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R2D2 Project
Basics of Decommissioning of Research
Reactors

Cost Estimate & Financial
Mechanisms

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Objectives

- Appreciate the approaches for making adequate provision of funds for decommissioning and the control of their usage
- Understand the importance of appropriate cost estimates and their uses
- Be aware of the cost estimating approaches for decommissioning including types of cost estimates
- Identify and understand the key components of a cost estimate
- Identify factors that have a major influence on the overall cost of decommissioning
- Appreciate the importance and available techniques for project financial reporting

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Funding of Decommissioning

- **The liability to be incurred from the shutdown and decommissioning of a nuclear facility needs to be identified as early as possible in plant life- and regularly updated**
- **Provisions need to ensure the availability of funds for decommissioning and to demonstrate to regulators and others that decommissioning is understood and there will be the financial means to achieve it**
- **The provisions need to be prudent to allow for uncertainties**
- **Cost estimates will be necessary to quantify the necessary provisions**



Funding Mechanisms

- **Various approaches have been utilised to ensure that funds are available when needed**
- **The chosen mechanism must be acceptable to the regulatory body**
- **There are many examples of funds being used for purposes other than decommissioning so a major issue is who should control the fund (the owner or a third party)**
- **In all cases the adequacy of the fund is dependent on the quality of the cost estimation it is based upon**



Types of Funding Mechanisms

- **1- Prepayment**
 - **Deposit made prior to start of operations**
 - **Held using various financial tools: trust funds, escrow accounts, certificates of deposit, government funds**
- **2- Surety, Insurance or Parent Company Guarantees**
 - **A guarantee that funds will be available from another party if licensee defaults**
 - **Using payment surety bonds, letters of credit, lines of credit, insurance**

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Types of Funding Mechanisms

- **3- External Sinking Fund**
 - **Two components- sinking account fund and insurance or surety mechanism**
 - **Payments from income made to sinking fund**
 - **As sinking fund increases over time, surety mechanism decreases maintaining overall sufficiency of funds**
- **4- Government owned facilities**
 - **Statement of intent from the government but not normally a set aside and separate fund**
 - **Estimate of cost or amount of financial assurance needed**

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Purpose of Cost Estimation

- To specify funding needed to meet all aspects of the decommissioning of the facility, satisfying regulatory requirements
- To allow options to be compared in building and updating the decommissioning plan
- To enable the facility to be an informed customer in tender specification and assessment when using contractors
- Its production requires an integrated decommissioning plan covering facility description, hazards, work activities, waste management, project schedule, human resource plans, etc



Effects of Weak Cost Estimation

- Poor cost estimates (or lack of any estimate) can result in:
 - Under-funding of the decommissioning of the nuclear facility
 - Non-compliance with regulatory requirements or expectations
 - Inappropriate strategies selected for implementation
 - Loss of confidence in the operator by the fund provider
 - Poor stakeholder perception of the operating organization or government authority
- **Black box / general cost estimates do not work !!!**



Cost Estimates- Constraints

The cost estimation will be undertaken within overall constraints on the decommissioning project such as:

- Rules and arrangements for ensuring health and safety
- Requirements to protect the environment
- Regulatory framework within which the decommissioning must be performed
- Policy on human resources and the use of contractors
- Criteria for clearance of materials
- Availability and limitations of waste storage or disposal facilities for radioactive or other materials



Uncertainty in Cost Estimates

- Different levels of uncertainty are accepted when performing a decommissioning cost estimate dependent on the use to which it is to be put
- Cost estimates may be quoted as a probabilistic confidence based on an analysis of project risks or for smaller projects often as a percentage range about a base cost
- Three typical levels of uncertainty quoted in cost estimates are:



Uncertainty in Cost Estimates

1. Order of magnitude range of base cost -30% to +50%

- Useful for option studies and prudently for early liability definition
- Based on similar project scope elsewhere

2. Budgetary range of base cost -15% to +30%

- Also used some local drawings but not entirely site specific
- Useful for refining funding provisions
- May assist in preparing to tender for better view

3. Definitive range of base cost -5% to +15%

- Site specific and very detailed; based on drawings and a detailed review of required activities and their costs
- For ensuring decommissioning project can be funded



Constructing Cost Estimates

The nature of work required in decommissioning generally allows costs to be calculated using five main types:

1. Activity dependent costs
2. Labour costs
3. Equipment costs
4. Waste transportation & disposal costs
5. Undistributed costs



1. Activity Dependent Costs

- “Activity dependent costs” reflect the cost of performing specific tasks
- Methods used to calculate these costs are
 - Unit Cost Factor Approach (preferred where the same task is repeated many times) and
 - Activity Specific Approach



