Introduction to cost assessment, funding and control in decommissioning projects

KNOWLEDGE PRODUCT

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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 abovementioned 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 under implementation in the JRC Nuclear Decommissioning and Waste Management Directorate (NDWMD), which becomes a knowledge generator extracting the knowledge from the ongoing decommissioning activities at the different sites (Geel, Ispra, Karlsruhe, and Petten).

The JRC NDWMD aims to become a Centre of Excellence in nuclear decommissioning knowledge management and develop a decommissioning knowledge platform which allows exchanging information and building on the best practices in the EU inside the multi-annual financial framework (2021 – 2027) strategy. The operational phase of the project is expected to start in 2024 to develop ties and exchanges among EU stakeholders and 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, to develop potential EU synergies.

This is a Knowledge Product prepared by 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 programme 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 nuclear power plant in Lithuania and repealing Regulation (EU) No 1369/2013

PRODUCT DESCRIPTION

This knowledge product was prepared by the Nuclear Decommissioning Knowledge Management Team based on the presentation on Cost Assessment, Funding and Cost Control in Decommissioning Projects given by Simon Carroll in the frame of the Decommissioning Summer School 2023 organised by the Joint Research Centre Nuclear Decommissioning and Waste Management Directorate J (NDWMD).

This report aims to guide those involved in nuclear decommissioning projects and suggest recently introduced cost estimate methods and techniques. The document discusses a generic decommissioning programme's cost assessment, funding, and monitoring. One of the main recommendations of this knowledge product is that **accurate estimation of liabilities, along with precise funding and cost monitoring, can enhance the quality of measurements and reduce delays, cost overruns, and safety risks in the project**. The report was created to share knowledge gained from decommissioning and radioactive waste management activities performed by the JRC Directorate J with all EU State Members.

ABSTRACT

This guide is meant for D&WM organisations to assess the financial status of their dismantling operations. It introduces **cost estimation techniques** and an internationally recognised **cost assessment format**. Additionally, it suggests using **Earned Value Management methodology** to monitor expenses during the final phase of a nuclear facility's life cycle.

OBJECTIVE

This knowledge product aims to provide knowledge and advice about cost assessment, funding and cost monitoring in decommissioning projects and provide guidance to other organisations that oversee nuclear facilities in Europe under these circumstances. The purpose of this document is to provide initial insights on how assist nuclear facilities with the cost estimate of the future decommissioning projects by guiding how to approach economic challenges that may arise and including useful documentation.

APPROACH

Initially, this document provides information on the fundamentals of cost assessment (see 2.1) and later describes what ISDC proposes as a standardised methodology to carry out this task (see 2.2). Then, Section 3 advises on how the funding of decommissioning projects should look, and Section 4.1 explains a system to grade the economic evolution of the project at a certain point in time. Finally, Section 5 summarises the primary outcomes of each section before.

TARGET USERS

This guidance is aimed at a wide range of potential beneficiaries: students, industry workers and utilities that will undergo a decommissioning programme. Even those with limited experience and knowledge in the nuclear industry can benefit from the advice provided in this document, as it focuses on projects rather than specific technologies. The information in this document can be immediately valuable to key players in the European field.

APPLICATION, VALUE, AND USE

This document provides an overview of the general lines of a decommissioning project cost estimate, covering all the activities and procedures involved, including waste infrastructure development and room clearance processes. It is important to manage project costs effectively to avoid technical and non-technical mistakes during and after plant operation. The ISDC format is recommended for assessing expenses and mitigating potential damage risks. The document also offers advice on designing a nuclear waste fund and suggests using Earned Value Management for control monitoring. These methods apply to all decommissioning projects planning, adapting the general lines provided to any nuclear facility dismantling programme's concrete features and boundary conditions.

KEYWORDS

DECOMMISSIONING, COSTS, RISK, FUNDING, ISDC.

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LIST OF ACRONYMS

AC: Actual Cost

BoE: Basis of Estimate

EC: European Commission

EV: Earned Value

EVM: Earned Value Management

IAEA: International Agency of Atomic Energy

ISDC: International Structure for Decommissioning Costing

NEA: Nuclear Energy Agency

PB: Planned Budget

WBS: Work Breakdown Structure

LIST OF FIGURES

1. SCOPE

This knowledge product outlines essential factors to consider when evaluating costs, funding, and monitoring expenses related to the decommissioning of a nuclear facility. It introduces the general methods, recommendations and the definition of potential liabilities that may arise during the decommissioning project, impacting the programme cost.

