IAEA-TECDOC-1476

Financial aspects of decommissioning

Report by an expert group

IAEA
International Atomic Energy Agency

November 2005

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FOREWORD

Estimating decommissioning costs and collecting funds for eventual decommissioning of facilities that have used radioactive material is a prerequisite for safe, timely and cost-effective decommissioning. A comprehensive overview of decommissioning costs and funding mechanisms was missing in the IAEA literature although the subject had been marginally dealt with in a few IAEA publications. Costing and funding issues were partially addressed by other international organizations, but there is a need to address the subject from the standpoint of the diverse social, economic and cultural environments that constitute IAEA membership.

In its role of an international expert committee assisting the IAEA, the Technical Group on Decommissioning (TEGDE) debates and draws conclusions on topics omitted from general guidance. TEGDE members met in Vienna in 2003, 2004 and 2005 to develop the basis for this publication. The views expressed here reflect those of TEGDE and not necessarily those of the IAEA. The IAEA wishes to thank all TEGDE members for their valuable contributions to the work on this publication. The IAEA officers responsible for the preparation of this publication were M. Laraia of the Division of Nuclear Fuel Cycle and Waste Technology and D. Reisenweaver of the Division of Radiation, Transport and Waste Safety.

EDITORIAL NOTE

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1. INTRODUCTION

Believing that countries with limited resources and decommissioning experience could benefit from information for decommissioning their facilities that have used radioactive material, the IAEA assembled a Technical Group on Decommissioning (TEGDE), which identified the strategies and the financial aspects of decommissioning as issues needing further guidance. The Decommissioning Strategy Group and the Financial Issues Group met in Vienna in May 2003 and May 2004 to organize and outline the scope and content of documents for these two issues. This document presents the results of the TEGDE Financial Issues Group. A separate document addresses the strategy issues of decommissioning.

1.1. Background and history

For many years, decommissioning of facilities that have used radioactive material was virtually ignored while the nuclear industry was rapidly growing. Starting in the late 1970s, regulatory awareness increased with respect to the environmental impact of decommissioning of these early reactors and fuel cycle facilities. More importantly, the cost of decommissioning was no longer viewed as a simple dismantling activity similar to conventional retired fossil power plants and other industrial facilities, where the value of the scrap recovery often was sufficient to pay for dismantling the facility. As labour costs rose and radioactive waste disposal costs soared, decommissioning costs became a major consideration in the overall life cycle costs of this industry. In the mid 1980s, the nuclear power industry in some countries experienced severe construction cost overruns, driving several utility power companies to have severe financial problems. Regulators realized that should operating nuclear power utilities suffer the same financial stress, the safe shutdown and decommissioning of facilities that have used radioactive material could become a financial burden on the owners, ratepayers, and government agencies. Estimates of the cost to decommission these large nuclear power plants quickly escalated in some Member States, driven by the rapidly increasing costs of radioactive waste disposal, and the limited number of facilities licensed to receive this waste. Even in countries enjoying more favourable waste management infrastructure, more accurate estimates of decommissioning costs were required by the growing maturity of the nuclear industry.

In response to these rising costs, regulators adopted the premise that those who had received the benefit of the electric power generated from the facility should pay for the decommissioning of the facility. While operation of a facility may bridge more than one (populous) generation, all those who benefited should be held responsible for payment of decommissioning. This accepted approach eliminates the often contentious issue of intergenerational inequity, wherein future generations are saddled with the liability of paying for decommissioning of a facility that ceased operation years earlier. Non-power reactor facilities (research, training, and materials testing reactors) soon adopted the same philosophy for funding decommissioning, and regulators established guidelines for minimum funding amounts to be set aside for these facilities.

The early power reactors were built in the late 1950s, many under joint funding of the governments and electric utility companies. Many of these reactors operated for only a few years in a demonstration mode to test various nuclear power technologies. The reactors that proved to be unreliable, unsafe, or too costly to operate were shut down, and the government bore most of the costs to decommission these facilities. The cost for decommissioning was minimal, as labour and waste disposal costs were low, and decommissioning regulations were virtually non-existent or developing.

The newer generation of power reactors was much larger and more complex. Regulators imposed safety system requirements based on redundancy (duplicate equipment), diversity (multiple power sources), and separation (systems located in protected cubicles at opposite sides of the building), to ensure no common mode failure would cause an accident. The additional equipment required to satisfy these safety criteria greatly magnified the plant complexity, and increased the difficulty and costs for decommissioning.

Early attempts to estimate decommissioning costs were based on simple ratios of the costs to decommission the smaller demonstration reactors, with inflation factors to account for labour and waste disposal cost increases. However, it soon became apparent that this simple approach would not adequately account for the complexity of the newer, larger reactors, nor would it account for the growing regulatory requirements for protecting public health and safety during decommissioning. A more definitive cost estimating approach had to be developed. Starting in the late 1970s and early 1980s, research was sponsored and funded to develop a reliable cost estimating methodology to apply to decommissioning these larger nuclear power plants (NPPs). In particular, in the United States of America, the Atomic Industrial Forum (AIF — now the Nuclear Energy Institute) funded a study to prepare guidelines for estimating NPP decommissioning costs [1]. As this cost estimating methodology evolved, the cost models became more sophisticated and too complex to perform by hand calculations. During this same period, the advent of the personal computer, with its speed and ability to handle many tasks, was quickly adapted to deal with this problem. The focus of cost estimating development returned to the issue of capturing all of the costs associated with decommissioning with a rational, reliable methodology. In Europe, the German company, NIS Ingenieurgesellschaft mbH developed the STILLKO decommissioning cost model [2], which was based on the experience, gained during the decommissioning of the Niederaichbach NPP (a gas-cooled heavy water-moderated reactor). In the United States of America, TLG Services developed the DECCER decommissioning cost model [3] based on the AIF study guidelines, which has been continuously updated as new information became available.

Some countries required each power utility to prepare and submit decommissioning cost estimates for regulatory review. These cost estimates were presented to the public, which allowed stakeholders to examine the estimates and scrutinize the estimators on the methodology used, and the reliability of the resulting costs. In some cases these meetings were held in a contentious atmosphere that served to compel estimators to improve the accuracy of the methodology, and to strive for completeness in the activities and processes necessary to safely decommission power reactors. The same methodology was soon applied to other non-power reactors and fuel cycle facilities, both privately and government owned.

1.2. Legal requirements

There is an identified need for legal requirements to assure funding adequacy. Such legal requirements are necessary to protect against misuse of funds, claims on funds during potential financial crisis, and mechanisms to assure funds are structured and managed to keep pace with inflation and escalation (note: the term "funds" as used in this document includes all forms of financial resources and it is not restricted to externally segregated funds). It is not possible to establish a specific methodology for assuring funding adequacy for all countries, as the NPP ownership, operation, and financial obligations differ too radically. However, the descriptions of the processes and methodology herein can assist in forming a policy and methodology that can serve the same purpose — to assure the safe decommissioning of retired facilities.

This publication serves to capture the lessons learned from this valuable experience, and to provide countries that have limited resources and/or experience in decommissioning with the basis to establish similar programs for their facilities.

2. BASIC PRINCIPLES, OBJECTIVE AND SCOPE OF THE REPORT

2.1. Basic principles

There are a number of basic principles upon which the recommendations in this report are based. The safe performance of decommissioning activities is dependent on adequate funds to complete the work without risk to public and worker health and safety, and the environment.

Those who have generated waste are responsible for its management and disposal. In order to meet this principle the funding for decommissioning must be sufficient, available, transparently managed, and used only for the purpose for which the funding was established. In line with this principle, the costs of constructing and operating disposal or management facilities for wastes including spent fuel must be addressed either separately from decommissioning itself or, in some cases (particularly where disposal facilities do not yet exist), as part of the overall decommissioning costs.

2.2. Objective

The objective of this report is to provide information on methods and strategy to assure funding adequacy, which includes sufficiency, availability, transparency, and assurance that the funds are used for the intended purpose. That is, the document will provide countries that have limited resources direction as to how to secure the necessary and sufficient amount of funds to pay for implementing a safe and environmentally acceptable decommissioning process for each type of facility. The assurance has to withstand the scrutiny of the owner/licensee, the regulators, and the public (stakeholders). The importance of this assurance cannot be understated, as it is unwise and unsafe to start decommissioning without sufficient funds to complete the process.

2.3. Scope

This report identifies what costs are included during the decommissioning of a facility that has used radioactive material. There has been much discussion and confusion as to applicable costs, depending on who has to pay and who has the responsibility for decommissioning and restoring a site. In every case the costs are site-specific, and generalizations or approximations from other facilities are usually inappropriate to use as a basis to establish a funding base. The owner/licensee, the regulator, and the public need to agree upon the detailed site-specific estimates of cost. A comprehensive standardized list of costs was developed under the direction of the Commission of the European Communities (EC), Organization of Economic Cooperation and Development – Nuclear Energy Agency (OECD/NEA), and the International Atomic Energy Agency (IAEA) [4], to address all the activities necessary to decommission most facility types. The estimator needs to review this list for applicability for the specific facility under consideration. As ownership changes or regulatory conditions change, the scope of an estimate will change with it to properly and adequately account for all costs. This can often be an iterative process, requiring periodic updates as conditions change.

The scope of this publication is to capture the key elements of the financial aspects of decommissioning, and to describe the drivers that need to be addressed to formulate a government policy to ensure adequate funds are established to pay for the future decommissioning of facilities. To that end, this report will identify and discuss the elements of decommissioning costs, the collection and management of funds, potential methods for reducing costs, the decommissioning strategy and timing of fund expenditures, the social needs related to decommissioning, and selected examples of how such cost estimates were developed.

2.4. Structure of the report

2.4.1. Identification of decommissioning costs

Over the past twenty-five years or so, there has been a growing interest in identifying a comprehensive list of decommissioning costs that need to be considered in preparing a cost estimate for funding purposes, and that may serve to track actual costs during implementation of a decommissioning project. Rather than attempt to create another list for this report, the IAEA – TEDGE Financial Issues Group decided to adopt an existing list prepared by experts in the decommissioning field under the guidance of the EC, OECD/NEA, and IAEA [4]. A decommissioning cost estimator can refer to this list to establish a Work Breakdown Structure (WBS) and a chart of accounts to develop a cost estimate. This is done in Section 3.

2.4.2. Collection and management of funds

Section 4 describes methods for the collection and management of decommissioning funds to assure the decommissioning project may be accomplished safely and cost effectively. Decommissioning addresses a broad category of facilities including power reactors, research reactors, fuel cycle facilities (mining, milling, fuel fabrication, and storage), research and manufacturing facilities, weapons facilities, and waste treatment and storage facilities. As experience has shown, premature shutdown presents a significant challenge to assure adequate funding is available when needed. Further, the various forms of ownership and licensure of these facilities can affect how the funds are collected and managed. Trust funds, whether internal or external to the owner/licensee are widely used, but for government agencies different forms of assurance need to be established. A legal basis is required for creating these funds, and assurance the funds will not be squandered for other purposes. Various government agencies have established policies to collect and safeguard these funds until they are needed to start decommissioning. The lessons learned from this experience have provided a foundation upon which to suggest methodologies that may be applied to developing nations to ensure adequate funding for decommissioning.

2.4.3 Potential methods for reducing costs

The conscientious management of the expenditure of these funds is as important as collecting sufficient amounts. Whether an owner/licensee elects to perform the decommissioning themselves or to hire a contractor to perform the activities can make a difference in how the funds are expended. The contracts that are written, whether they be fixed-price (lump sum), time and materials, or cost plus incentive fee affect the amount that is at risk to the owner/licensee. The classical project control techniques for monitoring progress, variance analyses, and accountability provide on-going controls that funds are being spent appropriately. Agreements between the owner/licensee and contractors as to the identified scope of work are an important method to assure unnecessary costs and project changes are not incurred. Section 5 identifies these methods of controlling and reducing costs.

2.4.4. Decommissioning strategy and timing of expenditure of funds

Section 6 describes some of the techniques for controlling the authorization for expenditure of funds based on the phase of the project. Funding limitations with a percentage of retained fees (a percentage of fees held back until work is completed) can be tied to the project initiation and planning phase, implementation phase, and site remediation phase. Pre-established milestones can be used to authorize such limited funds, and evidence of milestone completion used for releasing the retained funds. Government agencies may establish independent controls on spending to assure taxpayer monies are spent cost effectively.

2.4.5. Evaluation of the social needs related to decommissioning

Section 7 addresses some of the social issues related to decommissioning that can arise when a facility is shut down and decommissioned. These social issues are becoming more important, and recently government efforts are beginning to reflect this important aspect of decommissioning. In many cases, the local communities developed at the time these facilities were constructed, and the community infrastructure (schools, hospitals, businesses, police, fire brigades, etc.) grew to support the facility. Shutdown of these facilities can have a significant effect on the local economy, and government agencies are beginning to address this important element of cost and funding provision.

2.4.6. Selected examples of funding practices

This publication also describes selected examples of how decommissioning funding was developed and controlled in several countries. These examples provide lessons learned from specific experience, and may assist developing nations in formulating plans for developing funding assurance.

3. IDENTIFICATION OF DECOMMISSIONING COSTS

The methodology for estimating the costs of decommissioning have evolved over the last 25 years, from simple ratios of the costs to decommission earlier smaller facilities, to "bottom-up estimates" where detailed inventories of equipment and structures are analyzed and estimated for decontamination, removal, packaging, transportation, and disposal. The level of sophistication of these estimates has grown to the point where desktop personal computers can track all elements of the estimate. However, the broad spectrum of facilities to be decommissioned, from power and research reactors to small research laboratories, creates a challenge to accommodate all such types of facilities in a single, comprehensive data bank. A novice to this task can be easily overwhelmed at the prospect of developing a complex cost estimate.

The international nuclear decommissioning community recognized this dilemma and combined its resources of technical experts to develop a standardized list of costs to decommission virtually any type of facility. The IAEA-TEDGE Financial Issues Group decided to adopt this existing list prepared by experts in the decommissioning field under the guidance of the EC, OECD/NEA, and IAEA [4]. This section describes this standardized list, and in general, how to apply it for developing a cost estimate. A decommissioning cost estimator can refer to this list to establish a Work Breakdown Structure (WBS), and a chart of accounts to develop a cost estimate. The user needs to adapt this WBS for the specific facility being decommissioned, and for the appropriate phases.

3.1. Types of decommissioning costs identified in the EC/OECD/NEA/IAEA Standard List

During the mid-1990s, three independent groups of experts began compiling elements of decommissioning costs from the various phases of decommissioning projects for virtually any type of facility. One group was the OECD/NEA Task Group; another was the IAEA Consultants Group on Decommissioning and Waste Management Costs; and the third group was the Nuclear Fission Safety Program of the Commission of the European Communities (EC). These three groups met and reviewed their progress, and concluded they were all on the right track to capture these cost elements. In a spirit of true cooperation, these groups agreed to adopt one comprehensive list and offer it to the decommissioning community as a standardized list for cost estimating purposes.

