous metals for clearance: 25%
	Heat insulation to communal landfill: 50%
Heat insulation	To landfill: 100%
Contaminated soils and concrete debris	To VLLW disposal facility: 100%

Material routes for secondary and operational radioactive wastes	
Filters	LPC - HPC - cementation in FCC - NSR: 100%
Liquid radioactive waste	Evaporation - cementation in FCC - NSR: 70%
	Bituminisation - cementation in FCC - NSR: 30%
Contaminated spent resins, others	Cementation in FCC - NSR: 100%
Combustible waste, anthracite	Incineration - HPC - cementation in FCC - NSR: 100%
Compactable solid waste	LPC - HPC - cementation in FCC - NSR: 100%
Metal waste	Packaging - cementation in FCC - NSR: 100%
Sand	Cementation in FCC - NSR: 100%

Appendix 8. Overview of preparatory decommissioning activities

Status note: The planned, ongoing and completed designations have been assigned using available contract-signature and document-approval dates. Where implementation occurred later than originally scheduled, an activity has been retained as planned unless the available evidence supported a different status. The classifications should therefore be read as a reconstruction from available records rather than a complete contemporaneous implementation-status register.

Pre-decommissioning activity	Related projects	Reference	Schedule [month/year]	Costs (Million Sk)	Costs (MEUR estimate)*
0. Coordination, management and supervision of pre-decommissioning activities	PMU Consultant, phase 1	A1.1	10/03–12/07	440.00	14.61
	PMU Consultant, phase 2	A1.2	12/07–12/11	100.00	3.32
1. Separation of V1 NPP from the other SE EBO facilities remaining in operation					
Replacement of services that V1 NPP provides for other installations and facilities at SE EBO site (e.g. heating, process steam, back-up services, safety functions) and provision of new and/or modified services for V1 NPP systems (e.g. water, steam, heating, electricity)	Relocation of emergency response centre	A3-C	08/06–06/08	80.00	2.66
	Modification (separation) of the power supply system of V1 NPP and V2 NPP and SE VYZ	A5-A	11/07–07/12	120.00	3.98
	Modification of heating and steam distribution system	A5-B1	03/06–02/07	165.00	5.48
	Reliable heat and steam supply: Reconstruction of the auxiliary boiler station at the Bohunice site	A5-B2	04/05–05/06	175.00	5.81
	Modification of cooling and service water systems, and raw water inlet system	A5-C	01/09–12/09	75.00	2.49
	Replacement of operating fluids of the V1 NPP, V2 NPP and SE-VYZ	A5-D	12/11–12/12	70.00	2.32
Physical separation of V1 NPP from the SE EBO facilities remaining in operation	Reconstruction of the Bohunice area protection system, designated AKOBOJE	A3-A	03/06–04/10	510.00	16.93
2. Preparation and realisation of V1 NPP final shut down and termination of operation					
Establishment of a radioactive waste and spent fuel management strategy	Report on Bohunice V1 NPP decommissioning and historical waste management strategy	A1.1 (D8)	07/04–07/05	Included in A1.1	

Pre-decommissioning activity	Related projects	Reference	Schedule [month/year]	Costs (Million Sk)	Costs (MEUR estimate)*
	Spent fuel management	A5-E	04/06–12/06	40.00	1.33
Development of operating documentation amendments for the pre-decommissioning (shut-down) phase	Development of comprehensive documentation necessary for V1 NPP decommissioning licensing phase and decommissioning implementation phase	A2.1	06/06–07/11	80.00	2.66
Personnel training for new tasks in connection with operation termination after the final reactor shutdown					
Treatment of historical radioactive wastes	Treatment of historical waste, sludges and sorbents	C7-B	01/06–12/06	190.00	6.31
	Treatment and conditioning of historical waste	C7-C	07/05–12/06	180.00	5.97
	Additional transport means for liquid historical RAW from the V1 NPP to the existing treatment facilities	C7-D	03/05–12/06	25.00	0.83
	Technologies for historical solid waste retrieval	New	01/10–12/10	85.00	2.82
3. Assessment of V1 NPP status at the beginning of decommissioning					
Assessment of physical equipment/structures condition against the starting point of decommissioning	Decommissioning database	B6.4	09/06–10/07	240.00	7.97
Assessment of the radioactive inventory					
Preparation of the database needed for V1 NPP decommissioning					
Update (and completion) of the plant documentation	Document configuration management system	A2.2	08/06–12/09		
4. Assurance of availability of qualified personnel for decommissioning	Reorganisation of the V1 NPP management and personnel structure to facilitate decommissioning	New	01/07–12/11	35.00	1.16

