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Decommissioning policies, strategies and costs: an international overview

As many nuclear power plants will reach the end of their lifetime during the next 20 years or so, decommissioning is becoming an increasingly important topic for governments, regulators and industries. Decommissioning policies and strategies vary widely at the international level, and choices in strategy may also differ. In addition, project-specific characteristics largely influence decommissioning costs. Despite this, major cost drivers can be identified.

Governments are particularly interested in ensuring that money for the decommissioning of nuclear installations will be available at the time it is needed, and that no "stranded" liabilities will be left to be financed by the taxpayers rather than by the electricity consumers. For this reason, they have sought to understand the components of decommissioning costs and to periodically review cost estimates from nuclear installation owners. Robust cost estimates are key elements in designing and implementing a coherent and comprehensive national decommissioning policy, including the legal and regulatory bases for the collection, saving and use of decommissioning liability funds.

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Industry also has an interest in perfecting its knowledge of decommissioning costs so that it may develop a coherent decommissioning strategy that reflects national policy and assures worker and public safety, while also being cost effective.

The NEA study on decommissioning

A study[1] on decommissioning policies, strategies and costs was carried out by the NEA in 2001-02, with the objectives of compiling relevant data and analysing them in order to understand how national policies and industrial strategies affect decommissioning costs, and eventually identifying decommissioning cost drivers. The scope of the study was limited to commercial nuclear power plants, excluding prototypes, demonstration plants and plants where significant incidents or accidents would have occurred. This approach was adopted in order to obtain data representative of decommissioning activities undertaken by the nuclear power industry.

Table 1. Decommissioning policy overview

Included in national policy	Share of positive answers
Definition of decommissioning	50%
Defined decommissioning end-point	50%
Mandatory timescale for decommissioning completion	25%
Decommissioning license requirement	80%
Defined radioactive waste exemption levels	60%

Twenty-six countries provided data and information through the study's questionnaire. The questions on policy and strategy targeted issues of relevance for cost estimates. The proposed detailed cost structure[2] – namely cost elements (e.g. dismantling activities or site cleanup and landscaping) and cost groups (e.g. labour or capital) – was intended to support an in-depth analysis of cost drivers. However, most respondents reported results from existing studies and estimates based on national and/or company accounting frameworks and practices, which were not fully consistent with the scope and structure recommended in the questionnaire. These limitations were taken into account in the analyses presented in the report.

The data collected include decommissioning cost estimates for a large number of nuclear power plants, representing approximately one-third of the nuclear capacity in operation worldwide. It offers a robust base for statistical analysis and overall assessment. Decommissioning cost estimates were provided for a broad range of reactor types and sizes, reflecting the variety of nuclear power plants built and operated in the participating countries. All reactor types that have been commercially deployed (PWR, VVER, BWR, PHWR/CANDU and GCR) are covered by the study. The size of the reactors considered range from less than 10 MWe to more than 1 000 MWe.

Decommissioning policies and strategies

Decommissioning policy is defined as the framework implemented by governments, including laws, regulations, standards and mandatory requirements, that imposes the background rules to be followed by the nuclear industry for decommissioning projects. National decommissioning policies were found to differ on many aspects that may have an impact on costs. Key points in this regard are summarised in Table 1, which indicates the percentage of positive answers for each topic listed.

Decommissioning strategy, as defined within the study, relates to how the owners and operators of nuclear power plants apply national policy to their specific decommissioning project. Wide variations can be noted in the strategies adopted by industries in different countries and even by different operators in the same country. Operators/owners consider a broad range of issues in choosing a decommissioning strategy, covering technical feasibility, economic efficiency, regulatory constraints and socio-political aspects.

Regarding the decision-making process, national context and local situations are often driving factors for choosing between alternative approaches. For example, the status and trends in nuclear power development in the country, the local social conditions (e.g. unemployment, development of tourism) and the expected re-use of the site are primary factors considered in determining industrial strategies for decommissioning.

In terms of schedule, the majority consider both immediate and deferred dismantling when choosing a strategy; in some countries, however, the regulatory framework allows only one option. Each of the two options, immediate and deferred dismantling, was assumed for costing purposes by roughly half of the study respondents. It is interesting to note that, in practice, immediate and deferred dismantling are not always drastically different in terms of the overall schedule of decommissioning activities. For example, some immediate dismantling strategies lead to ending decommissioning activities 40 years after shutdown, while some deferred strategies with 30 years of dormancy will lead to a similar end of activities 40 years after shutdown. This largely explains the lack of impact of immediate versus deferred dismantling on decommissioning costs.