The publication, "A Proposed Standardized List of Items for Costing Purposes in the Decommissioning of Nuclear Installations," may be obtained from the OECD/NEA website at www.nea.fr [4]. The list is presented in a typical Work Breakdown Structure (WBS) format to simplify the presentation of material. The individual elements of cost are identified and defined in the full text of the publication. A summary of the major elements of the WBS in the Standardized List is as follows:

- 01 Pre-decommissioning actions
- 02 Facility shutdown activities
- 03 Procurement of general equipment and material
- 04 Dismantling activities
- 05 Waste processing, storage and disposal
- 06 Site security, surveillance and maintenance
- 07 Site restoration, cleanup and landscaping
- 08 Project management, engineering and site support
- 09 Research and development
- 10 Fuel and nuclear material
- 11 Other costs

3.1.1. Pre-decommissioning

This phase of decommissioning covers all activities related to preparations for actual work at the facility. It includes strategic and conceptual planning studies of the decommissioning strategies, detailed planning including preparation of the decommissioning plan, preliminary characterization data accumulation, and a baseline cost estimate for the work; transitioning workers from operations to decommissioning; and safety and environmental studies.

This phase includes activities normally associated with operation such as spent fuel transfer, processing of operational waste and some decontamination. These same activities may extend into the following post-shutdown phase. It is important for decommissioning planners and cost estimators to address these costs as either an operating or decommissioning expense. In most cases, these costs are considered as a decommissioning expense.

This phase also includes all license applications and approvals from regulatory bodies, revisions to technical specifications to reduce unnecessary requirements and costs after shutdown, adjustment of insurance premiums, reconfiguration of security provisions to facilitate the increased vehicular traffic and workforce, and operation and maintenance procedures.

During this phase, the release criteria are determined and agreed upon by regulatory bodies and all stakeholders. This criteria will affect the decontamination methods and costs for decommissioning, and to some extent determine the permissible end points for the facility buildings and structures. The facility radiological and hazardous material surveys and analyses are conducted, starting with an historical site assessment (HSA) of operational experience. This HSA can provide insight as to where to expect contamination and its levels of concentration and to thereby establish a work scope for its related activities. The disposition of all radioactive and hazardous material may require special planning and arrangements for packaging, transportation, and disposal and need to be taken into account during the preparation of the decommissioning plan.

During the pre-decommissioning stage it is necessary to evaluate availability, readiness, and performance of storage and disposal facilities for radioactive waste of various categories. Any requirements or terms of the waste storage and disposal facilities are taken into account during the development of the decommissioning programmes and plans. An evaluation is made of the sufficiency and availability of financial assets accumulated in the decommissioning fund for the normal financing of planned activities.

The organization that will perform the actual activities is also selected during this phase. This is typically either the owner/licensee (self-performing the work) or a qualified contractor (sometimes referred to as a Decommissioning Operations Contractor). If a contractor will perform the project, specifications are prepared and distributed to potential bidders. Their financial and technical qualifications are evaluated, and a contract is awarded.

3.1.2. Facility shutdown activities

This group of activities include permanent shutdown of the facility; removal of spent fuel and/or nuclear material; de-energizing/deactivating, draining and drying of all nonessential (to decommissioning) systems; decontamination of separate systems determined in the decommissioning plan, and areas for dose reduction; and storage and disposal of legacy, (operational) and decontamination waste. Asset recovery of resalable or transferable equipment can be accomplished at this time.

Spent nuclear fuel and/or nuclear material are transferred to the spent fuel pool or site storage facility, and disposition of unused fuel determined. Similar determinations of nuclear material (startup sources, irradiation sources, etc.) are made at this time.

The site characterization activities are performed (including an historical site assessment) to assess the scope and extent of radiological and hazardous/toxic material in systems, structures and soils. Measurement of these contaminants will include sampling and surveying of areas and systems, and analytical tools and computer programs used to characterize the facility.

Removal and disposition of special fluids is accomplished, including heavy water, sodium, organics, etc. The disposition of these materials may require special planning and arrangements for packaging, transportation, and disposal.

An evaluation is made of the residual condition (safe life) of building construction, equipment, and systems that will be needed during the decommissioning activities to ensure safety. Provisions are included for the continued maintenance and repair of building structures needed for the support of decommissioning activities.

3.1.3. Procurement of general equipment and material

A major decommissioning project will require purchase or rental of heavy equipment such as cranes, forklifts, trucks, etc. The purchase or rental option is evaluated based on the duration of the project and period of time this equipment is required. In addition, if there is a potential for this equipment to become contaminated, it is usually more cost effective to purchase the equipment. Similar determinations are made for decontamination equipment, if needed. Some of this decontamination equipment may have to be tested in the field, and adapted for the specific application. Such testing is performed during this period.

Procurement of health physics and radiation protection equipment such as portal monitors, portable monitoring equipment, and services for personnel dosimetry is arranged during this period. The owner/licensee evaluates whether the existing equipment is sufficient in number and capability to handle the increased workforce potentially encountered during decommissioning.

If the decommissioning strategy for the facility is deferred dismantling additional security equipment and services may have to be procured. This might include the moving of site boundary fences, installing additional closed circuit television cameras with recorders, and arranging for local security guard services to respond quickly to intrusion alarms.

3.1.4. Dismantling activities

Dismantling activities cover all the various tasks included in the work scope for each facility. It includes decontamination of areas and building structures, draining of spent fuel pools after fuel removal (if not previously performed), preparation for the deferred dismantling dormancy period (if appropriate), deactivation of nonessential electrical systems, and dismantling and removal of all contaminated (and non-contaminated, if applicable) systems from the facility. These activities are the bulk of the work to terminate the authorization or license. Guidance for the activities to be included in the cost estimate is included in the Standardized List, and will not be repeated here. The cost estimator needs to review this list to select the appropriate items for the site-specific estimate.

3.1.5. Waste processing, storage, and disposal

Radioactive and clean material removed from the facility are prepared for temporary storage, or for packaging, transport and final disposition as either contaminated material for burial, or clean material for recycling or disposal. Safety analyses supporting the Decommissioning Plan are performed to determine the risk in handling, packaging, storing, transporting, and disposal of the waste. Using information from the facility characterization data, the ultimate disposition of material can be determined. The disposition process may be worked backward, starting with the waste disposal facility waste acceptance criteria to determine the acceptable waste form, container, and allowable contents. The means of transporting the allowable containers is determined from this analysis, to select the mode(s) of transport (truck, rail, or barge), and the routes and necessary permits required to handle the vehicles. With predetermined allowable containers, the dismantling managers can determine the size to which the components need to be cut to fit into the containers. The methods to achieve that cutting campaign can be selected from the inventory of available tools.

Waste processing also includes the legacy waste left over from operations including spent resins, filters, stored liquids, special fluids (sodium, heavy water, organics, etc.), and residual chemicals. Where possible, this material is disposed of prior to shutdown by the operating organization. In the event a disposal facility is unavailable, provisions are made for temporary onsite storage.

3.1.6. Site security, surveillance and maintenance

Whether the facilities are being prepared for immediate dismantling or deferred dismantling, continuing activities of security, surveillance and maintenance are performed. Security systems and structures, including fences, access gates, and intrusion detection systems are maintained to insure there is continuing control to prevent trespassers or vandals from entering the site. Similarly, security and surveillance systems may be required to prevent the inadvertent or intentional transport of radioactive material from the site in the form of contaminated or clean tools and equipment. If the facility is placed in dormancy for deferred dismantling, security guards and intrusion detection equipment are maintained as needed, and additional assistance from local law enforcement agencies arranged, if required. Periodically, the owner/licensee needs access to the facility to perform surveillance measurements and inspections to ensure there have been no leaks, discharges, or degraded (corroded or cracking) enclosures. Security vehicles require maintenance and replacement, and armed guards (if required) need to maintain their proficiency in use of weapons.

Routine maintenance grounds keeping activities such as mowing grass, raking leaves, removing brush and trash, and snow plowing of roads are continued to facilitate routine inspections and to ensure security guard visibility and access is possible. Roads and parking lots are maintained to prevent erosion and cracking from weather induced freeze-thaw cycles. Storm drains are cleaned to prevent flooding of areas needed for access.

During dismantling, necessary and essential electrical systems are maintained, as well as natural gas or fuel oil for heating, diesel fuel for vehicles and heavy equipment, potable water, sewage systems, steam, and compressed air or special gases. Some of these utility services may also be required during the deferred dismantling period.

Monitoring and recording airborne radiation levels inside and outside of structures are performed, and liquid contamination levels in facility systems and storm drains are periodically measured. Soil sampling and subsurface water monitoring wells are measured periodically, and reports prepared for regulatory review.

3.1.7. Site restoration, cleanup and landscaping

Upon satisfactory demonstration that all radioactivity above unrestricted release levels have been removed, the authorization or license may be terminated. The non-radioactive systems that are no longer usable may be dismantled, removed, and sold for salvage or scrap.

The remaining buildings and structures that are no longer needed (sometimes called redundant facilities) may be demolished and below-grade voids filled to prevent subsidence. Some local regulations prohibit reinforcing rods and embedded steel to be included as crushed concrete fill, and may need to be separated and removed. If there is insufficient concrete rubble for fill, appropriate fill material may have to be brought to the site and deposited in below-grade voids. Other buildings that are intended to be re-used may have to be restored to function in their new application, or refurbished to meet current building codes. Final site restoration and landscaping may require gravel fill or grass to prevent soil erosion. Permanent markers may have to be installed to warn of buried below-grade foundations or buried abandoned pipe and conduit.

Local building officials may require an independent inspection to verify all site reuse standards are met, and documentation recorded in land records of the site. It may be necessary to place a time capsule on the site to describe the former facility, its operating history, and how it was decommissioned.

The decommissioning trust fund may have to include additional funding for perpetual care and surveillance, in cases of limited or restricted release of the property, deferred dismantling, or entombment.

3.1.8. Project management, engineering and site support

The costs for project management of the owner/licensee, and any contractors (if used), are a major cost element of the decommissioning project. As a minimum, it includes mobilization and preparatory work, project management and engineering services, public relations, support services, health and safety, and demobilization.

Mobilization includes establishing adequate office and/or trailer space, telephone systems, office machines and equipment, and crew change rooms and lockers, and lavatory facilities. General service transport vehicles and trucks, drivers, escort vehicles, construction equipment and consumables are procured and set up. Arrangements are made with local and interstate or inter-country agencies for vehicular permits, inspections, weigh stations, and police, fire brigade, and medical services. The site management personnel may have to be relocated, and arrangements made for temporary and permanent housing for relocated personnel. Radiological laboratories may have to be established, upgraded, or contracted out to local vendors for dosimetry, survey equipment, and repair and calibration of equipment.

The project management staff of the owner/licensee needs to be transitioned from operating to decommissioning positions to maintain continuity and to retain valuable experience necessary to execute the project. Organized labour contracts may have to be re-written to allow crafts to work across traditional work rules, often requiring redefinition of the work rules to conform to the tasks to be performed. Cost and schedule control planners, and task managers need to be assigned to track milestone completion for progress payments to contractors and vendors. Quality assurance engineers and quality control inspectors will have to re-write Quality Assurance Programs and procedures specific to decommissioning. Procurement, warehousing and material handling personnel are assigned to dispose of unnecessary spare parts, purchase consumable material, and control inventory. Administrative personnel for contracts, accountants, bookkeepers, secretaries, document control clerks, and janitors need to be assigned and procedures established. Engineering support for mechanical, electrical, civil, nuclear and maintenance are assigned for each type of activity planned.

Public relations may play an important role when stakeholders take an active role in project planning and execution. Information disseminated to the public through newspapers, radio and television may require periodic public meetings to explain what is planned and what progress is being made. Facility tours to local representatives, visiting guests, and regulatory body personnel require control of all documentation, passes, and scheduling.

Support services for management staff and crew housing, maintenance, food services, laundry facilities, trash removal, utilities, and medical services need to be provided. Computer services, and maintenance, software, and technical support also need to be provided.

Health and safety support provides for industrial safety and radiation protection personnel, technicians, and laboratory personnel. Area monitoring, portal monitoring, access control, instrumentation, and dosimetry, is required for each crew to protect against inadvertent exposure. Industrial safety personnel are required to monitor each activity, and to inspect equipment prior to and during use. Training for new crew personnel, and periodic re-training for certification requires instructors in specific disciplines.

Demobilization of personnel at the end of their assignment is tracked, and documentation of personnel records, exit dosimetry, and severance arranged for terminated workers. All clean equipment that can be returned to vendors, or owned equipment resold as salvage is dispositioned. All temporary utility services are terminated and removed if not required to support dormancy.

3.1.9. Research and development

Some projects require significant research and development of decontamination and dismantling technologies, and the development of working procedures prior to execution at the facility that will be decommissioned. The research may include literature searches, data collection, visits to other facilities undergoing decommissioning, and computer models of proposed methods and equipment. In some cases, new computer codes may have to be learned and adapted for a specific application. Physical mockups have become the most reliable method to test new or previously untested technologies, and such testing is best done at a vendor’s facility prior to application at the facility. These costs are tracked for total cost and project budget control.

3.1.10. Fuel and nuclear material

Fuel and nuclear material disposition costs may be an important element of the decommissioning cost estimate. In most cases, the site license cannot be terminated until all fuel and nuclear material is removed from the site to a central repository or reprocessed.

In some countries, the costs for final disposition or reprocessing are excluded from the decommissioning cost estimate; in others, these costs are included with decommissioning funds. The cost to transfer fuel and nuclear material from the reactor or facility to onsite temporary storage includes the labour, equipment (containers, canisters, and casks) and consumables associated with storage, surveillance, and maintenance. These costs may include the cost for a special storage license specifically for the fuel or nuclear material, unless they are not considered to be decommissioning costs. When the fuel or nuclear material is ultimately removed from the facility, the storage facilities (fuel racks, casks, storage concrete pad) are also decommissioned.

3.1.11. Other costs

Other costs cover all elements of cost that are not classified by the foregoing categories. They might include owners costs (for transition of employees, severance, etc.), consulting fees, regulatory fees, permits, licenses, inspections, taxes, insurance, overhead, general and administrative expenses, contingency, interest on borrowed funds and asset recovery costs.

3.2. Cost groups

The Standardized List also contains the cost groups for decommissioning projects including Labour, Capital Equipment and Material, Expenses, and Contingency.