1. Activity Dependent Costs

1.1 Unit Cost Factor Approach

- Applicable to large volumes of similar material or equipment e.g. large amounts of piping
- Unit cost factors incorporate local labour rates, equipment and material costs
- Productivity loss factors can be included to recognise the inefficiencies due to working circumstances
- Example of output
 - removal cost/linear metre of pipe
 - man-hours/component
 - burial volume/cubic metre of concrete



1.1.1 Unit Cost Factor Approach Productivity Loss Factor (PLF)

Allowing for the lengthening of the duration of activities due to working conditions/requirements

a	b	c	d	e
Work at height	Protective Clothing	Rad Area	Respiratory Protection	Breaks
0.15	0.23	0.15	0.38	0.10

Productivity Loss Compounding Formula: $(1+a+b+c) \times (1+d) \times (1+e)$

Combination of Applicable Factors						Compounded
	Height	Protective Clothing	Rad Area	Respiratory Protection	Breaks	Productivity Loss
Breaks only					0.10	1.10
Height & breaks	0.15				0.10	1.27
Rad, PCs & breaks		0.23	0.15		0.10	1.52
All except respirator	0.15	0.23	0.15		0.10	1.68
All except height		0.23	0.15	0.38	0.10	2.09
All factors	0.15	0.23	0.15	0.38	0.10	2.32

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1.1.2 Unit Cost Factor Example

Removal of piping - 2 to 10 cm diameter, insulated, contaminated
Contaminated pipe with a diameter of 2 to 10 cm will be cut with a reciprocating saw. The pipe will be cut into nominal 2 meter lengths during removal. The pipe will be placed into containers and sent to a shipping area. The insulation (5 cm fiberglass) will be removed and packaged for disposal.

Activity Description	Activity Duration (mins)	PLF	Adjusted Duration	Labor Category 1		Labor Category 2		Total Activity		Base
				Title: Laborer	\$25.00	Title:		Base	# of Man Cost	
Prepare area	10	1.52	15.2	2	0.51	12.67		2	0.51	12.67
Remove insulation	15	2.09	31.4	2	1.05	26.25		2	1.05	26.25
Remove pipe hangers	10	1.52	15.2	1	0.25	6.33		1	0.25	6.33
Cut pipe	5	1.52	7.6	2	0.25	6.33		2	0.25	6.33
Load pipe in container	2	1.52	3.0	1	0.05	1.25		1	0.05	1.27
	Total duration			72.4 min/ 2 meter piece						
	or			1.21 hr/piece				Craft Labor	2.11	52.85
	or			0.60 hr/meter				Supervisor ratio 5:1 rate \$45.00/hr	0.42	18.90
	Total Man-hours			2.53 man-hours/piece				Subtotal labor	2.53	71.75
	or			1.27 man-hours/meter				Overhead & profit @ 0%	0	0
								Total Labor Cost	2.53	71.75
								Equipment Costs:		
								Consumables/Materials (Herculite)	4 sq m @ \$2.00/sq m	8.00
								Saw Blades	.1 @ \$1.00/blade	0.10
								Absorbent material	2 sq m @\$5.00/sq m	10.00
								Bag for insulation	1 @ \$0.25 each	0.25
								Subtotal	18.35	18.35
								Overhead & Profit on equipment @ 10%	1.84	1.84
								Total equipment cost	20.19	20.19
								Total Task Cost to Remove Pipe	\$91.94 /piece	
								or	\$45.97 /meter	

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1. Activity Dependent Costs

1.2 Activity Specific Approach

Example of an activity specific calculation for a non-repeating task:

Mobilization

	Rate/ Hour	Number	Hours/ Day	Days	Sub Total	50% Overhead	15% Profit	Total
Laborer	25.00	3	8	10	6000	3000		9000
Supervisor	45.00	1	8	10	3600	1800		5400
Total								14,400

Equipment/Direct Costs

Transportation of equipment					5000	2500		7500
Misc. Supplies					2000	1000		3000
Temporary office & lab trailer (setup and initial month rental)					10000	5000		15000
Total								25,500

Grand total

39,900



2. Labour Costs

- Rates used for work must be directly applicable to the site location and project
- Components of directly employed local labour rates must include the base rate and other employment costs such as:
 - Fringe benefits (holiday, sick time)
 - Unemployment insurance/social security payments
 - National & local taxes on employers
- The labour rates of contractors are likely to include these but they may also charge overhead and profit
- Labour rates need to be specific to each role



3. Equipment Costs

- Rental rates- where capital purchase is not warranted
- Purchase cost- e.g. where equipment will become contaminated
- Operating costs (utilities & consumables)
- Maintenance costs
- Replacement costs



4. Waste Management Costs

Costs due to the following activities but beware of double counting of on-facility costs:

- Waste recovery
- Decontamination
- Processing and volume reduction
- Containers and packaging
- Interim storage
- Transportation
- Disposal charges

May be offset by income from recycling



5. Undistributed Costs

Costs that are spread over the entire project and not linked to a specific activity, e.g.