Pre-decommissioning activity	Related projects	Reference	Schedule [month/year]	Costs (Million Sk)	Costs (MEUR estimate)*
	Ensuring the availability of experienced operation personnel till the end of V1 NPP operation		2006–2011	900.00[1]	29.87
	Personnel training for new tasks in connection with V1 NPP decommissioning	New	01/07–12/11	25.00	0.83
5. Development of V1 NPP decommissioning documentation and management tools	The V1 NPP conceptual decommissioning plan	B6.1	05/05–05/06	25.00	0.83
	The environmental impact assessment report of V1 NPP decommissioning	B6.2	12/05–12/06	25.00	0.83
	The V1 NPP decommissioning stage plan & other documentation	B6.3	08/07–11/09	165.00	5.48
	Decommissioning management support system	New	01/10–12/12	20.00	0.66
6. Provision of new and/or modified infrastructure for V1 NPP decommissioning					
Adaptation of information (notification), and monitoring systems	Reconstruction of the public warning and notification system	A3-B	11/06–02/08	440.00	14.61
	Refurbishment of the radiation protection monitoring equipment	C12	01/09–12/10	95.00	3.15
Provision of sufficient decontamination capacities (enlargement of existing ones)	Provision of suitable decontamination facilities	A4	2009–2011	95.00	3.15
Provision of sufficient waste treatment capacities (enlargement of existing ones and provision of new technologies)	Treatment of metallic waste	C7-A	2006–2011	215.00	7.14
	Clearance of decommissioning materials	C10	01/06–12/10	135.00	4.48
Provision of sufficient waste storage and disposal capacities	Interim storage of RAW at Bohunice site	C8	2005–2007	450.00	14.94
				(385.00 BIDSF)	12.78
	Enlargement of the national repository at Mochovce	C9	01/06–12/12(12/20)	1,200.00 905.00[2]	39.83 30.04

Pre-decommissioning activity	Related projects	Reference	Schedule [month/year]	Costs (Million Sk)	Costs (MEUR estimate)*
	Very low level waste disposal facility	C11	01/06–12/10	175.00[3]	5.81
	Provision of sufficient buffer storage places for decommissioning materials	New	06/11–12/11	40.00	1.33
	Deep geological repository planning and implementation	New	2004–2095	23,000.00[4] (1,100.00 BIDSF)	763.46 36.51
Provision of sufficient mobile dismantling equipment for decommissioning purposes	Transport and storage means for decommissioning	New	01/10–12/11	165.00	5.48
	Mobile working and protection (safety) equipment for decommissioning	New	01/10–12/11	80.00	2.66
Modification of buildings and systems for decommissioning	Categorisation of equipment for decommissioning	included in B6.3			
	Implementation of physical modification of buildings and equipment	New	01/10–12/11	50.00	1.66
7. Other PDAs					
	Measures in the electrical transmission system incurred by V1 NPP final shutdown	New	2006–2011	10,300.00 (4,200.00 BIDSF)[5]	341.9 139.41

[1] Not included in decommissioning costs

[2] In case a new VLLW disposal facility is approved, the costs in brackets are to be considered. If not, costs without brackets are to be considered.

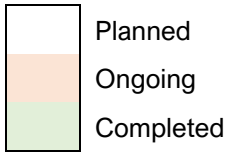
[3] Only in case the new VLLW disposal facility is approved.

[4] Not included in decommissioning costs.
This represents only part of the overall costs, related to V1 NPP. The Deep geological repository shall be used for V1, V2 and Mochovce NPP.

[5] Not included in decommissioning costs

*Exchange rate 1 EUR = 30.126 SKK

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Appendix 9. Main general investments