3.2.1. Labour

Labour costs include hourly wages for direct labour, benefits, holidays, relocation, per diem, retirement, medical insurance, life insurance, etc.

3.2.2. Capital equipment and material

Capital equipment costs are for purchased items such as cranes, trucks, forklifts, excavators, demolition hammers, etc. Some of these items may be resold for cost recovery when the project is completed. Material costs are for consumables, spare parts, protective clothing, etc.

3.2.3. Expenses

Expenses are generally for legal fees, taxes, insurance, consulting fees, rent, office material, utilities, etc.

3.2.4 Contingency

Contingency costs are for unforeseen, uncertain and unpredictable conditions typically encountered in decommissioning. In general, all contingency costs are spent as the project progresses, as these unforeseen events occur throughout the project.

3.3. Cost estimating methodology

Reliable cost estimating is one of the most important elements of decommissioning planning. Alternative technologies may be evaluated and compared based on their efficiency and effectiveness, and measured against a baseline cost as to the feasibility and benefits derived from the technology. When the plan is complete, those cost considerations ensure that it is economically sound and practical for funding.

Estimates of decommissioning costs have been performed and published by many organizations. The results of an estimate may differ because of different work scopes, different labour force costs, different money values because of inflation, different oversight costs, the specific contaminated material involved, the waste stream and peripheral costs associated with that type of waste, or applicable environmental compliance requirements. A reasonable degree of reliability and accuracy can only be achieved by developing decommissioning cost estimates on a case-by-case site-specific basis.

There is no universally accepted standard for developing cost estimates, or for that matter, any clear reference for terminology used in decommissioning. However, the Association for the Advancement of Cost Engineering International (AACEI) was founded as a resource for cost estimating methodology, and has established a program for education and certification of cost estimators to lend consistency to the process. The AACEI published a book to guide cost estimators in the new and evolving cost estimating practices from all facets of industry [5].

3.3.1. Types of cost estimates

There are three types of cost estimates that can be used and each have a different level of accuracy. These cost estimate types are summarized in the following paragraphs.

- Order-of-Magnitude Estimate: One without detailed engineering data, where an estimate is prepared using scale-up or -down factors and approximate ratios. It is likely that the overall scope of the project has not been well defined. The level of accuracy expected is -30% to +50%.

- Budgetary Estimate: One based on the use of flow sheets, layouts and equipment details, where the scope has been defined but the detailed engineering has not been performed. The level of accuracy expected is -15% to +30%.

- Definitive Estimate: One where the details of the project have been prepared and its scope and depth are well defined. Engineering data would include plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams and structural drawings. The level of accuracy expected is -5% to +15%.

It is apparent from these estimate types and levels of accuracy expected that even in the most accurate case, a definitive estimate is only accurate to -5% to +15 %. The cost estimator needs to exercise his judgment as to the level that the input data will support. In developing a funding basis for a project, the estimator includes sufficient margin (or contingency) to account for a potential budget overrun to account for this level of uncertainty.

3.3.2. Developing the cost estimate

Costs may be estimated in a number of ways. Recorded experience from other decommissioning projects, estimating handbooks and equipment catalog performance data are some of the sources used to develop cost data. The techniques used for preparing cost estimates will necessarily vary with the project's degree of definition; the state-of-the-art of the project; the availability of databases, cost estimating techniques, time, and cost estimators; and the level of engineering data available. Some of the more common estimating techniques are described in the following paragraphs.

(1) Bottom-up Technique: Generally, a work statement and set of drawings or specifications are used to extract material quantities required for executing each discrete task performed in accomplishing a given activity. From these quantities, direct labour, equipment, and overhead costs can be derived.

(2) Specific Analogy Technique: Specific analogies depend upon the known cost of an item used in prior estimates as the basis for the cost of a similar item in a new estimate. Adjustments are made to known costs to account for differences in relative complexities of performance, design and operational characteristics.

(3) Parametric Technique: Parametric estimating requires historical databases on similar systems or subsystems. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance. The analysis produces cost equations or cost estimating relationships that may be used individually or grouped into more complex models.

(4) Cost Review and Update Technique: An estimate may be constructed by examining previous estimates of the same or similar projects for internal logic, completeness of scope, assumptions and estimating methodology.

(5) Expert Opinion Technique: This may be used when other techniques or data are not available. Several specialists may be consulted iteratively until a consensus cost estimate is established.

The method widely adopted in estimating is the bottom-up technique, based on a building block approach known as the work breakdown structure (WBS). The building block approach follows the same logic whether the estimate is being generated to support a demolition or construction scenario. Using this approach, a decommissioning project is divided into discrete and measurable work activities. This division provides a sufficient level of detail so that the estimate for a discrete activity can apply to all occurrences of the activity. This estimating approach was developed and presented in the AIF/NESP-036 report [1].

3.3.3. Cost element definitions

It is constructive and helpful to group elements of costs into categories to better determine how they affect the overall cost estimate. To that end, the cost elements are broken down into activity-dependent, period dependent, and collateral costs as defined in the following paragraphs. Contingency, another element of cost, is applied to each of these elements on a line-item basis (as will be described separately) because of the unique nature of this element of cost.

(1) Activity-Dependent Costs: Activity-dependent costs are those costs associated with performing decommissioning activities. Examples of such activities include decontamination; removal of equipment; and waste packaging, shipping and burial. These activities lend themselves to the use of unit cost and work productivity factors (or work difficulty factors) applied against the plant and structure's inventories to develop the decommissioning cost and schedule.

(2) Period-Dependent Costs: Period-dependent costs include those activities associated primarily with the project duration: engineering, project management, dismantling management, licensing, health and safety, security, energy, and quality assurance. These are primarily management staffing level costs, developed by estimating the manpower loading and associated overhead costs based on the scope of work to be accomplished during individual phases within each period of the project.

(3) Collateral and Special Item Costs: In addition to activity and period-dependent costs, there are costs for special items, such as construction or dismantling equipment, site preparation, insurance, property taxes, health physics supplies, liquid radioactive waste processing and independent verification surveys. Such items do not fall in either of the other categories. Development of some of these costs, such as insurance and property taxes, is obtained from owner-supplied data.

(4) Contingency: Contingency can be defined as "a specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events that increase costs are likely to occur." [5]

The cost elements in a decommissioning cost estimate are based upon ideal conditions where activities are performed within the defined project scope, without delays, interruptions, inclement weather, tool or equipment breakdown, craft labour strikes, waste shipment problems, or burial facility waste acceptance criteria changes, changes in the anticipated plant shutdown conditions, etc. However, as with any major project, events occur that are not accounted for in the base estimate. Therefore, a contingency factor is applied.

Early decommissioning cost estimates included a contingency of 25% that was applied to the total project cost. More recent and accurate approaches apply contingencies on a line-item basis, yielding a weighted average contingency for the cost estimate. One source for the line-item contingencies is the AIF/NESP study [1], which discusses the types of unforeseeable events that are likely to occur in decommissioning and provides guidelines to apply for various activities.

(5) Scrap and Salvage: The cost estimate includes an evaluation of the scrap and/or salvage values from material that are determined to be clean, or that were never exposed to radioactive or hazardous material contamination. The evaluation is based on recent cost data obtained from one or more of the references included this section.

Salvage is defined as removed material that has an identified market for resale or reuse at a specific facility. Accordingly, pumps, motors, tanks, valves, heat exchangers, fans, diesel engines and generators, etc. are the types of components that are candidates for salvage. Scrap is defined as removed material that is certified to be noncontaminated or activated, and may be sold to a scrap dealer for ultimate recycling as a raw material. Examples of scrap material are copper wire and bus bars, stainless steel plates and structural members, carbon steel and stainless pipe, carbon steel structural shapes, beams, plates, etc.

The market for salvageable material from facilities that have used radioactive material is limited, owing to the very specific purpose for which they were intended. Market prices fluctuate depending on the buyer's expense to remove the component intact and to package it and transport it to its new application in a reusable condition. These expenses reduce the resale value of salvaged material.

For steel scrap, material is sold on an as-is, where-is basis. There are no warrantees or representations as to the reusability of the item. Market prices are usually posted daily in newspapers and journals.

Site reuse for new productive applications after decommissioning is another way of partly offsetting decommissioning costs.

(6) Work Breakdown Structure (WBS): The WBS is used to categorize cost elements and work activities into logical groupings that have a direct or indirect relationship to each other. The work groupings are usually related to the accounting system, or chart of accounts used for budgeting and tracking major elements of the decommissioning costs.

(7) WBS Levels: The WBS elements are generally arranged in a hierarchal format similar to a company's organization chart. The topmost level of the WBS would be the overall project. The second level would be the major cost groupings under which project costs would be gathered. The next level would be the principal component parts of each direct or indirect cost category for that cost grouping. Subsequent levels are often used to track details of

the component parts of the grouping so that a clear understanding of all the cost bases can be made.

(8) Chart of Accounts: The project management or accounting software used on major projects usually identifies categories of costs in terms of a chart of accounts. The chart of accounts is where the individual cost items of labour, equipment, consumables, capital expenditures, recycle services, transportation or disposal services are budgeted and cost-controlled on a rigorous basis. The Standardized List [4] may be used to establish this chart of accounts.

3.3.4. Cost estimating process

A thorough cost estimating process flows from an overview of the project, to the scenarios evaluated or selected, to the assumptions critical to the approach, to the details of the cost elements and the work schedule, and then to a summary of the principal cost drivers. While there are no hard and fast rules for formatting the process, there are logical guidelines to follow so that cost estimates can be easily tracked and compared.

(1) Scope of Work: The scope of work for the project needs to be clearly stated at the outset of the estimate to ensure the estimator and reader understands what is included in the estimate, and the extent of effort required. The scope identifies assumptions and exclusions of the systems and structures to be removed and dismantled, and the amount of site restoration required.

(2) Decommissioning Strategies: The decommissioning strategies to be evaluated which are immediate dismantling, deferred dismantling or entombment.

(3) Collection of Information: A site-specific estimate uses defined engineering data, including site and plot plans, general arrangement and architectural drawings, piping and instrument diagrams, one-line electrical diagrams, equipment specifications, reference manuals, etc. to provide a basis for the facility systems and structures requiring decontamination and dismantling. Data collection includes the site radiological and hazardous material characterization information; site specific inventory of systems and structures; local labour costs for skilled labour and management; local consumables and materials costs; and taxes, insurance, engineering and regulatory fees.

(4) Preparation of the Cost Estimate: The application of unit costs to the inventory of systems and structures for each dismantling activity provides the activity-dependent costs. The estimate of the project management staff costs for the duration of the project provides the period-dependent costs. Collateral costs and contingency are added to develop the total decommissioning cost.

(5) Preparation of the Schedule: The overall schedule is developed from a logical and planned sequence of activities. The duration of each activity is estimated from the individual activity steps, and the sequence evaluated to obtain the critical path (longest time) to accomplish the work. Iterations are often necessary to arrive at a reasonable schedule. This work is usually performed using scheduling computer software.

The decommissioning cost estimate and schedule are not stand-alone documents; they are an integral part of the planning for a project from the concept to the final implementation. The cost estimate and schedule are linked inseparably, as changes to the cost affect the schedule as to when activities may be accomplished, and changes to the schedule affect the overall cost. An accurate cost estimate and schedule provide the ability to track costs and project trends.

4. COLLECTION AND MANAGEMENT OF DECOMMISSIONING FUNDS

Decommissioning of facilities is inseparable from the issue of radioactive waste management. In accordance with the ethical principle of intergenerational fairness, these management costs need to be borne by the generations that had the benefit from the primary, producing activity. Therefore, it is important to set aside sufficient funds so that, when the moment comes, the financial resources needed to decommission facilities, remediate sites and manage the attendant wastes are available. A liability on future generations would exist if these funds were proven to be insufficient. A liability can have several originating causes, such as:

- Underestimation of the actual costs by the operator or owner of the facility, or by the holder or owner of the radioactive material,
- Negligence,
- Transfer of ownership of the installation or site without transfer of the corresponding provisions,
- A reduction in the operating time (reducing the time available to collect funds),
- Owner/operator financial problems, and
- Ignorance.

The word liability can also be used to indicate a responsibility, both financial and non-financial, that an entity may have.

Liabilities identification concerns all the facts that would enable governments, institutions, or others to determine whether every operator or owner of a facility or radioactive material have provided, or are providing, the requisite financial resources in time to cover the future costs of decommissioning, remediation and waste management. Iterative evaluations enable the responsible parties to estimate the potential liabilities and take the necessary corrective measures in time. Liabilities management is to assure that appropriate frameworks exist for funds to accrue, to be managed, and to be disbursed at the appropriate time. The longer the time period between permanently ending facility operations and decommissioning and/or waste management activities, including spent fuel management, the greater the potential for a shortfall of funds available to implement the management programs.

Ultimately, the existence of adequate funds is linked to the safety of the public. This link is recognized in the Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [6], which states in Article 22 that:

> *"Each Contracting Party shall take the appropriate steps to ensure that [...] adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning".*

4.1. Legal requirements for decommissioning funds

It is internationally accepted that legal requirements are required to form the basis to ensure financial resources are sufficient and available to cover all decommissioning and waste management costs. These funds need to meet the following minimum criteria:

- Contributions to the fund are to be made by facilities using radioactive material during their operation to ensure sufficient funds are available at the time of final shutdown to cover all decommissioning and waste management expenses.

- Contributions are to be in line with the estimated service life, defined time schedule, and chosen strategy, to cover (1) decommissioning of the facility, (2) long-term management of conventional and radioactive wastes, and spent fuel and wastes from reprocessing operations not already fully covered in legal requirements or as operational costs.

- The funds are to be managed and reviewed periodically in a manner ensuring liquidity compatible with the timetable for the decommissioning obligations and their costs.

- The funds are to be used only to cover the costs of the decommissioning obligations in line with the decommissioning strategy, and not be used for other purposes. To this end, the funds are to be established under a legal framework.

Acts, decrees and directives normally provide the authority for the funds to be established and preserved. This is important as it demonstrates, at the highest possible level, that there will be funds available to deal with the issues of decommissioning, waste management, and spent fuel management.

4.2. Defining and estimating decommissioning costs

Decommissioning of a facility is a major industrial undertaking that can take many years, depending on the strategy approach. The cost of decommissioning operations can be very high. Estimates of the full decommissioning of a 1000 MW(e) NPP range from about 150 million euros to nearly 750 million euros. It is essential to avoid any possibility that decommissioning will not be able to start as planned, can not be carried out using the appropriate safe procedures or be abandoned before completion due to a lack of resources.

As indicated in Section 3, "Identification of Decommissioning Costs," many factors affect decommissioning costs. Excluding spent fuel management, the three cost elements representing a significant share of the total are project management, dismantling and waste treatment /disposal.