2. INTRODUCTION TO COSTS ASSESSMENT

When planning a decommissioning project, it is crucial to predict the costs involved accurately; this requires having access to all relevant information, as the more data is provided, the more accurate the cost estimate will be. However, no project is perfect, and there will always be some unknowns that need to be addressed. Therefore, it is essential to assess costs to achieve the project's objectives.

2.1. Cost Assessment Fundamentals

Cost assessments estimate the resources and associated costs needed for a concrete decommissioning project. The specific purpose of this assessment will determine the content and level of detail required. There is a variety of purposes:

1	Financial oversight and planning, including funding arrangements
2	Project planning and management
3	Procurement
4	Communication with stakeholders
5	Information sharing within the industry (benchmarking)

Three main features characterise every decommissioning cost assessment:

- **Completion**: Every cost evaluation will estimate resources and costs to complete "something" – an activity, process or project.
- **Not unique**: The methods used in decommissioning are the same as those used in other industries.
- **More than just a number**: The amount and quality of the information presented is a critical part of the assessment, and care should be exercised in interpreting the result.

The selection of the approach to the cost estimate depends on **the level of accuracy the project needs**. The most widely adopted method for a detailed cost assessment is **the bottom-up approach,** which increases the level of detail of its estimation when more information is in hand. The other techniques are used and may be more suitable for a particular estimate, depending on the specific

need for cost information and the available information. Each method is associated with information needs and entails varying efforts to produce a cost assessment. All of them appear in Figure 1. Techniques available for cost assessmentFigure 1.

The estimation grade relies on the assumptions made, the completeness and quality of the information available at the specific point in time it was prepared, and the **calculation methodologies** applied.

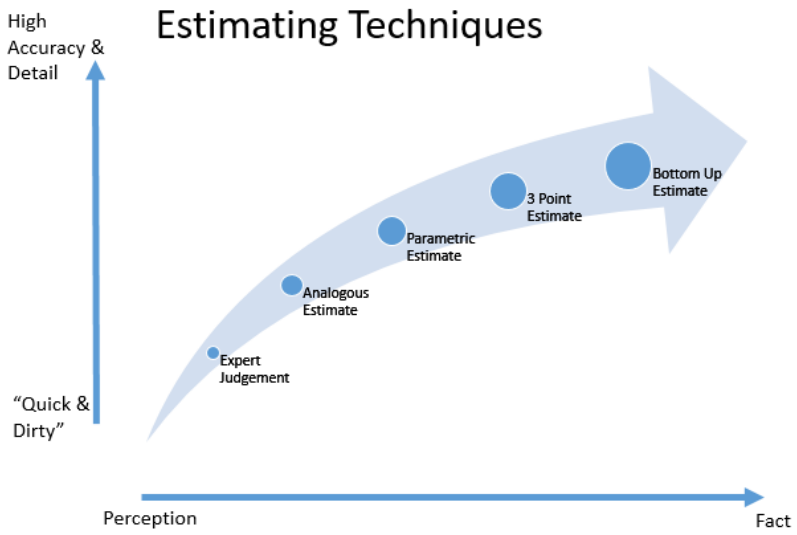

Figure 1. Techniques available for cost assessment

A cost estimate uses three **core elements**: the Basis of Estimate (BoE), the Work Breakdown Structure (WBS), and the programme schedule.

Basis of Estimate (BoE) in Decommissioning

It is the foundation upon which the cost estimate is developed and based on the currently applicable decommissioning plan or decommissioning concept for the facility. The BoE contains the documentation which cost estimates will rely upon to be consistent and reliable. Many bases of the BoE can appear in a decommissioning cost estimate:

Assumptions and Exclusions	Waste Management
Boundary Conditions and Limitations	Spent Fuel Management (If included)
Decommissioning Strategy Description	Sources of Data
Endpoint/ State	Cost Estimating Methodology
Stakeholder Input / Concerns	Descriptions of Techniques and Technology Used
Facility Description and Site Characterisation	Calculation Methodology
Schedule Analysis	Uncertainty and Management of Risk

Work Breakdown Structure (WBS) in Decommissioning

The WBS provides a clear and concise understanding of the work that needs to be done. This information is essential for stakeholders to understand the decommissioning project's scope and make informed decisions. The WBS is typically organised into three levels:

- **Level 1:** The top level of the WBS identifies the major work packages that need to be completed.
- **Level 2:** The second level of the WBS identifies the sub-work packages that need to be completed within each significant work package.
- **Level 3:** The third level of the WBS identifies the tasks that must be completed within each sub-work package.