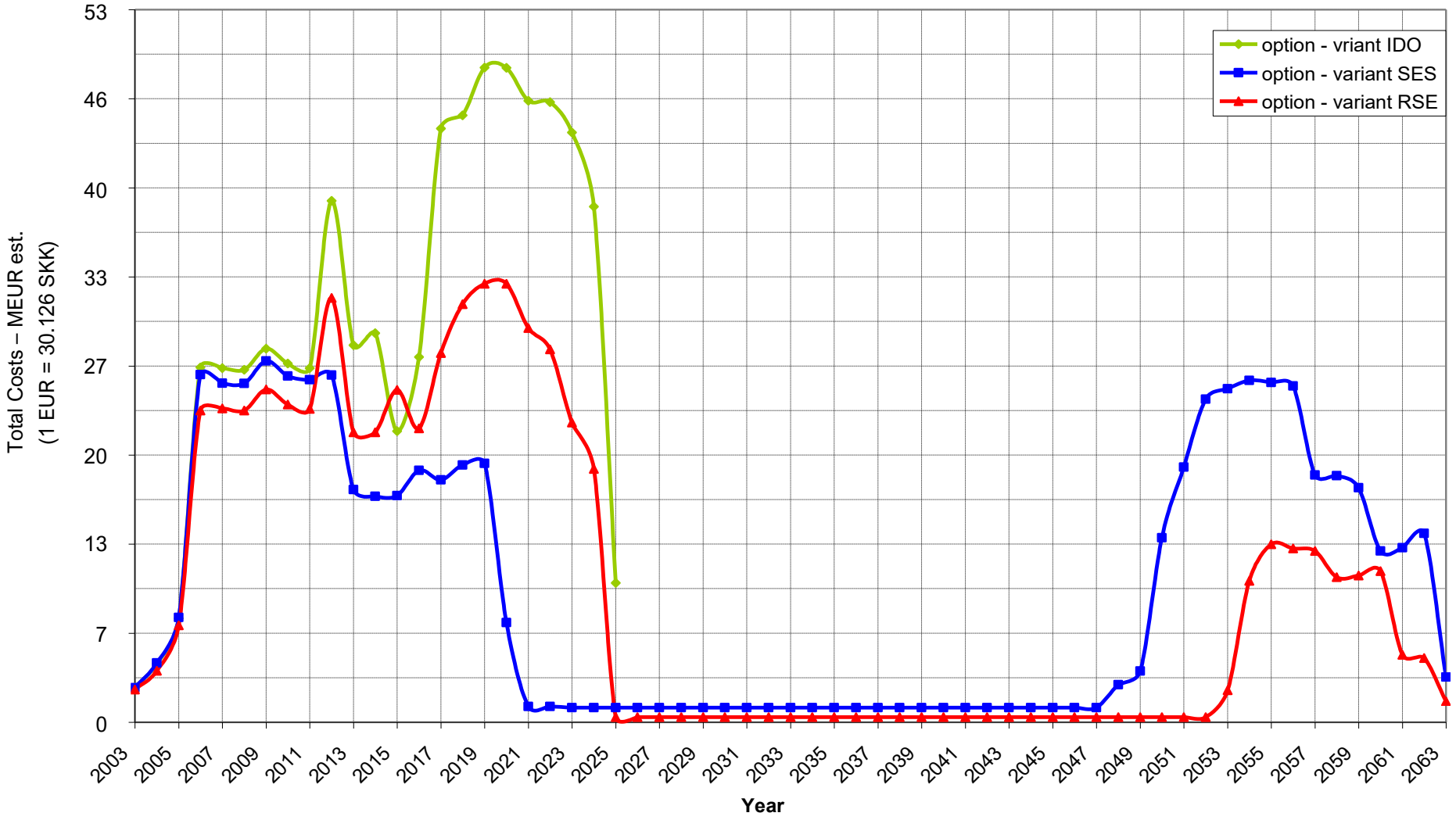
PSL item No.	Name	PDA project	Schedule	Price	
			month/year	MSKK	MEUR estimate*
01.0101	PMU Consultant, phase I	A1.1	10/03-12/07	440.00	14.61
01.0101	PMU Consultant, phase II	A1.2	12/07- 12/11	100.00	3.32
01.0101	Spent fuel management	A5-E	04/06- 12/06	40.00	1.33
01.0101	Development of comprehensive documentation necessary for V1 NPP decommissioning licensing phase and decommissioning implementation phase	A2.1	06/06- 07/11	80.00	2.66
01.0102	Decommissioning database	B6.4	09/06- 10/07	110.00	3.65
01.0102	The V1 NPP conceptual decommissioning plan	B6.1	05/05- 05/06	25.00	0.83
01.0103	The V1 NPP decommissioning stage plan & other documentation	B6.3	08/07- 11/09	165.00	5.48
01.0104	The environmental impact assessment report of V1 NPP decommissioning	B6.2	12/05- 12/06	25.00	0.83
03.0100	Treatment of metallic waste	C7-A	2006- 2011	215.00	7.14
03.0100	Mobil cranes	---**	2006- 2011	40.00	1.33
03.0100	Excavator with demolition tongs and hammer	---**	2006- 2011	15.00	0.50
03.0100	Demolition tongs	---**	2006- 2011	7.00	0.23
03.0100	Demolition hammer	---**	2006- 2011	4.00	0.13
03.0100	Loader	---**	2006- 2011	18.00	0.60
03.0100	Demolishing beetle	---**	2006- 2011	3.00	0.10
03.0300	Refurbishment of the radiation protection monitoring equipment	C12	01/09- 12/10	95.00	3.15
03.0300	Mobile working and protection (safety) equipment for decommissioning	PDA new	01/10- 12/11	80.00	2.66
03.0400	Reconstruction of the public warning and notification system	A3-B	11/06- 02/08	440.00	14.61
04.0100	Provision of suitable decontamination facilities	A4	2009- 2011	95.00	3.15
04.0601	Relocation of emergency response centre	A3-C	08/06- 06/08	80.00	2.66
04.0601	Modification (separation) of the power supply system of V1 NPP and V2 NPP and SE VYZ	A5-A	11/07- 07/12	120.00	3.98
04.0601	Modification of heating and steam distribution system	A5-B1	03/06- 02/07	165.00	5.48
04.0601	Reliable heat and steam supply: Reconstruction of the auxiliary boiler station at the Bohunice site	A5-B2	04/05- 05/06	175.00	5.81
04.0601	Modification of cooling and service water systems, and raw water inlet system	A5-C	01/09- 12/09	75.00	2.49
04.0601	Implementation of physical modification of buildings and equipment	PDA new	01/10- 12/11	50.00	1.66
04.0602	Reconstruction of the Bohunice area protection system, designated AKOBOJE	A3-A	03/06- 04/10	510.00	16.93