As the decommissioning industry has matured and gained experience, it has been shown that dismantling costs can be estimated reliably and managed adequately while decommissioning activities are carried out. The experience acquired has demonstrated that the organizations responsible for decommissioning activities tend to use cost estimating methods specific for their conditions and requirements.

The underlying assumptions used to estimate the costs need to be well determined and well understood. Of greatest importance, is that the cost estimates are in line with the chosen decommissioning strategy: immediate dismantling, deferred dismantling or entombment.

Waste disposal costs may be among the most uncertain, as only a few countries have operating waste repositories for part or all types of decommissioning waste. However, based upon extensive research activities, including in the field of economics of repositories, waste disposal cost estimates may be estimated within a reasonable range of uncertainties. Large volumes of material arise during decommissioning activities and the costs for radioactive material and waste management and disposal could, as already mentioned, make up a substantial part of the overall decommissioning costs. A country's specific situation on the availability of waste treatment, storage, and disposal possibilities will strongly affect the degree of uncertainty of the waste management cost.

Furthermore, the fund, if so desired and planned for, may be used to cover other activities, including research and development on radioactive waste management, encapsulation of the spent fuel, construction of the repository, expenses for regulatory control, etc. The cost estimates can be prepared according to the current decommissioning plans and technology. Thus, changes or corrections in plans, possible innovations, and change in the cost level as well as changes in national policy may affect the estimated liability. Additionally, the uncertainty of available information about prices and costs need to be taken into account in a reasonable manner. Benchmarking, although difficult in some cases, is performed to have a better confidence in the overall cost estimates.

4.3. Collection of funds

The way decommissioning funds are accumulated varies from country to country. In some cases, the calculated sum of decommissioning is accumulated year-by-year over the entire planned lifetime of the facility. Elsewhere, other methods may be used such as requiring the funds to be collected over a shorter period than the expected lifetime of the plant, or obliging the operator to make a down payment for all future costs as a condition for obtaining the first operational license. In this way, some of the risks associated with premature shutdown of the facility may be reduced.

The growth of the fund is dependent on the investment strategy, i.e. how aggressively or conservatively the funds are invested, thereby determining the amount of money to be collected. It is reasonable that the owners who are depositing monies into the funds will want to see the greatest possible return on the investment such that they will, in the long run, have to deposit less money. On the other hand, governments tend to have a more conservative approach and want to protect the capital in the fund. To achieve this, they are willing to accept a lower rate of return. A balance is required between these two perspectives for optimal performance of the fund.

Another key factor is that the detailed methods for calculating and reporting liabilities differ from country to country, and sometimes between operators in a given country. In practice, two main methods — current value and net present value — and sometimes variations of these are generally used for calculating future financial liabilities associated with decommissioning. In both methods, the value of the liability is adjusted periodically as the cost estimates evolve, due to technology progress, regulatory changes, and inflation, as applicable.

The current value method evaluates the financial liability based on what decommissioning would cost today if the expenses were incurred at present. In that case, the value of the liability is equal to the decommissioning cost estimate and does not depend on the timing of decommissioning activities; it is independent of the time when the expenses will occur.

The net present value method evaluates the liability based on the discounted decommissioning costs, taking into account the expected expense schedule. The estimate requires assuming a discount rate and depends on the timing of decommissioning activities and the associated expenses; the later the expense will be incurred, the lower is its net present value. For example, if the current estimate for decommissioning a facility is 500 million euros and is expected to escalate at 3 percent per year, and assuming the facility was to be decommissioned 40 years from now the expected future cost would be 1,631 million euros. Assuming a 5 percent discount rate, the net present value of this cost would be 232 million euros. If the facility were to be decommissioned 60 years from now, the future cost would be 2,946 million euros, and the net present value would be 158 million euros. However, determinations of net present value can be deceiving because it assumes the escalation rate and discount rate remain unchanged over long periods of time. The owner-licensee needs to evaluate the risks associated with these assumptions when selecting a funding strategy.

The main difference between the two methods is that the net present value accumulates the funds more slowly and is more sensitive to assumptions on expense schedule and the rate of return on capital set aside. Since the provisions are set up faster in the current value method, the interest generated by the accumulated provisions is higher and, if the provisions are tax deductible, the charge for the owner/operator is alleviated.

In the event funds are not being collected either because of financial stress (bankruptcy, inadequate cash flow, or simple delinquency), or lack of legal structure to require collections, it may be necessary to change the decommissioning strategy by delaying or prolonging decommissioning. In some cases it may be necessary to impose enforcement actions against the licensee.

4.3.1. Nuclear power plants

While in most cases the funds are referred to as "decommissioning" funds for simplicity, in principle they are required to cover all nuclear costs that remain at the end of a NPP's normal life. In other words, they cover the decommissioning activities and complete management of the resulting decommissioning waste. Within the scope of decommissioning this may also include the on-site storage of spent fuel and possibly the management of spent fuel (reprocessing or final disposal), although some countries, and the IAEA, consider all spent fuel costs to be operational costs.

Different approaches in the establishment of funds may be possible: one unique fund can cover the costs of decommissioning, including the resulting decommissioning waste and spent fuel management, or separate funds can be raised to cover each of these activities.

NPPs have a normal operating life cycle of at least 30 years, and even 60 years of operation is possible. Operators are expected to constitute provisions from the sale of the electricity during this long life cycle in order to cover the future nuclear costs. Several different approaches of collecting are being applied:

- Collection over the expected life cycle of the NPP.
- Collection over a shorter period (typically 25 or 30 years) than the expected life cycle of the NPP.
- Collection as a prepayment to the fund before startup.
- Collection at the start of decommissioning.

These options have their advantages and disadvantages. In general, a collection over the entire expected life cycle will lead to lower annual amounts to be transferred to the fund, but a collection over a shorter period or prepayment will reduce the risks associated with premature shutdown. Collection at the start of decommissioning is not a recommended practice, as the decommissioning activities are usually not permitted to begin until all funding is in place. Since spent fuel is being produced continuously, the collection period for the management and disposal of spent fuel is typically distributed throughout the entire life cycle of the NPP.

In some cases for NPPs with multiple units, collection of funds may be organized on a site-wide basis, or if the owner has several sites, collection may be organized on a fleet basis. In other cases, funds cannot be transferred to other units. Premature permanent shutdown for decommissioning raises issues of depletion of the fleet fund concept.

1. Privatized utilities

Generally, it is the electricity consumer who is paying for the nuclear liability and, depending on the electricity pool of the utilities, generally no distinction is made between “nuclear” and “non nuclear” electricity. In accordance with the applicable legal basis and rules in a country, the contribution is built into a consumer’s total electric bill, or the contribution is clearly indicated in the form of a special levy on the sold nuclear KWh.

2. State owned utilities

Besides the collection possibilities that exist for privatized utilities, the taxpayer is indirectly contributing to the funds since they are collected from public budgets. In some cases for state owned utilities, the distribution companies can collect a special levy via the electricity bill.

4.3.2. Other facilities

Other facilities under consideration are research reactors, fuel fabrication plants, reprocessing facilities, enrichment facilities, research laboratories and manufacturing plants.

1. Privatized facilities

As for commercial NPPs, the consumer is paying a share of the decommissioning costs in the price of the “product or service” being purchased. The contractual relations can define specific conditions if, for example, the consumer has to pay his share of the decommissioning cost when the project begins. In this case, the consumer has to make a provision for this amount.

2. State owned facilities

For state owned facilities, such as research reactors, decommissioning typically will be paid from public budgets (so indirectly by the taxpayer) when the costs arise. In other cases, the consumer is paying a share of the decommissioning costs in the price of the “product or service” that is being purchased, such as radioisotopes or material tests.

4.4. Management and control of decommissioning funds

The ownership of the funds varies from one country to another. In some countries, the licensee/owners (operators) are allowed to accumulate and manage their own decommissioning funds that remain in their own accounts (so-called internal management of the funds, or accruals). In other countries, the funds are collected from the operators or the electrical system and managed by separate, independent bodies (so-called external management, or trusts).

Both approaches of management have the same goal: to cover the expected costs and to have the money available at the time the costs occur. These funds need to be managed in such a way to ensure that they retain their value, and the funds may not be spent on anything other than their identified purpose. The liabilities that remain following closure of a nuclear facility are to be managed safely, even though this may be over a period that ranges from a few years to possibly even more than 100 years. It is vitally important that the financial resources for the safe management of these costs can be guaranteed over the full period. This assurance is essential for public confidence.

4.4.1. Internal management

One possibility that has been adopted is to have the operators responsible for collecting and managing the funds. The operators are also appointed as directly responsible for carrying out the decommissioning work. In this case, the contributions are held within the operator accounts in the form of reserves. In some countries there are separate reserves for decommissioning (including the decommissioning waste), and for the management and disposal of spent fuel. It is important that the formation of the reserves and the spending of the fund be established as a legal requirement with control of spending. With internal reserves there is a risk funds may not be available when needed. In particular in cases where separate accounts are not established, special measures may be required to verify that the fund meets the basic principles of sufficiency, availability, transparency and assurance that they are used only for the purpose for which they were set aside.

4.4.2. External management

Alternatively, the creation of an external trust fund, independent from the regular accounts of the utilities has been put forward in Europe, and is already being applied in several countries. Different options are possible in the system of external management, such as:

- The operators are required to contribute to an external financial fund. It can be a bank or treasury account, subject to specific rules protecting the fund from misuse and financial risks.

- It may be required to create a legally established external fund, managed by a body that is independent from the operator. Specifically, the funds can be kept and managed by the national administration or private institution.

In the case of an external account or trust fund, the modalities for reimbursing can vary, mainly according to the assignment of responsibilities for decommissioning. If the operator will carry out the decommissioning, it will use the funds as need arises. In some situations there is a specific company created for decommissioning that takes over the ownership of the facility from the operator at the closure. Thereafter, the account/fund manager distributes the funds in installments as the decommissioning work progresses.

Decommissioning Trust Funds are usually held in trust by an external organization (bank or trust company) that is only empowered to release funds under the direction of the owner/licensee or the regulatory body. Release of the funds may be tied to specific milestones of the project, and may only be released when documented evidence is presented to support authorization of expenditure.

In some countries, the facility operators contributing to the fund are entitled to borrow back a certain percentage (up to 75 percent) of the capital of the fund against full securities, and at a defined interest rate. In addition to that, the state has the right to borrow the rest of the capital of the fund.

In the case of a unique external national fund for several nuclear operators, each operator can be said to have its own "account" in the fund, and the state authorities regularly establish the required balance of that account. In the case where the operator can no longer take care of its obligation for financial provisions, the state can take over the account and the securities furnished by the operator to the fund to guarantee that the fund can return monies to the state in a timely manner.

In principle, assets are invested in such a manner as to ensure an optimal balance between risk and return. Implications for the investment concept are a long-term saving process with a lengthy investment horizon, a sustainable nature of investment income, and sometimes individual goals for each facility.

Specific guidelines can be defined, such as:

- Only low-risk investments are permitted,
- Investments in companies associated with the legally obliged contributors to the funds are prohibited,
- Investments in companies that have invested the majority of their assets in nuclear facilities are prohibited, or
- Investments into domestic or international money markets are permitted.

The management of the fund itself can be entrusted to a variety of custodian banks and asset managers with the task of investing the funds' assets. These investment policies and their compliance with specified guidelines can be monitored by submitting regular reports from a specific investment committee or external experts.

Different asset management possibilities exist, such as:

- Investment in national currency bonds,
- Investment in international currency bonds,
- National equities and international equities (indexed and active), or
- Investment in real estate.

4.5. Fund adequacy

There are considerable uncertainties related to the growth of the funds as a result of the chosen investment strategy, the management/mismanagement of the fund or inflation rates. These suggest that a balance is required between the rate of return and the preservation of the fund value in order to preserve it for future implementation of the decommissioning project.

4.5.1. Monitoring

The constitution of the fund's provisions considers a number of questions to be answered, such as the assumed operation life, the collection period, securing provisions in the event of financial difficulties or an accident, and the ability to prosecute shareholders and other companies in the event of missing funds.

Estimating the contributions to be paid in the fund is a crucial step. Calculations are based on both the estimated decommissioning costs and on the various assumptions made. The assumptions may include the time when the costs will arise, inflation, and the anticipated interest rate on the accumulated capital.

The annual contributions are reviewed periodically (e.g. every year, every 5 years). They are also examined and adopted as necessary if a new situation has occurred, or if a significant modification of costs is to be expected due to unforeseen circumstances. The annual contributions can also change if, as a result of developments on the financial markets, the accumulated capital deviates from the target level within a certain bandwidth. The applicable bandwidth could be from -15% to +20 %. The absolute value of the lower limit is less than the upper limit as a conservative measure.

In addition to basic contributions, an owner/operator could also be obliged to retroactively pay the respective contributions that would have been required if the fund had been in existence at the time the facility commenced operation. Furthermore, an insurance policy could cover contingencies as they occur, such as if the costs become higher than expected, if the expenses need to be met earlier than expected or if the actual amount in the fund is lower than was expected. The process of periodic cost calculations and the review and determination of fees and insurance policies needs to be well defined.

4.5.2. Premature permanent shutdown

In the case of state owned facilities, the costs to decommission the facilities are covered by taxes. Funding may only be limited to the extent the government places annual limits on the amount of funds available to perform the activities.

In the case of privately owned facilities, all models share a common problem, namely that in the event of premature decommissioning, financial difficulties of an operating company, or its take-over by another company, financial resources maybe lacking unless:

- An obligation to pay additional contributions can be imposed on the other operators in the sense of joint liability,
- An insurance policy is provided, or
- A bank guarantee is provided.

As a precaution against insolvency, the part of the assessed liability that is not covered by the money in the fund is covered with securities furnished by the operator. The securities can be given to the fund or to the state. Mortgages on a nuclear facility itself cannot be accepted as securities. Each security is required to be separately accepted by the regulatory body. An additional 10% of the supplementary securities covering the assessed liability are normally given to the state as an additional precaution against unforeseen events.

4.6. Tax treatment of funds

In some countries the concern for the liquidity of the fund and its security against poor investment performance has favored investment in low risk, low return securities. These types of funds have been given favorable tax treatment to offset the low return on investment. They are generally called qualified funds, as they qualify for this favorable tax treatment. However, investment in a higher risk, higher return security such as equities (stock) will generally provide a greater return to the fund and require a smaller collection from ratepayers. These are called nonqualified funds. The tax treatment on nonqualified funds is usually at the higher corporate tax rate. Usually the return on these nonqualified investments is great enough to cover the corporate tax rate and still return a greater contribution to the fund than qualified funds.