- Period dependent costs (costs per unit time)
- Permits & licenses
- Environmental surveys
- Other direct costs
- Exchange rate variations

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5. Undistributed Costs

5.1 Period Dependent Costs

- Costs that apply for a defined period of time in the project or change to a different level at a given point
- Typical examples:
 - Management staff
 - Energy costs
 - Insurance premiums
 - Property taxes
 - Health Physics supplies

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5. Undistributed Costs

5.2 Permits and Licenses

Regulatory and related charges, e.g.:

- **Decommissioning license or authorization**
- **Environmental discharge and waste disposal permits**
- **License termination fees**
- **Your Site ?????**



5. Undistributed Costs

5.3 Environmental Surveys

- **Often performed by an independent organization**
 - **Baseline**
 - **Updating**
 - **Final**
- **Potential types of costs**
 - **Collection of samples**
 - **Laboratory analysis**
 - **Quality Assurance checks**



5. Undistributed Costs

5.4 Other Direct Costs

- **Costs that cannot be attributed to a particular activity or task**
- **Examples**
 - **Special equipment used for entire project**
 - **Health Physics monitoring support & equipment**
 - **Off-site training**
 - **Dosimetry or environmental monitoring services**
 - **Public relations**



Elements of a Cost Estimate

Factors Affecting Cost

- **End product requirements**
- **Site specific information**
- **Assumptions**
- **Regulatory constraints**
- **Site survey/radiological profile**



Factors Affecting Cost End Product Requirements

- What type of information should the cost estimate provide when completed
- Examples
 - Work/cost breakdown structure used
 - Total project costs
 - Disposal costs
 - Labour costs
 - Waste disposal volumes and costs
 - Labour costs and man-hours required
 - Contaminated equipment removal costs
 - Clean component removal cost

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Factors Affecting Cost Site Specific Information

- Information critical for the development and support of the cost estimate
- Types of information (**Do you have these???**)
 - Property asset records
 - Site drawings
 - Site tour and description
 - Discussions with site personnel
 - Local labour and equipment costs
 - Site radiological profile or conditions

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Factors Affecting Cost Assumptions

- Information used when developing the cost estimate
- Typical list of assumptions
 - Work hours per day or week
 - Craft labour rates for local area
 - Location of waste disposal sites
 - Disposal facility fee structure
 - Spent fuel disposition & shipping schedule
 - End-of-life activation/contamination estimates
 - End-of-life hazardous material & asbestos status
 - Final facility shutdown date
 - Volume reduction/decontamination strategy



Factors Affecting Cost Regulatory Constraints

- Removal from control & reuse limits
- Spent fuel & waste management policies
- Health & safety considerations
- Radiation protection and optimization constraints



Factors Affecting Cost Site Survey/Radiological Profile

- Good radiological data is needed for the cost estimate
- Data will be used to determine:
 - Extent of contamination
 - Identification of contaminated systems & components
 - Worker protection requirements
 - Waste packaging, transportation & disposal requirements
- **The better the data, the better the estimate**



Calculating Cost Estimates

- Define all activities & their sequence
- Identify dismantling and other tasks from material takeoff sheets
- Develop activity costs
- Develop the decommissioning schedule
- Determine period dependent costs
- If Deferred Dismantling is planned – do not forget facility and site maintenance costs in the estimate
- Apply contingency (and profit) to total
- Allow for escalation (inflation) and discounting as per financial policies



Cost Estimate Calculations Determine Activities and Sequence

- **Typical activity sequence for contaminated facility**
 - **Mobilization of workforce at location**
 - **Training**
 - **Removal of contaminated equipment**
 - **Decontamination of structures and removal of wastes**
 - **Final surveys**
 - **Removal of cleaned structures (if required)**

NB Areas outside the radiological controlled area will be a subset of these steps



Cost Estimate Calculations Material Takeoff Sheets

- **Very important for unit cost factor approach**
- **Using records and visits develop an inventory of equipment and material prepared on a room by room basis or by system and containing:**
 - **List of equipment that will need to be decontaminated or removed**
 - **Material of construction**
 - **Volumes or amounts of material by type**



Cost Estimate Calculations Develop Activity Costs

- **Large volume items**
 - **By system or component**
 - **Use unit cost factor approach**
 - **Example - 2500 metres of 2 to 10 cm diameter, contaminated, insulated steel pipe**
 - **Summarize cost by system or component**
- **Special/unique items**
 - **Define dedicated crew for selected tasks, i.e. remote cutting of the reactor vessel**
 - **Break tasks into step-by-step actions**
 - **Calculate costs for each step**