The WBS can be further subdivided into more levels as needed, and the level of detail in the WBS will depend on the size and complexity of the decommissioning project. Figure 2 shows how a principal activity during decommissioning, such as dismantling, should be structured in a WBS.

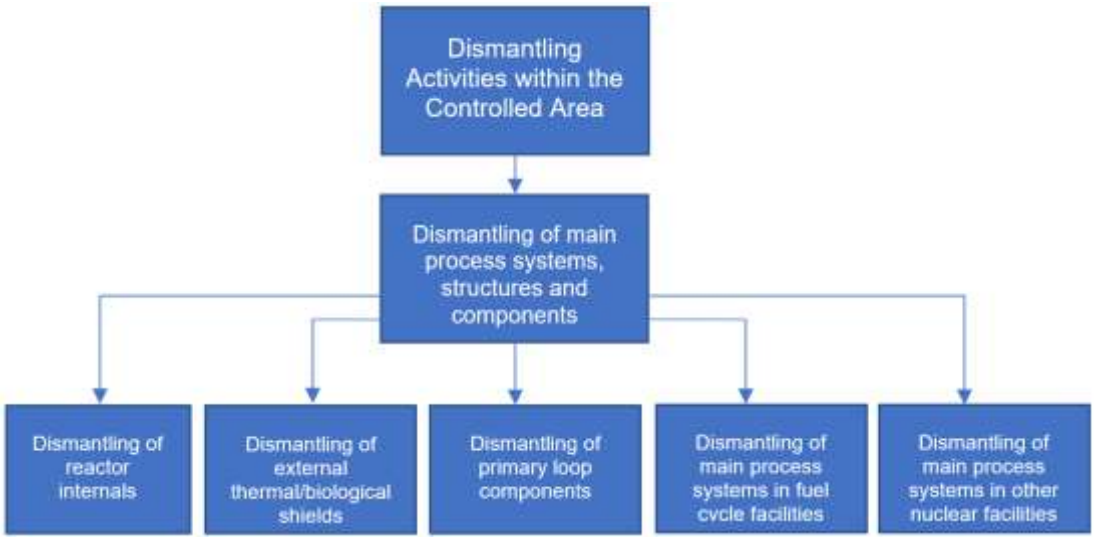

Figure 2. Example of a WBS from a principal activity of a decommissioning project

Schedule in Decommissioning

The project schedule is an integral part of a detailed cost estimate. It is activity-dependent and will draw from the cost estimate database to establish the extent of each activity that needs to be completed. The duration of a decommissioning project affects its cost significantly through the period-dependent expenses and the application of selected techniques for the activity-dependent work. In decommissioning, **costs can be period-dependent or activity-dependent**:

- **Period-dependent costs** are costs that are incurred over a period of time, regardless of the amount of work that is done. These costs include things like security, insurance, and site management.
  - Costs associated primarily with the **project duration**: programme management, engineering, licensing, health and safety, security, energy and quality assurance.
  - Primarily **management staffing and overhead costs**.
- **Activity-dependent costs** are costs that are incurred as a result of specific activities being carried out. These costs include dismantling, removing, and disposing of radioactive waste.
  - Costs associated with performing **specific activities**: decontamination, removal, packaging, transportation and disposal or storage.
  - Unit **cost and work productivity factors** are applied against the plant inventory to develop each activity's decommissioning cost and schedule.

2.2. Cost Assessment Guidance

There is a considerable variety in the format content, practices and requirements of cost estimates depending on the country the decommissioning project is located. Because of this, international guidance was developed to improve the quality of cost assessments. There are two main **reports to guide the process of decommissioning costs estimation**: the International Structure for Decommissioning Costs (ISDC) of Nuclear Installations [1] and the Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities [2].