5. POTENTIAL METHODS FOR REDUCING COSTS

NPPs may consist of single unit or multiple unit sites. Single unit sites have to bear the entire burden of costs where the facility, craft workers, and management costs are included in the cost of decommissioning the single unit with no sharing of on-site expertise or experience possible. Such single unit situations rely on the experience gained at other plant sites where these activities were performed earlier. In some cases, it may be necessary to use a delayed decommissioning strategy to take advantage of experience from other sites and to allow the trust fund to grow through investment until adequate to cover all costs.

Multiple unit sites have the advantage of the learning experience from decommissioning the first of the units, where specialized tools and techniques can be reused, refined, or optimized for the later unit's activities. Perhaps the greatest savings may be from the acceleration of schedule of the latter units from the lessons learned from the earlier units, as the management costs represent one of the major elements of the total costs.

Research reactors, associated post-irradiation examination/production facilities, research laboratories and industrial facilities are usually single unit sites or special purpose facilities. In these cases, the similarity of decommissioning activities does not lend themselves to significant cost reductions in the activities of the latter units.

From a cost management perspective, there are several tools and techniques available to the owner/licensee to reduce and control costs. This section will discuss some of these options.

5.1. Use of international experience and proven technologies

There is a wealth of international decommissioning experience that can be drawn upon to reduce costs without compromising safety. This experience is based on proven technologies demonstrated at projects involving nuclear power reactors, research reactors, weapons production facilities, other fuel cycle facilities, research laboratories and manufacturing plants. Incorporating this experience into the planning and implementation of a decommissioning project offers numerous opportunities to reduce costs, maintain schedule and improve safety performance of the project.

5.1.1. International experience

Decommissioning experience began as early as the late 1940s, with the shutdown and decommissioning of some of the first demonstration reactors and weapons research facilities.

These demonstration reactors determined a specific nuclear technology's capability for producing power, manufactured radioisotopes for medical or industrial uses, or produced weapons for military purposes. Some of the early facilities built in the United States of America, the United Kingdom, France, the former Soviet Union, and other countries were experimental, and actual operation may have lasted only a few years before the technology was deemed ineffectual or problematic. The early shutdown led to the decommissioning of these facilities, and the technologies used for decommissioning were first-of-a-kind methods. Nevertheless, they formed the groundwork for subsequent research and development to improve them for later decommissioning programs. For example, the technologies applied for chemical decontamination at these early facilities advanced our knowledge into the nature of corrosion films, and the types of solvents (acids and caustics) most effective at reducing or eliminating the contamination embedded into these films. Reports of these decontamination technologies were valuable sources of information as to how to apply them to carbon steel, stainless steel and aluminum components. One such report [7] is regarded as a major reference in decontamination technology. More recent decontamination technologies are only adaptations of these basic methods, refined to provide greater decontamination factors with reduced secondary waste generation. Similarly, early methods developed to segment carbon and stainless steel components using oxyacetylene or plasma arc cutting torches are still used today. They have been enhanced using computer-controlled robotic devices to perform cutting operations remotely with reduced exposure to the workers. These experiences were captured in various documents, such as the US Department of Energy decommissioning handbooks [8–10] and the IAEA reports [11–13], and are available to decommissioning planners to guide them as to the best technologies to use for a specific application. Many of these technologies were reported at international conferences, with lessons-learned from these experiences.

The decommissioning planners for facilities currently being dismantled are encouraged to research these references to learn how not to repeat the failures, and to adapt such existing technologies for their present projects. The industry is young enough to access the personnel involved in these early projects to guide planners in adapting the technologies for specific applications.

5.1.2. Proven technologies

The decommissioning planner is advised to use proven technologies in current projects. Attempting to develop new technologies for a project is subject to numerous delays and cost overruns. If such new technologies are deemed to be needed, a specific task should be identified early in the program to design, test, and prove the technology before it is attempted on the project. This usually involves building mockups, extensive testing, and modifications to the tooling or method before it is judged sufficiently reliable to use. Further, regulatory bodies need to be appraised of the intended technology to be developed so that approval of its use will not be delayed. As part of the technology development, cost-benefit analyses of its effectiveness need to be made to demonstrate that it will effectively perform its intended function. The cost-benefit analyses include such factors as cost, schedule improvement, dose to workers and primary or secondary waste generation. Such determination includes the waste form, and how and where wastes will be dispositioned. Each such technology development needs to include the risks to the project from both a cost and schedule perspective, as well as the safety to the workers and the public.

5.2. Reuse of systems and structures

The potential for reuse of existing systems and structures for some intended future application also offers a means for reducing decommissioning costs. It is often assumed that the nuclear facility is required to be decontaminated to unrestricted release conditions, and the estimated costs and funding are based on achieving that objective. However, the decommissioning planner may find that reuse of the existing systems and structures in their contaminated state may be an option for reducing costs. Consultation with management's objectives for the facility may prove to be a cost effective method for reducing the work scope and costs.

5.2.1. Non-contaminated systems and structures

Clearly, non-contaminated systems and structures may have reuse capabilities in other similar nuclear facilities or perhaps non-nuclear applications. Certainly, clean scrap may be recycled effectively if it can be proven there is no residual contamination above clearance levels. While the value of scrap metal may not yield significant cost recovery, the value of avoiding disposal of the metal in a landfill can be a significant savings to the project. Some of this metal, such as stainless steel and copper, may have intrinsic value in the marketplace and may be considered a strategic material in some countries.

Non-contaminated structures such as administrative office buildings, warehouses and site infrastructure facilities such as cooling water intakes, discharges, screen houses, transformers, switchgear, roads, fences, etc. may provide the elements for a replacement power plant, either for a nuclear or fossil-fueled generation station. Alternatively, these facilities may be parceled off individually for other industrial facilities.

Similarly, demolished clean concrete from these structures may be used on site for fill of below-grade voids, or crushed and transported off site to be reused as railroad beds, feed aggregate materials for new concrete, or industrial fill.

5.2.2. Contaminated systems and structures

If the owner/licensee foresees the potential for reuse of the site for a replacement nuclear facility, there may be no need or incentive to decontaminate these facilities for unrestricted release. They may be reused in their contaminated state for the replacement facility. For example, although replacement power facility may not be in the immediate planning of the owner/licensee, a longer-term viewpoint may demonstrate the ultimate use of these facilities. A cost-benefit analysis of these options is performed preceding any planning for decommissioning. Chemical, electrochemical, or mechanical decontamination techniques may be applied to remove surface contamination and potentially release material for unrestricted use. The associated reduction in radioactive waste generation can be a significant cost reduction technique.

5.2.3. Cost-benefit analyses of decontamination and waste management

A cost-benefit analysis on the total life cycle costs of each proposed technique is performed to determine the potential cost reductions, and includes all direct labour, materials, equipment, primary and secondary waste generation and occupational exposure. The selection of processes is to be researched as to where they have been successfully applied, the lessons learned and precautions necessary in handling potentially hazardous material and chemicals. The secondary waste generated can often create significant problems for treatment and disposal, and result in cost increases over direct removal and disposal. Some countries mandate decontamination of essentially all material regardless of cost to minimize the volume of radioactive waste going to the disposal facilities.

5.3. Management of fund expenditures

The owner/licensee evaluates its options regarding whether it has the proper resources to perform the work safely, and whether it is cost effective to self-perform the activities or to hire an outside contractor. For facilities that have just recently permanently shut down, qualified and experienced personnel are likely to be available to perform the decommissioning activity. Resources may be required from the outside for facilities that were shut down many years earlier, where the operating staff has already terminated and dispersed. The owner/licensee needs to evaluate these options relative to the available funds to accomplish the work.

5.3.1. Self-performance of decommissioning

For facilities shut down in the near past, the operating staff has extensive operating experience of the systems that may be needed to support decommissioning such as heating, ventilation, air conditioning, fuel pool cooling, reactor water volume control, waste management systems, cranes, etc. To recruit outside personnel for these activities is usually not cost effective and likely to incur a time delay while the new employees are trained sufficiently to operate the equipment. Some of these job functions have a finite duration, and these former operating personnel may have to be furloughed (terminated). Some may be willing to be trained to perform decommissioning activities under the direction of more experienced management. This new assignment gives the employee continued employment and the owner gets the benefit of his operating experience. However, the owner/licensee needs to recognize that such extended employees may not be motivated to accomplish the work in a timely manner, and to therefore keep costs under control. This is a common attribute of extended employees and may extend up to senior management positions. Controlling costs under this scenario can be a significant challenge. Often, owners are compelled to offer incentives to such employees to complete a given milestone of work in a specified time to receive a lumped-sum incentive payment.

There are specific advantages in having one management team be responsible for the contracting the work, approving and accepting the performance, and approving payments. One advantage is the elimination of multiple parties where the issue of responsibility is passed from one party to the other. Failure to achieve a specific milestone may be blamed on the other party's failure to meet its objective. Holding one party, the owner/licensee, responsible for cost reductions without compromising safety is a significant advantage to the single management team philosophy. If the owner/licensee is managing the project, its facility knowledge of systems operation and maintenance needed to support decommissioning can be a major asset to the reduction of decommissioning costs. The owner/licensee is perhaps most knowledgeable as to the number and types of facility personnel needed to perform such operation and maintenance activities. The owner/licensee can best balance the utilization of existing personnel for both operations activities and decommissioning activities, without compromising risk to the project or safety to the workers and public.

The owner/licensee may retain the consulting support of an oversight committee of experts to review and recommend technical, financial and safety approaches to improve the program and to control costs. Such committees meet periodically to review progress and to guide the project.

5.3.2. Decommissioning contractor performance

Alternatively, the owner may decide to retain an experienced contractor to manage the field activities. The contractor usually has extensive experience from similar projects, and can effectively manage specialty subcontractors, organized labour contracts, and heavy equipment purchase or rental. The contractor's fee for such services is negotiable, and the terms and conditions can result in incentives for both the contractor and the owner management team to accomplish the objectives within budget and schedule.

Under this scenario, the owner/licensee operates in an oversight mode, wherein the contractor presents documentation that specific milestones have been achieved before payment is released. With the pressures of making payroll, paying subcontractors, and other vendors, the contractor's cooperation is usually prompt. The owner/licensee may also be responsible for maintaining operable systems important to decommissioning, using existing personnel to perform these activities.

5.4. Types of contracting methods

The type of contract negotiated between the owner/licensee and the contractor (or the contractor and subcontractors) is a powerful mechanism to control costs and maintain a project within budget and schedule. The driving force of competition among contractors will lead them into committing to perform the work and to absorb a certain amount of risk in return for a potentially attractive return (fee). The more risk they absorb, the higher the potential fee to the contractor, and conversely, the potential for greater losses if they cannot perform the work scope within the agreed upon contract price and face major financial losses. The owner/licensee balances the benefits of putting a contractor at risk, versus sharing the risk to ensure the project is completed successfully. When the facility site conditions (i.e. characterization) are not well known, the owner/licensee accepts some of the risk and structures the contract to protect both the owner and the contractor for a win-win situation.

5.4.1. Fixed-price (lump sum) contracts

Fixed-price contracts (also called lump sum) involve contractor bids on a fixed scope of work within a fixed period of time and for a single price. All of the contractor's costs for labour, material, equipment (direct costs), and overhead, general and administrative expenses (indirect costs), contingency and profit are included in the lump sum. Milestones are established for the purposes of progress payments, but the owner/licensee does not have access to the contractor's cost basis or fee. The fixed price is unchangeable unless the work scope changes and the owner/licensee agree to the terms and conditions of the extra cost.

This type of contract favors the owner/licensee in that the contract value is known and not readily subject to change. However, it does require a comprehensive and accurate site characterization that is agreed upon between the owner/licensee and the contractor before the contract is signed. In one such arrangement, the owner/licensee required the prospective bidders to direct the characterization team retained by the owner to sample and survey any area of the plant where the bidders believed there might be contamination. The resulting sample information was made available to all bidders to assist them in preparing their fixed-price cost estimates. Upon award of the contract, the successful bidder was not permitted to claim out-of-scope change orders for reasons of new or undiscovered contamination. Five major contractors bid on the project and the successful bidder agreed to these terms. The owner/licensee was assured of a fixed cost, even though one or more subcontractors had to complete the work at as much a twice their original bid price. The risk to the owner/licensee in this type of contracting is that the contractor backs out of the contract and either faces severe financial difficulties, allows the bonding company (if used) to hire a contractor to finish the work, or pays the liquidated damages. These interruptions could significantly delay progress on the project at additional cost to the owner/licensee.

5.4.2. Time and material contract

This type of contract is used where the owner/licensee has not performed an adequate characterization of the facility, or such detailed characterization is not possible because of poor documentation of prior history or because of extremely high radiation/contamination areas prohibiting manual access for sampling and surveying. Other reasons may include an indeterminate work scope, wherein the working conditions are likely to change as the contractor progresses in the planned project. The contractor is expected to provide its best estimate of the cost for owner/licensee budgeting purposes, but is allowed to charge his normal direct and indirect costs, and profit on an hourly basis for the crew and management team assigned to the project for the duration on the job. There is no contingency for the contractor included in this type of contract. This type of contract is usually written for relatively small, unique projects where the total budget is within the capabilities of the owner/licensee. Sometimes, time and material contracts may be imbedded within a larger fixed price contract for the special conditions mentioned earlier.

5.4.3. Cost-plus-fixed fee contracts

This type of contract is a compromise between the former two types. It provides reimbursement of direct and indirect costs to the contractor, and a negotiated fixed fee for the overall project. Direct and indirect costs and an earned percentage of the fixed fee are paid on a milestone completion basis. There is no contingency for the contractor included in this type of contract. For projects where the scope is subject to change, the contractor is protected from uncertainties and the owner/licensee’s costs are under greater control than under a time and materials contract. The only risk to the contractor is if the project takes considerably longer to complete than anticipated, and the overall fee percentage begins to dwindle. The contractor continues to commit experienced labour resources at a diminishing profit.

5.4.4. Target cost-plus-incentive-fee

Both owner/licensee and contractors favor this type of contract since it provides a high degree of control by the owner/licensee, and a reward for good performance to the contractor. The contractor bids the target cost (including direct and indirect costs, and usually contingency) for the project and negotiates a percentage incentive fee for completing the job sooner at lower cost. It encourages creativity and high productivity of the workforce to improve on the target cost, while also boosting morale of the workforce to feel pride in their accomplishment. Often, the contractor shares the incentive fee with its key personnel for successfully achieving cost and schedule improvements. However, the owner/licensee usually provides for a penalty if the contractor fails to meet the target cost or schedule, deducting a proportionate amount from the incentive fee for cost and schedule overruns. Other penalties may be imposed if the contractor work practices result in safety violations or injury to workers or the public. The competitive bidding process ensures the bidder will not inflate the target cost unreasonably, as the next bidder is likely to attempt to under-bid the work.