Cost Estimate Calculations Develop Decommissioning Schedule

- **Use critical path method of scheduling**
- **Use shortest possible schedule**
- **Check man-loading**
- **Perform non-critical tasks at most appropriate times**
- **Perform tasks in parallel**



Cost Estimate Calculations Determine Period Dependent Costs

- **Costs that are not activity dependent but accrue over time**
- **Examples may be**
 - **Management costs**
 - **Welfare costs**
 - **Energy costs**
 - **Insurance**
 - **Health Physics supplies**



Cost Estimate Calculations Contingency

- **Contingency**
 - **An amount added to the estimate to allow for unknown and unforeseen events that experience has shown may occur. Based on risk of unknown event occurring. Can be either added to each task or placed on total**
- **Provides greater assurance that sufficient funding will be available to perform the task**
- **Not a safety factor for poor planning**



Reporting a Cost Estimate

A report of a cost estimation process should include the following:

- Factors identified as affecting cost
- Cost estimate calculations
- A summation of detailed costs across areas and the projects as a whole
- All the information used: waste volumes, disposal costs, man-hours, etc
- Any assumptions made and their justification



Project Financial Control

- A process will be needed to control access to decommissioning provisions to ensure they are used effectively and for the intended purposes
- During project design and execution, cost estimates will need to be developed in more detail to allow effective implementation
- Assumptions, exclusions, risks and contingencies need to be clearly stated alongside any cost estimate
- It may be appropriate to release funds progressively as confidence grows in the project to successfully deliver the plan
- Processes for ongoing monitoring and control of expenditure are needed to manage the project and maintain stakeholder confidence



Funding Release and Control (1) Pre-implementation

- For some plants the first use of funds may be to complete work outstanding from earlier periods
- In some cases available cost estimates may still have significant remaining uncertainty and may need to be further developed before implementation
- Following approval of strategic approaches further funds will be needed in the preparatory phase to
 - build thorough knowledge of plant, hazards etc
 - quantify and reduce project risks
 - determine more detailed costs and
 - confirm appropriateness of decommissioning plan



Funding Release and Control (2) Project Implementation

- Agreement is sought for funds for full implementation of the project based on the more detailed and higher confidence project design, schedule and cost
- Some contingency funds may be held back
- Project implementation will be subject to defined monitoring, control and reporting processes on e.g. safety, schedule, cost and risks
- Once the liability is extinguished and contracts closed any unused funds can be returned

But it's all dependent on cost estimation....



Project Monitoring and Reporting

WHY?

- To know where you are in delivering the project
- To identify and act on problems at an early stage
- To be able to forecast time, budget and interface requirements to maintain project progress
- To demonstrate stewardship to the fund provider
- To maintain regulator and stakeholder confidence in progress

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Project Monitoring and Reporting

HOW?

- Data gathered at a detailed level and summed up the WBS
- Covering all key indicators- safety, cost etc
- Schedule
 - critical path updating
 - milestones (dates of key events)
 - bulk monitors of progress achieved (e.g. tons of concrete removed)
- Costs
 - Cost of task versus budget
 - Budget utilisation versus plan

These may not always indicate real achievement- therefore increasing use of Earned Value analysis

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Earned Value

Schedule Performance Index (SPI)

$$\text{SPI} = \text{BCWP}/\text{BCWS}$$

BCWP: Budgeted cost of work performed

BCWS: Budgeted cost of work scheduled

SPI >1 ahead of schedule

SPI=1 on schedule

SPI<1 behind schedule

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Earned Value

Cost Performance Index (CPI)

$$\text{CPI} = \text{BCWP}/\text{ACWP}$$

BCWP: Budgeted cost of work performed

ACWP: Actual cost of work performed

CPI >1 costs under budget (savings or a soft budget?)

CPI=1 costs on plan

CPI<1 costs exceeding budget

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Earned Value

Advantages

- Allows project manager to understand value for money and thereby implications for schedule and cost to completion
- Powerful evidence for stakeholders

Disadvantages

- Unless scaled to match the size and complexity of the project, it may be either too lightweight or too costly
- No provision to measure project quality, so it is possible for a project to appear under budget, ahead of schedule and scope fully executed, but still have unsuccessful results



Summary

- Adequate funding and financial control are key steps in a successful decommissioning project- both rely on cost estimation
- Well developed cost estimating methodologies are available
- The better the data, the better the cost estimate
- Monitoring and reporting are essential to timely identification (and resolution) of project problems and to maintain stakeholder support
- Techniques are available but need to be used with care



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