PSL item No.	Name	PDA project	Schedule	Price	
			month/year	MSKK	MEUR estimate*
04.0603	Replacement of operating fluids of the V1 NPP, V2 NPP and SE VYZ	A5-D	12/11- 12/12	70.00	2.32
04.1101	Techniques for reactor dismantling	---**	2015-2015-opt.1 2050-2055-opt.2 2054-2060-opt.3	1,000.00	33.19
04.1301	Protective scafanders	---**	2015-2022	0.20	0.01
04.1801	Equipment for high-pressure water jetting decontamination	---**	2020-2024	4.50	0.15
04.1802	Accessories for static support during the special drainage cutting (out of floors)	---**	2021-2023	8.30	0.28
04.2200	Clearance of decommissioning materials	C10	01/06- 12/10	135.00	4.48
04.2300	Personnel training for new tasks in connection with V1 NPP decommissioning	PDA new	01/07 -12/11	25.00	0.83
05.0600	Treatment of historical waste, sludges and sorbents	C7-B	01/06- 12/06	190.00	6.31
05.0600	Treatment and conditioning of historical waste	C7-C	07/05- 12/06	180.00	5.97
05.0600	Additional transport means for liquid historical RAW from the V1 NPP to the existing treatment facilities	C7-D	03/05- 12/06	25.00	0.83
05.0600	Technologies for historical solid waste retrieval	PDA new	01/10- 12/10	85.00	2.82
05.1201	Special fragmentation place for reactor	---**	2016-2025 opt.1 2050-2055 opt.2 2054-2060 opt.3	100.00	3.32
05.1202	Recycling machine for building wastes	---**	2012-2025	86.00	2.85
05.1501	Interim storage of RAW at Bohunice site	C8	2005- 2007	450.00	14.94
05.1501	Provision of sufficient buffer storage places for decommissioning materials	PDA new	06/11- 12/11	40.00	1.33
05.1503	Transport and storage means for decommissioning	PDA new	01/10- 12/11	165.00	5.48
05.1601	Enlargement of the national repository at Mochovce	C9	01/06- 12/20	905.00	30.04
05.1601	Very low-level waste disposal facility	C11	01/06- 12/10	175.00	5.81
08.0102	Reorganisation of the V1 NPP management and personnel structure to facilitate decommissioning	PDA new	01/07- 12/11	35.00	1.16
08.0206	Document configuration management system	A2.2	08/06- 12/09	130.00	4.32
08.0402	Decommissioning management support system	PDA new	01/10- 12/12	20.00	0.66
	Total			**7,001.00**	232.39

*Exchange rate 1 EUR = 30.126 SKK

**Items shall represent future project which include engineering, design and supply.

Appendix 10. Time dependence of annual total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)



Appendix 11. Time dependence of cumulative total costs of V1 NPP decommissioning options (including VAT and without historical RAW management)