International Structure for Decommissioning Costs (ISDC) of Nuclear Installations

The ISDC of Nuclear Installations [1] is a framework developed by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), together with the European Commission (EC), to help countries calculate the costs of decommissioning. The document provides a framework for calculating decommissioning costs that can help manage the decommissioning of nuclear facilities and can be used to compare decommissioning costs between countries. The document provides a general cost structure and a standard reporting format, and a hierarchical structure for the cost estimate Figure 3 [1], even though more levels can be added:

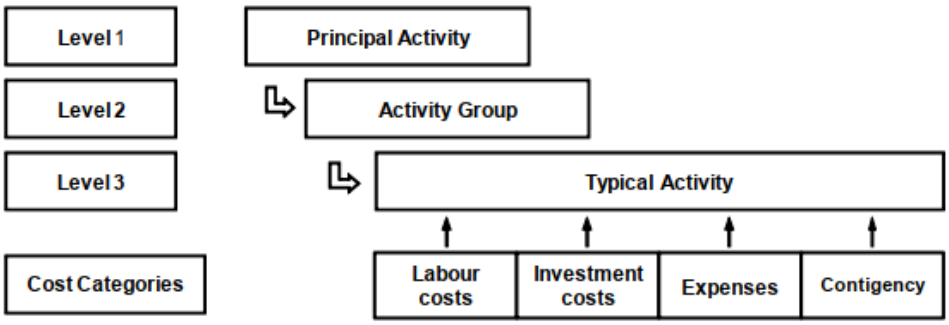

Figure 3. Main hierarchical structure of the ISDC

The ISDC's first cost category establishes the following cost classification (Level 1 – Principal Activities):

- **Pre-decommissioning actions**: Specific engineering, planning and management activities.
- **Facility shutdown activities**: Activities carried out during the transition period after the shutdown until the licence for decommissioning is obtained.
- **Additional activities for safe enclosure and entombment**: Preparatory activities which need to be implemented for decommissioning scenarios involving deferred dismantling.
- **Dismantling activities within the controlled area**: Removing the contaminated and activated systems and structures from the controlled area and identifying contaminated items outside the controlled area.
- **Waste processing, storage, and disposal**: All the activities involved in managing the historical/legacy and decommissioning waste resulting from the actions undertaken.
- **Site infrastructure and operation**: activities concerned with site security and surveillance, site operation and maintenance, site upkeep, operation of support systems and radiation and environmental safety monitoring.
- **Conventional dismantling, demolition, and site restoration**: activities for the dismantling of conventional systems on premises outside of the controlled area and demolition of structures, both for buildings initially located within the controlled area and outside of it.

- **Project management, engineering, and support**: All activities concerned with managing decommissioning activities, engineering, technical, safety and other relevant support during all phases of the decommissioning project.
- **Research and development**: Activities concerned with research and development specific to the decommissioning project, where the information available to the project is insufficient, research and development work are typically contracted to specialised institutions and companies.
- **Fuel and nuclear material**: All activities defined within the decommissioning project for spent fuel and nuclear materials.
- **Miscellaneous expenditures**: cost items directly related to a decommissioning project (i.e., within the project scope) but cannot be allocated in the abovementioned activities.

Every principal activity contains 4 or 6 activity groups organised into two more levels (Level 2 and Level 3), including a set of typical actions that should take part in every decommissioning step in any nuclear facility. The user can look them up in reference [1].

Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities

This NEA and IAEA joint activity builds on ISDC by guiding how to consider risk and uncertainty in decommissioning cost estimates clarifies some aspects of the ISDC report, and ensures alignment with current good practices in cost estimation. This report guides how to address uncertainties in decommissioning project cost estimates. Four different sources of uncertainty are identified in the document: technical, regulatory, economic, and schedule uncertainties.