Decommissioning costs

Decommissioning cost estimates (see Table 2) remain below 500 US$/kWe for nearly all water reactors considered in the survey. For gas-cooled reactors (GCR), the reported cost estimates are significantly higher (around 2500 US$/kWe), but it should be noted that only four cost data sets were reported for this reactor type and they refer to old reactor designs not at all comparable with the high-temperature, gas-cooled reactors (HTGR) under development today.

Dismantling and waste management/disposal generally represent a large share (one-fourth to one-third) of total decommissioning costs; each one of these two elements may reach up to 60% of total costs in some cases. Three other cost elements usually represent around 10% each of the total cost: security survey and maintenance; site cleanup and landscaping; and project management, engineering and site support. The other elements seldom exceed 5% of total decommissioning costs.

Regarding waste management and disposal, the weight of radioactive waste arising from decommissioning activities is around 10 tonnes per MWe for any reactor type, except for the gas-cooled reactors for which it is ten times higher, around 100 tonnes per MWe. This is one of the reasons why decommissioning costs do not seem to vary significantly according to the type of water reactor considered.

Decommissioning is a labour-intensive activity and labour costs may be a significant component of total decommissioning costs. However, on the basis of cost data sets provided for the study, there is no evidence of correlation between average national manpower costs and total decommissioning costs. This might be the result of industry strategy adaptation, shifting from manual intervention to automated equipment when and where high labour costs make it economically efficient.

Table 2. Summary of decommissioning cost estimates

Reactor type *(no. of data sets)*	**Average cost** *(US$/kWe)*	**Standard deviation** *(US$/kWe)*
PWR (21)	320	195
VVER (8)	330	110
CANDU (7)	360	70
BWR (9)	420	100
GCR (4)	>2500	-

Decommissioning cost drivers

The study's findings on cost drivers are only tentative owing to the variability in coverage and comprehensiveness of responses. However, they generally confirm earlier national and international analyses and publications. In particular, they highlight the importance of project-specific characteristics and issues in the understanding of decommissioning cost elements.

The main factors identified as having minor impacts on decommissioning costs are: type and size of the reactor (GCRs excepted); immediate or deferred dismantling option; and unit labour costs. The major cost drivers concern: scope of decommissioning activities; regulatory standards including waste classification and clearance levels; site conditions and re-use; and radioactive waste disposal.

The scope of decommissioning activities taken into account in cost estimates, including the


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Dismantling operations at a nuclear power plant in the United Kingdom.

assumed starting and end-point, obviously has a major influence on total cost. This scope is largely delineated by national policy. Analysing in detail the relationship between policy changes and costs could provide valuable information to policy makers. Such an analysis would, however, require more detailed information on national decommissioning policy and cost estimates than was available for the study.

Regulatory standards in force – including clearance levels, allowable radiation doses to workers and the public, environmental norms and standards – define the framework and boundaries of decommissioning activities and have a major impact on the cost of decommissioning. For example, maximum acceptable dose to workers has a direct impact on manpower requirements and the cost of labour. Environmental regulations and mandatory decommissioning end-points have an impact on the scope and schedule of decommissioning activities, which in turn are key cost drivers.

Site-specific conditions of a decommissioning project that have an impact on cost include the number, type and status of units located on the same site and the intended re-use of the site (for example, nuclear facilities or a recreation park). The scope and end-point of decommissioning activities vary widely depending on such site-specific issues as the continued operation of nuclear facilities during and after the unit under consideration is decommissioned.

The quantities and specific characteristics of radioactive waste arising from decommissioning are a major cost driver. An in-depth study in this field would be needed to identify and analyse separately the impacts of regulations (clearance levels), technical progress (plant design and operation, waste treatment) and socio-political context (cost and implementation of waste disposal facilities).

Providing for future decommissioning costs

The information provided for the study shows that in all countries, decommissioning costs are robustly estimated and thoroughly analysed by operators, regulators and governments. Cost estimates based upon engineering models and feedback from experience are carried out, regularly updated and often audited by independent bodies. These estimates are used in particular to assess the amount of decommissioning funds necessary. Various measures and schemes are in place in each country to ensure that the decommissioning funds are accumulated in a timely fashion to be available when expenses will occur.

References

1. NEA (2003), *Decommissioning Nuclear Power Plants: Policies, Strategies and Costs*, OECD, Paris.
2. EC, IAEA, NEA (1999), *Nuclear Decommissioning, A Proposed Standardised List of Items for Costing Purposes*, OECD, Paris.