5.4.5. Target cost-plus-incentive-fee with shared savings

This type of contract is identical to the previous arrangement, except the owner/licensee and contractor share in the savings achieved in performing the work below the targets. Under this arrangement, the owner/licensee has a vested interest to assist the contractor to meet its targets, rather than to be in an adversarial role. Working as a team generally improves productivity, morale, and efficiency, thereby improving target performance.

5.4.6. Other arrangements

Other contractual arrangements are possible following these examples of standard contract terms and conditions. In the end, the owner/licensee has a better chance of succeeding to meet its objectives of cost control and schedule if it participates in a cooperative manner with the contractor. Owner/Licensees, who seek to drive the contractor to the brink of bankruptcy, usually end up paying for poor performance, incurring safety risks, schedule delays, and cost overruns.

5.4.7. Written agreement of project original scope and schedule

While the contract between the owner/licensee and the decommissioning contractor may identify the scope and schedule in broad categories, a more detailed scope and schedule document is prepared to ensure there is total agreement between the parties before the work begins. Failure to implement such agreements has resulted in adversarial relationships between the parties and usually is settled in litigation at significant additional cost. This agreement is a living document as scope changes are implemented and periodically updated to record change orders. The level of detail in this agreement is greater than what is recorded in the contract modifications.

5.5. Project cost and schedule controls

A rigorous project cost and schedule control system is one of the methods to control and prevent costs from escalating beyond budgeted amounts, and to complete the project safely within budget and schedule. Project management controls available to the owner/licensee and the decommissioning contractor follow accepted and proven methodologies widely used in both the construction and decommissioning industry. The methodology involves dividing the project into phases establishing a detailed WBS as described in Section 3 herein. Project baselines are established for costs, schedule, occupational radiation exposure, waste generation and any other parameter appropriate to the project that is to be closely monitored. A Program Evaluation and Review Technique (PERT) is used to monitor performance of the project baselines, with a variance analysis performed for each baseline as the project is implemented. The methodology provides a rational basis for forecasting the estimated costs at completion to compare against the projected budget.

Appendix A provides an overview of the process, baselines, variation analysis tools and forecasting methods available to control costs and schedule.

6. OPTIONS FOR DECOMMISSIONING FUNDS AND THEIR EXPENDITURE

If the magnitude of the initial liability remains constant with time, the changes to the payment stream need only be responsive to changes in the general economy. However, decommissioning liabilities can be more volatile with increases or decreases in the cost of decommissioning, which is sensitive to changes in regulations, waste disposal policy, politics and plant conditions as the generating facility ages. Consequently, a funding plan developed for decommissioning a facility needs to be more responsive than for plans designed for the retirement of conventional assets. Nuclear decommissioning trusts need to be adequately funded, disbursements restricted to pre-identified trust fund objectives and be designed to permit sufficient flexibility such that the facility owner can pursue the most advantageous disposition alternative at the cessation of operations. It is important, therefore, that the trust be periodically reviewed and updated to respond to any changes in the requirements for the remediation of the facility as they occur. Early recognition and funding takes full advantage of the remaining period of operation for investment growth.

The IAEA has stated its position regarding financial assurance as follows:

> *"A mechanism for providing adequate financial resources shall be established to cover the costs of radioactive waste management and, in particular, the cost of decommissioning. It shall be put in place before operation and shall be updated, as necessary. Consideration shall also be given to providing the necessary financial resources in the event of premature shutdown of the facility"[14, para. 3.17].*

The concept of establishing decommissioning trust funds was to ensure withdrawal of funds for purposes other than decommissioning would not occur. There are numerous examples where funds established for pensions, or supposedly dedicated for replacement equipment were used by companies for other purposes. When the time came for actual dispersal for their intended purpose, the funds were inadequate or missing entirely. Regulatory bodies therefore established rigorous rules to control the access to these decommissioning funds and the timing as to when they could be withdrawn.

Another element of this issue is whether it is necessary for all of the funds to be available at the time decommissioning is begun. In some cases, particularly for premature shutdown, the trust fund may not be fully funded and a strategy is developed and accepted by the regulatory body to allow the decommissioning to proceed as the fund grows. Alternatives to this issue include consideration of whether deferred dismantling is an acceptable approach. What remedies are available in the event of a shortfall of funding? Are there acceptable solutions to the regulatory bodies?

This section will identify some of the regulatory approaches and options used to control decommissioning expenditures during the phased approach of project management from pre-shutdown engineering and planning, post-shutdown project initiation, and full project implementation.

6.1. Withdrawal of funds for engineering and planning

Some regulatory bodies have established specific guidelines identifying the types of expenditures that may be made in preparation for decommissioning. Engineering and planning activities are expenditures that come under these guidelines. Specific controls may be implemented by the regulatory body or other governmental agency to ensure the owner/licensee does not have the authority to withdraw funds without an independent regulatory oversight as to how these funds are to be used.

6.1.1. Prior to facility permanent shutdown

Prior to facility permanent shutdown, the owner/licensee needs to provide a preliminary decommissioning cost estimate to determine if there are adequate funds available to begin decommissioning. This allows the owner/licensee additional time to adjust collections to make up any shortfall in funds so safety during decommissioning will not be compromised. The cost to prepare these cost estimates is usually considered as a legitimate decommissioning fund expense.

6.1.2. Following facility permanent shutdown

Following facility permanent shutdown, detailed engineering and planning activities are performed as discussed in other sections of this report. These activities include transition expenses necessary to address the transition from operations to decommissioning. In general, they do not include physical changes to the facility, removal of equipment, or purchase of dismantling or demolition equipment.

6.1.3. Withdrawal amount limitations

To ensure owner/licensees do not abuse this feature, specific limitations are imposed by the regulatory body as to the amount that can be withdrawn from the trust fund. A goal might be a limit of three percent of the total decommissioning cost that may be expended on engineering and planning activities during the lifetime of the facility.

6.2. Withdrawal of funds for decommissioning implementation

As decommissioning physical activities represent the largest portion of the decommissioning funds, similar controls are established by regulatory bodies to ensure funds will be spent appropriately. Spending limits are established relative to specific milestones to require certain documents to be submitted for review before withdrawal of funds will be permitted.

6.3. Funding availability at shutdown

The previous discussion focused on adequate preplanning for decommissioning so full funding would be available at shutdown. However, that is not always the case and numerous owner/licensees have been faced with inadequate funding at shutdown. Such cases arise when a facility is shut down prematurely and the contributions to the trust fund have not had sufficient time to build up to the full amount needed, or the performance of the trust fund in the financial markets has been poor and inadequate funds are available at time of shutdown. Planners for decommissioning need to address these issues so that work can proceed expeditiously and safely.

6.3.1. Premature shutdown

Numerous facilities in the United States of America and in Europe have faced with premature shutdown (before the end of their licensed lives). The reasons may be technical, where performance of the facility does not meet safety criteria; operational, where reliability has been poor; financial, where the economics of operation of the nuclear facility in a competitive environment with fossil-fueled or hydroelectric generation facilities has not been favorable; or political, where the local populace and government are not in favor of nuclear facilities. In any event, early shutdown of the facility precluded adequate collection of trust fund monies from the ratepayers (consumers).

In such cases, regulatory bodies have established guidelines to deal with this situation. It may be required that implementation of decommissioning activities not be started until all funds are accumulated in the trust. However, if the owner/licensee can demonstrate that it has the capability to augment the fund shortfall by additional collections, the decommissioning work may be allowed to proceed. In countries where the government is responsible for funding decommissioning, it ensures that adequate funds will be available as decommissioning proceeds.

6.3.2. Trust fund performance

Trust funds are usually invested in low risk, low interest bearing investments. The fund performance can vary with the economic changes taking place in the markets, and shortfalls are likely to occur periodically. The owner/licensee monitors the fund performance and makes appropriate adjustments to the fund balance to ensure adequate funds will be available when needed.

6.3.3. Decommissioning cost escalation

Decommissioning costs have escalated over the years at rates generally higher than normal inflation rates. The cost drivers are typically more rigorous regulatory requirements, the rapidly rising cost of waste disposal, and technical scope changes from the owner/licensee or the stakeholders. In any event, the trust fund needs to keep pace with these escalation factors through earnings on the investments, or decommissioning cannot proceed.

6.3.4. Deferred dismantling

An alternative to increasing the level of payments to the fund is to consider deferred dismantling. In principle, if decommissioning is delayed for several decades the trust fund growth may have sufficient time to build up to the amount needed to complete all the work. However, there is some risk that the fund performance may not be sufficient or decommissioning costs may rise faster than the fund growth. Projections of fund growth based on historic models can be deceptive and close monitoring of the gap between costs and fund balance is required to provide assurance funds will be available when needed.

7. SOCIAL IMPACTS OF DECOMMISSIONING

The financial aspects of decommissioning facilities that have used or use radioactive material raise important issues that go beyond the costs of physically removing radioactivity and dismantling/demolishing the facility. There are direct costs for the operator associated with personnel changes resulting from the transition from operation to decommissioning, and ultimately to the complete cessation of all work at the facility. In addition to such direct costs to the operator, decommissioning of a large nuclear facility can result in significant indirect economic and social impacts on the surrounding community.

Direct impacts are typically similar to those encountered in other industries and are generally recognized to be the operator's responsibility, for example severance pay, worker retraining, special measures to attract and retain appropriately-qualified staff, and so on.

Indirect impacts include those on the surrounding community that may result from the loss of jobs, reductions in the tax base and impacts on service industries. The responsibility for the costs of these impacts is not necessarily the operator's, but successful resolution may be a prerequisite to acceptance of a decommissioning project. The issues are brought to light during decommissioning planning in order to allow political and social decision-making to enable the satisfactory completion of the decommissioning project.

In some cases, facilities were constructed in remote regions of the country where little or no regional resources of personnel, residences, and local services previously existed. For many of these facilities, entire towns, roads, schools, and fire, police, and hospital services were constructed to serve the workers. Dealing with this infrastructure while terminating facility operations poses complicated social issues for both the operator and the community.

Depending on the facility and the corresponding infrastructure, two different cases can be identified:

(1) Facility/site with created local community (NPP, nuclear research centres, etc).

(2) Facility/site without created local community (research reactors, hospitals, etc).

The role of social factors for the first case is very important for successful decommissioning of the facility. In this case, the final stage of decommissioning and the future of the nuclear site can determine the social needs. Inadequate consideration of social needs can significantly hinder the decommissioning and create political problems to accept the project by the local population.

The impact of the social needs for the second case is smaller since the community was not created specifically for the facility. Despite this, such factors like unemployment, local municipality tax changes, and staff training for decommissioning are considered during the decision-making process.

In assessing the requirements for financial provisions for decommissioning costs, it is generally accepted that direct costs, including such items as costs associated with changes in the operator's workforce, need to be included in the cost estimates and financial provisions. Indirect costs are much more difficult to account for, since the owner's responsibility, if any, is generally determined on a case-by-case basis, depending on the particular situation at the place and time decommissioning occurs. In some cases, some of these indirect costs may be considered a regional or national responsibility, while in others the owner of the facility may also contribute to their resolution.

7.1. Direct social and economic impacts of decommissioning

Plant shutdown affects management, staff, and workers with respect to future employment opportunities. During decommissioning, most owner/licensees attempt to employ as many existing employees as possible to capture their experience and facilitate decommissioning operations. This approach is widely used for countries without decommissioning experience and a corresponding infrastructure. However, since some employees' experience or skill sets are not adaptable to decommissioning, special consideration to provide job opportunities in the community or elsewhere may be required.

1. Job training for decommissioning

In anticipation of plant shutdown, many owner/licensees notify employees of the impending employment termination and take proactive steps to prepare them for the shutdown actions. Those employees needed to support the decommissioning are given specialized training to prepare them for their new responsibilities. This may include sending them to special or related courses so they can virtually step into their new jobs as decommissioning workers when the time arrives. Those not needed to support decommissioning are provided with opportunities to interview with potential new employers.

2. Retention funds to keep key employees

Prior to announcing the permanent shutdown of a facility, management needs to identify those employees who are essential to decommissioning operations. These employees may be offered attractive incentive plans to retain them through specific milestones of the project.

3. Severance funds for redundant employees

Those employees who are not required to perform the activities for decommissioning may be offered employment in other parts of the company, or a severance package and specific date of termination. The severance package may be the company standard severance amount or it may be increased in recognition of the circumstances surrounding the termination.

4. Job re-training for employees

In some cases, companies have provided job re-training, either onsite or at special courses offered at local universities and private schools. Such re-training programs go far in maintaining good relations within the community and with the remaining employees.

The costs of these direct measures need to be estimated and provided for by the operator. In some cases, these costs may be considered operational, but in many others they are recognized as part of the decommissioning costs and included in the decommissioning funding provisions.

There are close links between these impacts and the choice of the decommissioning strategy. For example, the cost of re-training employees needs to be assessed vis-à-vis the cost of employing an experienced contractor to perform some or all of the decommissioning work.

Dealing with issues such as training, severance and incentive packages can have a significant impact on worker morale and on safety, both before and during decommissioning. For example, as shutdown of the facility approaches, worker morale can be affected negatively, perhaps to the extent of affecting safety culture and increasing rates of accidents. It is therefore important that the management of the facility anticipates such potential impacts and takes appropriate measures to prevent negative consequences.

7.2. Indirect social and economic impacts of decommissioning

As noted earlier, local communities formed by the construction and subsequent operation of the facility are also affected by its decommissioning. Shutting down the facility greatly affects the local community and its long-term survival. The effect is felt on the employment levels, local business and services, schools, police and fire organizations, and on local entertainment facilities.

Facility shutdown may have a great effect on the contributions to town taxes. Often the owner/licensee is a large contributor to the local municipality's tax base. Reduction or loss of this income could drive the town into a downward spiraling financial position, jeopardizing its survival. The loss of tax income may mean reductions in services and increases in the tax burden on other businesses and residents.

Those terminated workers who cannot find employment in the local communities may be forced to relocate their families to other regions. This has the impact of disrupting family ties, where offspring who have settled into the community would undergo personal hardship in the uprooting of relationships. Relocation may even require selling homes at below their normal market value to generate cash to purchase a replacement home in another community. The secondary effect of numerous homes coming on the market simultaneously is known to drive down the value of homes in the area. This might attract new business if the community is perceived as a growing community. If not, it could be detrimental to the economic survival of the remaining residents.

Local businesses affected by the plant shutdown are likely to take the same or similar course of action as terminated employees. Businesses thrive on income and growth. Without these two factors, businesses are likely to relocate, causing a spiraling effect on the community. Some businesses may seek new business opportunities by relocating. Others may change their focus or the types of services they provide.