This report helps incorporate essential cost estimate elements in a decommissioning project that are not fully included in the ISCD. In addition, it adjusts some terminology to improve its clarity and consistency. For example, the ISDC does not clarify what an ISDC “contingency” is; hence this report defines the cost-estimate elements and uncertainties as drawn in Figure 4 and Figure 5:

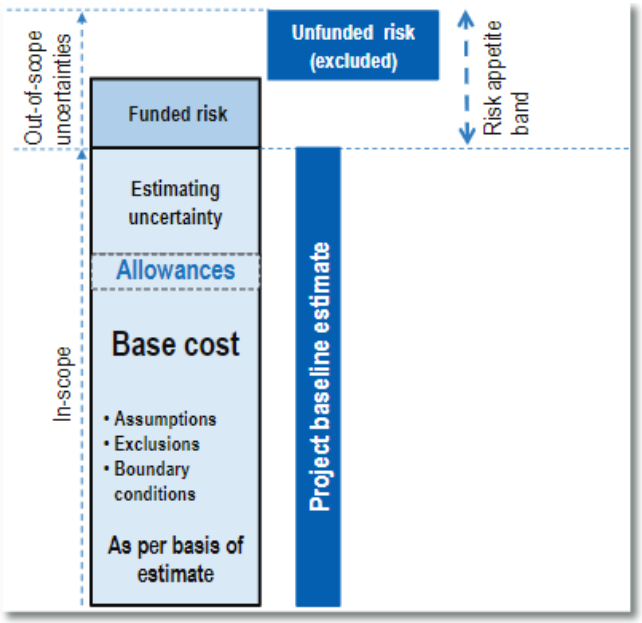

Figure 4. Basic elements of a cost estimate

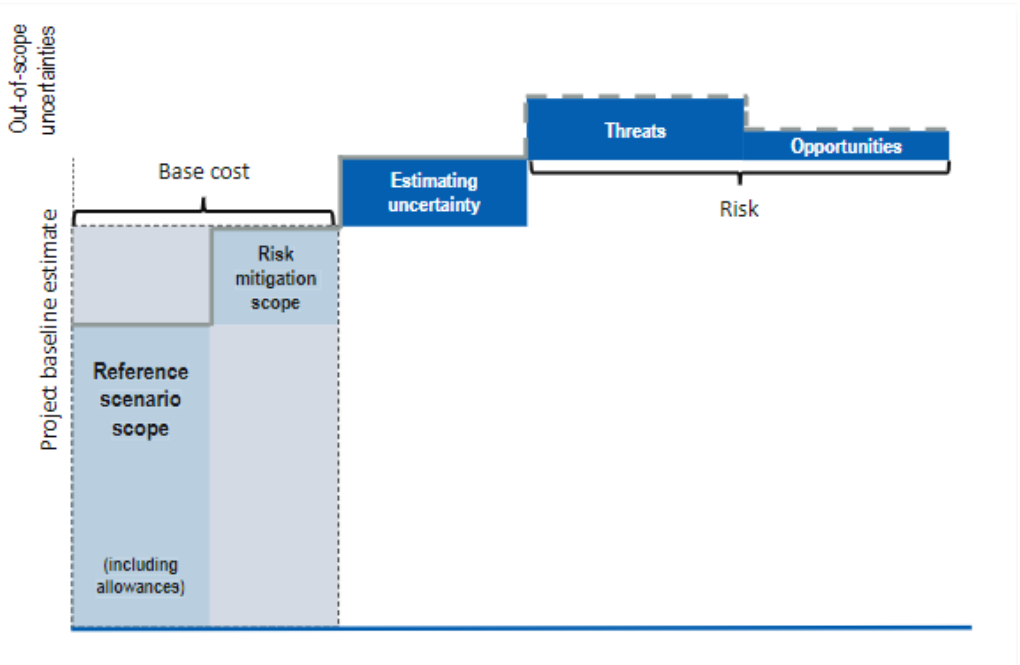

Figure 5. Generic example of the elements of a cost estimate

The report defines key terms that do not appear in the ISCD report, such as the risk mitigation scope, estimating uncertainty or threats/opportunities. **Risk mitigation scope** complements ISCD "contingency" (renamed to Estimating Uncertainty). The report addresses new risk elements and provides a risk framework to help their identification. A stepwise approach is suggested to proceed with the assessment and the analysis, plus the document lists the usual risks in decommissioning projects. Finally, a method for calculating a funded risk provision for a general project baseline estimate is illustrated in Figure 6 [2] below:

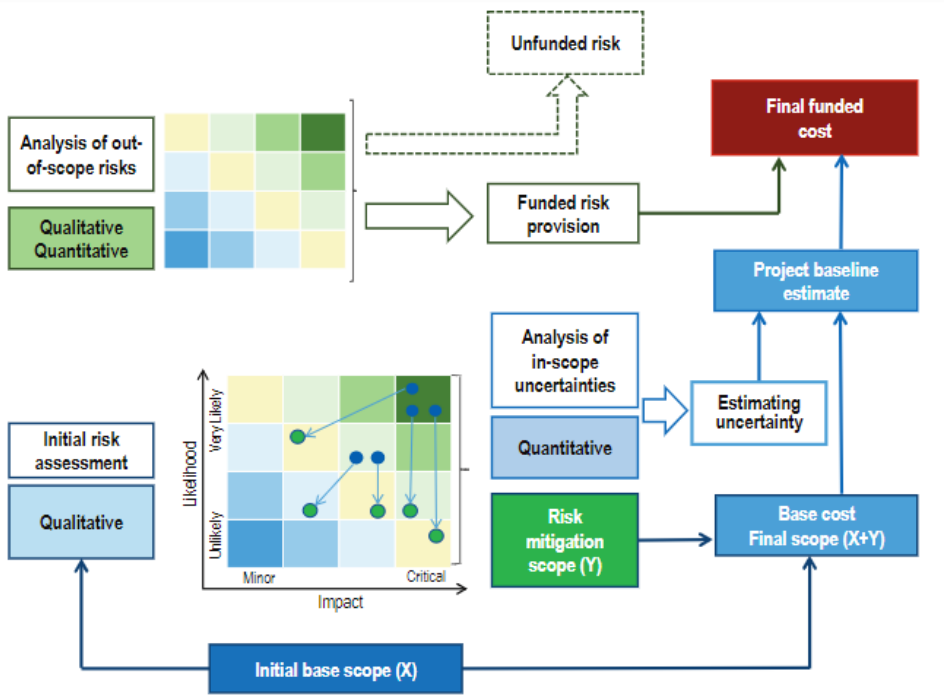

Figure 6. Final funded cost, including the addition of a funded risk provision to the project baseline estimate

All of this reinforces the thought of **taking uncertainties fully into account**, as cost assessment typically grows over time as more information is gathered. This also means that, by explicitly and comprehensively addressing project cost risk, it is possible to provide a **more complete picture of the likely costs**. Figure 7 [2] illustrates what has just been said:

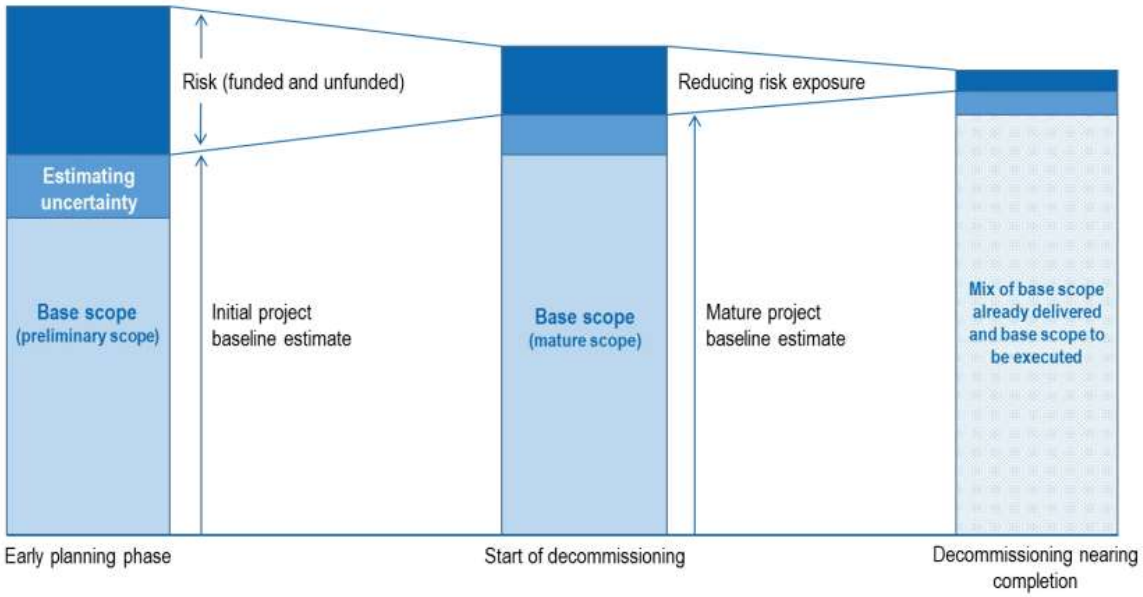

Figure 7. Change in-scope maturity and relationships between elements of a cost-estimate over time