One way to offset the impact of a nuclear facility shutdown is for the local community to attract replacement industries. Owner/licensees can be instrumental in assisting town planners to make this happen. For example, when an NPP is decommissioned, replacement generating stations can be constructed using the existing infrastructure at the site, complete with electrical transmission equipment and power lines, water resources and a ready labour pool. The value of these nuclear sites for replacement power generation is well acknowledged and the continued job opportunities for the existing workers would resolve or alleviate many of these social issues. Beyond that, the existing owner/licensee can be influential by working with the town and other industries to promote the relocation of other industries to the community.

It is difficult to determine a priori who should be held responsible, and to what extent, for the costs of these indirect impacts. In the case of a nuclear facility built in a pre-existing community, the indirect costs may be borne entirely by the community, as would be the case for any other business in the region. In the case of a purpose-built community, it may be decided that the operator should contribute financially to the resolution of the indirect effects. In all cases, however, it is likely that the decision will be finalized only when the facility is shut down, and that the resolution of these issues may be a time-consuming process. It is therefore difficult to include such indirect costs in the financial provisions required to be set aside during the operational stages. Nevertheless, it is important that the indirect cost issues be identified, evaluated, and discussed as early as possible in the planning process for decommissioning, because of the significant impacts they can have on the decommissioning strategy and costs.

Appendix B provides additional guidance on the social impacts of decommissioning.

8. RECOMMENDATIONS

The international community has recognized the importance of establishing decommissioning funds to prepare for the eventual permanent shutdown of facilities. The safe performance of decommissioning activities is dependent on adequate funds to complete the work without risk to public and worker health and safety, and the environment. The social issues relating to the local impact of facility permanent shutdown also require consideration of adequate funding and planning to minimize the impact on the community. Whether a facility is owned by a government body or a commercial facility owned by a private company or shareholder investors affects how the funds will be provided and the assurance level that the funds will be adequate. Since decommissioning is normally a long-term program, planning begins virtually at time of startup to ensure proper steps are taken to assure funding adequacy. In the case of premature shutdown, time for planning is abbreviated and attention is paid to the same issues in an accelerated manner. This section will summarize the recommendations for financial planning for decommissioning.

8.1. General long term planning recommendations

8.1.1. Nuclear power plants

Planning begins at the time of facility startup or sooner. While the long-term objectives may not be clearly defined, the basic concepts of either immediate dismantling or deferred dismantling are basic to identifying the elements of planning. Such long term planning includes the following:

(1) Prepare a detailed cost estimate in a manner that can be updated periodically as conditions change.

(2) Prepare a funding plan so it can be adjusted periodically.

(3) Seek and secure approval from regulatory bodies to collect funds for contribution to the trust fund.

(4) Establish a core group within the organization to follow decommissioning issues throughout the life of the facility.

(5) Prepare a preliminary transition plan to identify the functional personnel and activities needed to transition from operations to decommissioning.

(6) Work with regulatory bodies to support them in the development of regulatory actions and rules.

(7) Maintain an open dialogue with local politicians and the public, and hold public meetings to keep everyone informed on developments affecting the community.

8.1.2. Government owned facilities

Planning the decommissioning for government owned facilities takes a slightly different course. Since taxpayers will ultimately provide funding in the year(s) needed for expenditure, long term financial planning will not require early contributions to a trust fund. Nevertheless, knowledge of the costs for decommissioning can alter long term planning for decommissioning. Long term planning includes the following:

(1) Prepare a detailed cost estimate in a manner that can be updated periodically as conditions change.

(2) Establish a core group within the organization to follow decommissioning issues throughout the life of the facility.

(3) Prepare a preliminary transition plan to identify the functional personnel and activities needed to transition from operations to decommissioning.

(4) Maintain an open dialogue with local politicians and the public, and hold public meetings to keep everyone informed on developments affecting the community.

8.1.3. Commercially owned facilities

Commercially owned facilities include small research reactors, hot cell facilities, radioactive source fabrication facilities for field x-ray examination services, and other isotope generation facilities. In general, the owner/licensees have to demonstrate to the regulatory body that sufficient funds have been placed in an external trust or a financial instrument (insurance policy, certificate of deposit, or other such guarantee) is available to pay for decommissioning. The specific structure of these guarantees varies from country-to-country. Long-term planning includes:

(1) Prepare a detailed cost estimate in a manner that can be updated periodically as conditions change.

(2) Demonstrate funding or a funding plan is available so it can be adjusted periodically, subject to the financial review of the regulatory bodies.

(3) Establish a core group within the organization to follow decommissioning issues throughout the life of the facility.

(4) Prepare a preliminary transition plan to identify the functional personnel and activities needed to transition from operations to decommissioning.

(5) Work with regulatory bodies to support them in the development of regulatory actions and rules.

(6) Maintain an open dialogue with local politicians and the public, and hold public meetings, to keep everyone informed on developments affecting the community.

8.2. General short term planning recommendations

8.2.1. Nuclear power plants

Short term planning will usually be associated with premature shutdown of the facility prior to its license expiration. Such action may be prompted by poor operating performance of the facility, poor economic performance relative to competing technologies, or a reversal in political support for the facility. In any event, the relatively short time available for planning will affect the ability and timing to collect sufficient funds to decommission the facility promptly. The steps that can be taken under these circumstances should include the following:

(1) Update the existing decommissioning cost estimate or create a new cost estimate if one does not exist.

(2) Evaluate the existing trust fund balance relative to the amount needed to decommission as identified in the cost estimate.

(3) Solicit the regulatory body for permission to collect additional funds to accumulate the needed decommissioning amount. Note that if a government agency or the public directed the permanent shutdown (by order or mandate) of the facility, there may be recourse through government funding sources to supplement the trust fund.

(4) Notify shareholders there may be a need for additional funds to supplement the trust fund balance. The note regarding directed or mandated shutdown applies in this case as well.

(5) Meet with regulatory bodies with respect to current applicable laws, regulations and guidelines to implement decommissioning.

(6) Prepare a preliminary transition plan to identify the functional personnel and activities needed to transition from operations to decommissioning.

(7) Begin an open dialogue with local politicians and the public if not already established, and hold public meetings to keep everyone informed on developments affecting the community.

8.2.2. Government owned facilities

Short term planning for government owned facilities is more difficult to implement. Generally, the lengthy process of identifying the financial liability (cost estimate and schedule), requesting funding through the budgetary process, securing legislative approval and authorization of spending can take years to implement for large nuclear installations. If the government chooses to use an organization other than the incumbent facility operator to manage the decommissioning, a formal bid solicitation process is normally used to ensure fair bidding procedures. A bid specification is prepared, distributed to interested bidders, source selection board appointed, site tours arranged, and responses to bid specification questions prepared and distributed to all bidders. When bids are received, the source selection board reviews all bids, creates a list of bid contractors within the competitive range, conducts oral presentations to further examine the competitive bidders and then awards the contract. This bidding process has been known to require several years. Hence, the short term planning for government owned facilities is effectively non-existent.

8.2.3. Commercially owned facilities

Short term planning for commercially owned facilities is essentially identical to long term planning because of the relatively small size of these facilities and lower cost of decommissioning. Commercial facilities generally have no defined economic or technical life as in the case of nuclear power plants, and the operating lifetime is more likely governed by the market forces controlling the product or services produced. Accordingly, the short term planning is essentially the same as long term planning and the decision to implement decommissioning is a relatively straightforward process.

8.3. Specific recommendations

In light of the issues discussed in this report, specific recommendations are provided for each of the major areas related to assuring the adequacy of funding for decommissioning. These are summarized in the following paragraphs.

8.3.1. Recommendations for cost estimating

(1) Prepare cost estimates on a site-specific basis.

(2) Review and adapt the EU, OECD and IAEA report, “A Proposed Standardized List of Items for Costing Purposes in the Decommissioning of Nuclear Installations” [2] for development of site-specific cost estimates.

(3) Prepare a Work Breakdown Structure (WBS) of the site-specific activities for the facilities to be decommissioned.

(4) Address whether spent fuel storage and disposal costs are to be included in decommissioning costs and funding.

(5) Base the cost estimate and planning on the historical site assessment and detailed characterization performed for the facility.

(6) Address how waste will be transported and disposed in accordance with applicable regulations and identify available disposal facilities.

(7) Evaluate whether the owner/licensee will self perform the management and implementing of decommissioning or whether a contractor will be used.

(8) Evaluate the facility shutdown activities and sequencing necessary to prepare the facility for decommissioning.

(9) Estimate the costs for procurement of general equipment and material.

(10) Estimate the cost of dismantling the facilities.

(11) Determine the cost of waste disposition and appropriate alternatives.

(12) Include the costs for security, surveillance, and maintenance.

(13) Include the costs of site remediation and landscaping, if appropriate.

(14) Include the costs for project management of both the licensee/owner and the contractors, if used.

(15) Include contingency in the estimate for unexpected costs that are likely to occur.

(16) Evaluate the level of detail of costs needed for the estimate — order of magnitude, budgetary or definitive estimates.

8.3.2. Recommendations for collection and management of funds

(1) Government regulatory authorities need to establish a legal basis for requiring financial assurance.

(2) Contributions to the fund are to be made from the nuclear installations (except for government-owned facilities where funding is provided by the state).

(3) The financial resources earmarked for decommissioning are to take into account all the expenses related to the decommissioning project "from the cradle to the grave"

(4) A distinction between nuclear and non nuclear electricity is preferable, and contributions are to be proportionate only to the sold nuclear kWh

(5) In line with the principle of transparency, fund adequacy needs to be reviewed and managed periodically, with all commercially non-sensitive information open to the public.

(6) Funds are only to be used for the purpose for which they have been established.

(7) Use the current value, or net present value methods to evaluate funding adequacy for future decommissioning activities.

(8) Evaluate whether collection of funds must be made over the operating life of the facility, a selected shorter period, a prepayment before startup and operation, or paid up front at the start of decommissioning activities.

(9) Consider licensee/owner management of funds, or external trust fund managers.

(10) Monitor the adequacy of the fund balance, and investment performance of the trust funds.

(11) Provide for the potential for premature shutdown of the facility.

(12) Make sure that financial resources are available when needed.

(13) Consider the tax treatment effects on the fund balance.

(14) Addressing the principle of transparency may be more difficult in the case of internally managed funds, and consequently ensuring that the basic principles (adequacy, availability and use) are also fully met.

8.3.3. Recommendations for reducing costs

(1) Establish the principle that the primary responsibility of the licensee/owner is the protection of the worker, the public and the environment.

(2) Review and include in the planning for decommissioning the learning experiences from other facilities that have been decommissioned.

(3) Use proven technologies from international experiences.

(4) Consider reuse of systems and structures as a means for reducing costs.

(5) Manage fund expenditures using a contractor or by self-performing the management.

(6) Evaluate the various types of contracting methods including fixed-price (lump sum), time and materials, cost plus fixed-fee, and target plus incentive fee or shared savings.

(7) Ensure there is a written agreement of the project scope, cost and schedule.

(8) Enforce a rigorous project cost and schedule control system to control costs.

8.3.4. Recommendations for options of decommissioning fund expenditure

(1) Ensure regulations are established to limit expenditures for approved activities — engineering and planning, dismantling and site restoration.

(2) Prepare cost estimates prior to shutdown to quantify the magnitude of the liability and fund adequacy.

(3) If funds are not adequate at time of shutdown (premature shutdown), delay decommissioning activities until funding levels can be built up to adequate levels.

(4) Monitor trust fund performance and adjust collections accordingly.

(5) Monitor decommissioning cost escalation and adjust funding accordingly.

8.3.5. Recommendations on social impacts

(1) Direct costs of decommissioning activities are generally included in funding.

(2) Indirect costs of social impacts are determined on a case-by-case basis. Sometimes indirect costs are a regional or national responsibility.

(3) Direct costs include job training for decommissioning, retention funds for key employees, severance funds for redundant employees and job re-training for employees for future job opportunities.

(4) Indirect costs may include the effect on town taxes, employment levels in the community, market value impact of homes vacated by employees relocating to other jobs and communities, and the effect on local businesses. The degree of impact of indirect costs must be evaluated and the responsibility of payment of these costs determined.

(5) Pre-shutdown pre-planning evaluates these indirect costs and what can be done to offset the effects. This might include constructing a new power generation facility at the site or inviting new businesses to the community.

International experience in decommissioning funding is a valuable resource for guidance on the issues discussed in this publication. The decommissioning planner is advised to take full advantage of this knowledge and apply it to the specific facility being or planning to be decommissioned.

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Appendix A

PROJECT COST AND SCHEDULE CONTROLS

Project management controls available to the owner/licensee and the contractor follow proven methodologies within the construction and decommissioning industry. The overall objective is to ensure the project is competed safely, and within budget and schedule. The Project Management Institute (PMI) [A1] recommends a project be divided into phases for tracking costs and schedule, using a Work Breakdown Structure (WBS) approach for identifying cost items. The Association for the Advancement of Cost Engineering International (AACEI) [A2] endorses a cost and schedule control methodology also based on a WBS. The work should be divided into the various phases of the project to track progress, and to identify variances in meeting budget and schedule. The WBS shown in the EU/OECD (NEA)/IAEA, "Standardized List of Cost Items" [A3] provides a starting point for developing the project WBS.

A.1. PROJECT WORK BREAKDOWN STRUCTURE (WBS)

Decommissioning project phases can generally be related to the recommended PMI phases as follows:

PMI phases	Decommissioning phases
Project initiation	Pre-shutdown planning
Planning — preliminary studies	Post-shutdown pre-planning
Planning — detailed design	Post-shutdown detailed planning
Execution	Decommissioning activities and license termination
Controls	Project management (all phases)
Closeout	Site restoration

Using the Standardized List of Cost Items as a guide, the cost and schedule estimator may develop a site-specific WBS for each project.

A.2. Project baselines

Project baselines are established during the initiation phase of the project to monitor and control the processes and activities throughout the programme. They provide management with feedback as to how the project is managed, and whether intervention at higher levels is necessary to prevent a safety incident, or cost and schedule overruns (or other parameters such as occupational exposure, waste quantities generated, etc.).

A.2.1. Baseline cost estimate

As mentioned earlier, a baseline cost estimate is a key ingredient to the detailed planning phase of the project. This estimate is usually prepared after a detailed characterization of the facility, wherein the essentially static conditions of radioactive contamination can be determined from historical assessments and actual field measurements. The scope of planned work can be clearly identified for the conditions existing at the facility at a fixed point in time.

Estimates of the planned activities can be made based on the inventory of equipment and structures that must be decontaminated, removed, packaged, and shipped for disposal. The size of the management organization can be established and the duration of the project determined. Usually the WBS is developed to identify specific milestones for completion. Costs to accomplish each element of the WBS are used as the control measurement parameter.