3. BASICS ON DECOMMISSIONING FUNDING

After calculating what the decommissioning project will cost, keeping in mind all the uncertainties, it is time to find out how to finance the project and when money will be needed. Three questions need to be answered:

- What are the **substantial liabilities** of the project?
- When is the project going to create **revenue**?
- When are these **substantial liabilities** going to arise?

These **substantial liabilities** are the cost of building up the infrastructure, the management and disposal of spent fuel, the decommissioning of facilities, the management and disposal of radioactive waste, the costs of research and development and the costs of regulatory supervision.

The moment when these drawbacks occur varies a lot. It can happen during the development of the waste infrastructure (during and after operation), as waste and spent fuel management arises or at an end-of-life phase of the project (final disposal of waste and spent fuel). This means that **funding will need to be available over an extended time frame**, in different amounts, depending on the overall programme of expenditure. Therefore, multiple interacting elements must be considered to design a correct nuclear waste fund that satisfies the project's needs (see Figure 8). In addition, some critical considerations in fund management are related to principles, policy, instructions, procedures, prudence, and risk appetite.

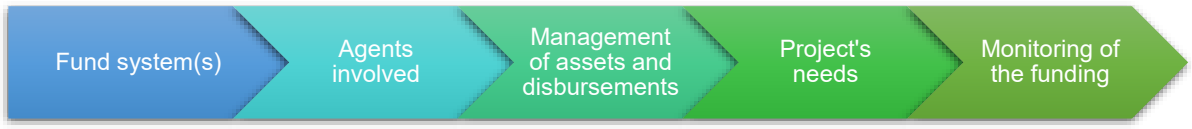

Figure 8. Multiple interacting elements of a funding design

The **facility's revenue** will be created during the operational life of the facility. Typically, funds are accumulated while the nuclear facilities are productive and earning money. These earnings will come, for the most part, from a fee based on electricity sales or an annual payment.

Finally, it is suggested to review and adjust **the funding design**. This will contain activities like the establishment of targets and benchmarks, the evaluation of performance, the review of assumptions or the response to new information. The system created will have to be stable and resilient so roles are always clear and the evolutions of expectations and experience are managed so that functionality and performance are improved over time.

4. COST CONTROL

Cost management covers the entire life cycle of a project from the initial planning phase towards measuring the actual cost performance and project completion. **Cost control** is part of cost management, and it is concerned with **measuring variances from the cost baseline and, where necessary, taking effective corrective action.** The key elements of cost controls are:

What has to be done

- Accurate **description of budget and detailed activities** against which the performance can be measured
- Use detailed budget **estimate and tracking profiles**

What has been done

- **Setup reports** giving actual performance data that is consistent with the detailed budget
- Ensure **reports provided in a timely fashion**

How well are things being done

- **Analyses of the performance** to date
- Quality depends on **resolution and accuracy of the baseline** and the timeliness and correctness of progress reports

What still needs to be done

- **Forecast the potential result of the current situation**, in case no action is taken to the current performance

What need to be done better

- **Actions needed to bring the project's** performance in line with **the expectations**
- Implies **adjustment of the baseline** plan: the resources, estimate, schedule, budget, etc

Are things being done better?

- **Verify if the goals** of corrective actions **were achieved**

4.1. Earned Value Management

Simply measuring expenditure does not paint the whole picture of the project's economic performance. To do so, **Earned Value Management (EVM)** relates it to the actual work. It helps to notice the project's past, present, and future financial health. Earned Value Management requires a baseline that monitors three key parameters of every work package [3]:

1	**Planned Budget (PB):** Authorised budget to complete an activity
2	**Earned Value (EV):** Value of the completed work, expressed in monetary terms
3	**Actual Cost (AC):** Real cost to carry on with the works

These three values help the project leader analyse the project's evolution with time. As Figure 9 shows, EV can be compared with PB and AC to evaluate the performance until a specific moment of the programme.

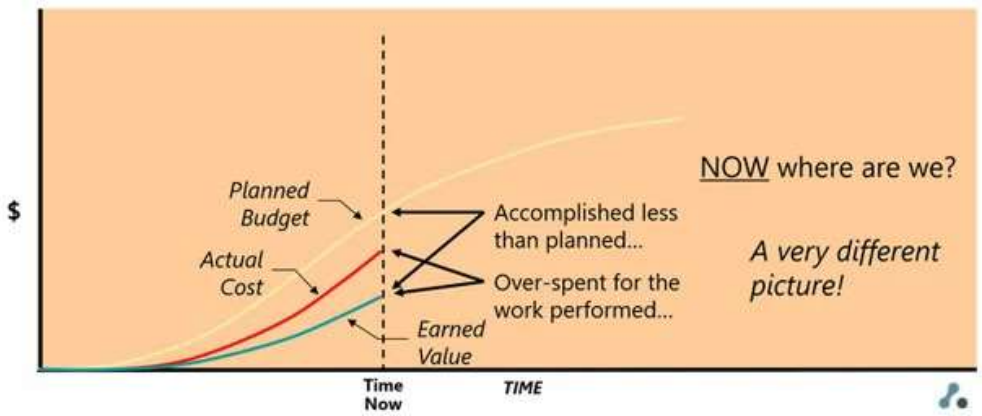

Figure 9. Example of Earned Value Management at some point during a project's life

Two situations can be assessed [3]:

- **Variation from the Schedule (EV-PB)**: This difference determines if the project is behind or ahead of schedule. If the difference is > 0, it would be ahead; if it is < 0, this would mean some delays have happened.

- **Variation from the Budget (EV-AC):** This difference is whether the project has had any cost overruns. In Figure 9, the difference is < 0, which means there has been some over-expenditure until that moment.

5. SUMMARY OF ACTION ITEMS

This section is a recap of the main themes discussed in the previous sections:

COST ASSESSMENT
Constantly evolving practice in cost estimation. There is a general trend towards showing greater levels of detail in estimates and a more explicit representation of uncertainties.
Cost assessment is information, not just a number. The quality of the information and how it is presented are critical to understanding.
ISDC helps to: • Reliably calculate decommissioning costs • Have a consistent and comprehensive approach to the treatment of uncertainties • Demonstrate the validity of estimates & manage costs
FUNDING
There is a need for specific funding mechanisms for back-end liabilities –the scale of the penalties, the timing of when revenue is generated and when the liabilities arise.
Designing a funding mechanism – what to cover, how it will operate, fund management, risk, and how the system can be adjusted if necessary.
Various funding arrangements exist – countries have developed arrangements suitable for their specific situations and systems of law and finance.
COST CONTROLS
They are part of project cost management.
They are concerned with measuring variances from the cost baseline and, where necessary, taking timely, effective corrective action.
Require detailed, accurate information on project plans, work done and schedule; quality monitoring of performance; and timely reporting.
Earned value management is an approach to assessing and conveying information about project progress and enabling forecasts of projected cost outcomes.

6. CONCLUSIONS

This report provides the ideal financial funding structure for nuclear facilities, which generate revenue only during their operational lifespan. Additionally, it covers key elements of cost monitoring and proposes using Earned Value Management to evaluate the project's progress at any given time. The information in this report will be precious to companies who need to build capacity in this area.

The goal is to ensure that the approved budget is not exceeded and that funding is never lacking throughout the project. To achieve this, the project's leader and team must consider all potential circumstances that could affect the project's progress. The first step is to accurately assess the costs associated with each activity involved in the project, using internationally accepted cost estimation and uncertainty-addressing methodologies to mitigate risks.

7. REFERENCES

[1] IAEA, 'International Structure for Decommissioning Costing (ISDC) of Nuclear Installations', 2019. [Online]. Available: https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/isdc-nuclear-installations.pdf

[2] 'Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities'. OECD. [Online]. Available: https://read.oecd-ilibrary.org/nuclear-energy/addressing-uncertainties-in-cost-estimates-for-decommissioning-nuclear-facilities_9789264284289-en#page32

[3] *PMBOK Guide*.