A.2.2. Baseline schedule

In like manner, the schedule for performance of these WBS elements is identified and used to measure performance progress. The schedule is developed in concert with the costs to establish the size of the field labour resources required to accomplish the work. A precedence network is established to show the inter-relationship of WBS elements and associated costs.

A.2.3. Program evaluation and review technique

A Program Evaluation and Review Technique (PERT) is used to monitor performance of the project based on the baseline cost and schedule estimates. This process, also called a cost and schedule control system, relies on several parameters developed for specific activities in the WBS. The AACEI, "Certification Study Guide," [A2] provides the following definitions of management performance measurements for a project, and guidance in applying these measurement parameters to control a project.

A.2.3.1. Cost and schedule parameters

BCWS	=	Budgeted Cost of Work Scheduled	What was planned to be done
BCWP	=	Budgeted Cost of Work Performed	What was done at budget rates
ACWP	=	Actual Cost of Work Performed	What was paid for the work
BAC	=	Budget at Completion	Original budget plus changes
EAC	=	Estimate at Completion	Actual cost plus estimate to complete
	=	(ACWP) + (BAC – BCWP)	
CV	=	Cost Variance	Earned work minus actual cost
	=	(BCWP) – (ACWP)	
SV	=	Schedule Variance	Earned work minus work planned
	=	(BCWP) – (BCWS)	
SPI	=	Schedule Performance Index	Measure of schedule performance
	=	(BCWP) ÷ (BCWS)	
CPI	=	Cost Performance Index	Measure of cost performance
	=	(BCWP) ÷ (ACWP)	

Cost and schedule variance are usually given an action range of acceptability wherein an explanation for overrun or under-run is explained in a statement of the problem, cause, and corrective actions planned or taken to bring the specific activity into conformance. This variance analysis is self-correcting in that overstatement of a correction is accountable within the next reporting period. That is, if the proposed correction is insufficient, the following reporting period will show a continuing variance, and additional correction will be required. The relationship between BCWS, BCWP, and ACWP is shown in Figure A.1.

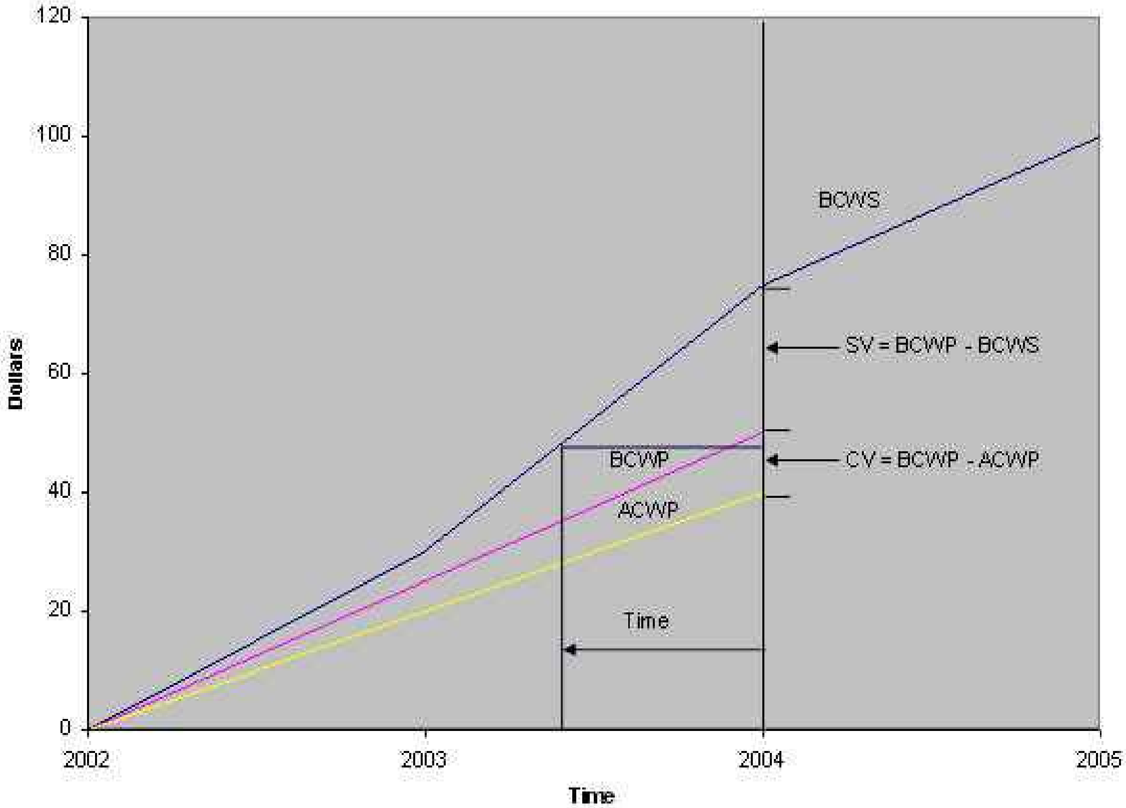

Figure A.1: Relationships of BCWS, BCWP, and ACWP.

A positive variance and an index of 1.0 or greater indicate favorable performance. The project manager will usually establish dollar, man-hour, or percentage thresholds requiring variance analyses. The thresholds may be based on the year-to-date BCWS, as follows:

BCWS < $250,000	%CV = (BCWP – ACWP) x 100 ÷ BCWP	= ± 10% and
	$CV = (BCWP – ACWP)	= ± $15,000
	%SV = (BCWP – BCWS) x 100 ÷BCWP	= ± 10% and
	$SV = (BCWP – BCWS)	= ± $8,000
BCWS ≥ $250,000	$CV = (BCWP – ACWP)	= ± $25,000
	$SV = (BCWP – BCWS)	= ±$15,000

(Note: These percentages and dollar values are for illustrative purposes and do not represent recommendations. The management organization needs to establish the thresholds and ranges of variability for each project.)

A.2.3.2. Earned Value Parameters

EV	=	Earned Value	(% complete) x (BAC for that account)
Overall =		Overall Progress	$\frac{\text{BCWP for all accounts}}{\text{BCWS for all accounts}}$

Performance measurements using the SPI and the Critical Path (CP) Total Float (TF) is another way to monitor project performance.

TF > 0

SPI > 1.0 Ahead of schedule on CP; more work being done than planned

SPI = 1.0 Ahead of schedule on CP; some shortfall in work on non-critical activities

SPI < 1.0 Ahead of schedule on CP; significant shortfall in work on non-critical activities

TF = 0

SPI > 1.0 CP on schedule; more work being done on non-critical activities than planned

SPI = 1.0 CP on schedule; total work volume as planned

SPI < 1.0 CP on schedule; shortfall in work on non-critical activities

TF < 0

SPI > 1.0 CP activities behind schedule; total work more than planned; indicating excess attention to non-critical activities

SPI = 1.0 CP activities behind schedule; total work volume as planned; indicating too much attention to non-critical activities

SPI < 1.0 CP activities behind schedule: total work less than planned; need more overall effort

A.2.3.3. Forecasting parameters

There are three methods for forecasting:

(a) Forecast Costs EAC = (ACWP) + (BAC – BCWP)

(b) Forecast Rate of Progress EAC = BAC ÷ CPI

(c) Forecast Using Curves by extrapolation

A.2.4 Baseline radiation exposure estimate

In a similar manner, a baseline occupational radiation exposure estimate may be prepared for each major activity at the beginning of the project, and actual exposure is recorded and compared against the baseline value for that activity. Variances against this baseline are explained and corrective actions identified to bring the activities into conformance.

A.2.5 Other control parameters

Additional parameters may be established for monitoring and control of the project, depending on the activities to be performed. These might include generated waste volumes or weights, number of shipments of waste per reporting period, and the number of reportable safety incidents or accidents. The number of such additional parameters is evaluated relative to the anticipated risk associated with a specific activity and the overall effect on completing the objective in a timely and safe manner.

A.3. Project milestone identification for fee/incentive/sharing basis

As discussed under Section 5.2.5 of the main report (Target Cost-Plus-Incentive-Fee with Shared Savings), specific milestones may be established annually, or for shorter duration projects, for the entire project using these project control parameters. Typically, the owner/licensee assigns a Task Manager to each major activity. The Task Manager walks the site daily/weekly with the decommissioning contractor's superintendent(s) to assess progress against each milestone. Immediately prior to invoicing for the work accomplished, the Task Manager and superintendent will agree on the percent complete and earned value achieved. The incentive amount is distributed proportionately based upon the agreed-upon incentive fee-sharing split, although most contractual arrangements include provisions for the owner/licensee to retain some percentage fee until the project is completed.

A.4. Project scope-change controls

Whether a project contractual arrangement is fixed-price or time and materials the owner/licensee and decommissioning contractor needs to have a contract change control policy and procedures in place prior to the start of work. The policy clearly states how changes to the contract scope will be handled, the documentation required, and the necessary approvals secured prior to work being implemented. To facilitate the process, and to eliminate unnecessary work stoppages, the owner/licensee establishes a minimum value of dollars or labour hours such that work may continue and the change order implemented within a set period, i.e. 10 working days. This change order process is critical to maintaining project progress, and in settling disputes amicably without resorting to costly litigation.

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APPENDIX B

FINANCIAL ASPECTS OF DECOMMISSIONING ON SOCIAL ISSUES

The financial aspects of decommissioning facilities that have used radioactive material raise important issues that go beyond the costs of physically removing radioactivity and dismantling/demolishing the facility. There are direct costs for the operator associated with personnel changes resulting from the transition from operation to decommissioning, and ultimately to the complete cessation of all work at the facility. In addition to such direct costs to the operator, decommissioning of a large facility can result in significant indirect economic and social impacts on the surrounding community [B1].

Direct impacts are typically similar to those encountered in other industries and are generally recognized to be the operator's responsibility, for example severance pay, worker retraining, special measures to attract and retain appropriately-qualified staff, and so on. Accordingly, the operator is generally responsible for pay for these direct effects from the decommissioning trust fund.

Indirect impacts include those on the surrounding community as a result of the loss of jobs, reductions in the tax base and impacts on service industries. The responsibility for the costs of these impacts is not necessarily the operator's, but will rest with the local community paid for with the available tax income. Generally, the tax income to the community from the facility undergoing decommissioning will reduce on a sliding scale related to phase accomplishment of the activities. The successful resolution of these issues may be a prerequisite to acceptance of a decommissioning project, and some negotiation between the operator and the local community leaders may be necessary to supplement taxes during the transition. The issues are to be brought to light during decommissioning planning in order to allow political and social decision-making to enable the satisfactory completion of the decommissioning project.

In some cases, facilities were constructed in remote regions of the host country where little or no regional resources of personnel, residences, and local services previously existed. For many of these facilities, entire towns, roads, schools, and fire, police, and hospital services have been constructed to serve the workers. Dealing with this infrastructure while terminating facility operations poses complicated social issues for both the operator and the community.

Depending on the facility and the corresponding infrastructure, two different cases can be identified:

- Facility/site with created local community (NPP, nuclear research centres, etc.), or
- Facility/site without created local community (research reactors, hospital reactors, etc.).

The role of social factors for the first case is very important for successful decommissioning of the nuclear facility. In this case, the final stage of decommissioning and the future of the nuclear site can determine the social needs for decommissioning. Inadequate consideration of social needs can significantly hinder the decommissioning and create political problems to accept the project by the local population.

The impact of the social needs for the second case is smaller since the community was not created specifically because of the facility. Despite this, such factors like unemployment, local municipality tax changes, and staff training for decommissioning must be considered during decision-making for decommissioning.

In assessing the requirements for financial provisions for decommissioning costs, it is generally accepted that direct costs, including such items as costs associated with changes in the operator's workforce, should be included in the cost estimates and financial provisions. Indirect costs are much more difficult to account for, since the owner's responsibility, if any, is generally determined on a case-by-case basis depending on the particular situation at the place and time decommissioning occurs. In some cases, some of these indirect costs may be considered a regional or national responsibility, while in others the owner of the facility may also contribute to their resolution.

B.1. Impacts on purpose-built communities

The importance of safety and protecting the public from potential accidents often drove industry planners to construct their facilities in remote locations. Sometimes the government selected remote locations for national security reasons -- out of sight from potential subversives. Nevertheless, a local infrastructure was constructed or developed to provide the residential and commercial services needed to support workers at these facilities.

B.1.1. Limited-license life of nuclear plants

By regulation, NPPs have a design life of about 40 to 60 years. At the end of that period, the owner/licensee and the regulator must determine whether the reactor vessel has sufficient ductility to continue at operating pressure and temperature without brittle failure. At this time, no NPP has reached that operating duration to deal with brittle failure of the vessel. Most NPPs that have been decommissioned were terminated for economic rather than technical reasons. Because of this limited license life, decommissioning is a planned event, and long term planning allows owner/licensees, communities and the workforce to prepare for the ultimate shutdown of the facility.

B.1.2. Creation of local communities for facilities

Workers were attracted to the remote locations of NPPs and other facilities with the promise of good paying jobs, benefits, and the opportunity to improve their standard of living. The constructors, whether private utilities or government organizations, paid for and constructed roads and even homes, and provided such services as schools, police, and fire fighting equipment, hospitals, etc. Over the years of facility operation, the communities grew and attracted other businesses, such as food and clothing stores, entertainment and recreation facilities, and in some cases other industries.

B.1.3. Potential for non-continuation of nuclear operations at site

Whether for technical or economic reasons, the potential for non-continuation of operations at a nuclear site is a real possibility. Early demonstration (experimental) NPPs were shut down for technical reasons, usually because the technology being demonstrated was not successful or too costly, or because new safety design criteria mandated they be shut down. Later generation plants were shut down in the 1990s because of (1) the negative economics of operation in lower alternative power cost regions where power from hydroelectricity, coal, and natural gas was less expensive, and (2) the then apparent perception that nuclear power could not be made competitive with these alternative sources. However, just a few years later nuclear power is proving it is less expensive than coal and gas fueled generation.

Many other facilities, such as weapons facilities, were shut down following the end of the Cold War period in 1989, and major environmental remediation programs were begun to clean up and dispose of these facilities or put them into long-term safe storage. In most cases, the government (federal and some state) has had to address the resulting social impacts on these communities.

Research nuclear reactors were shut down mainly for economical or technical reasons. Since a research facility in mostly cases needs the state donations, many research nuclear reactors were stopped or shut down. In most cases, the social impact on local communities is insignificant.

B.2. Direct social and economic impacts of decommissioning

Plant shutdown affects both management staff and workers with respect to future employment opportunities. During decommissioning, most owner/licensees attempt to employ as many existing employees as possible to capture their experience and facilitate decommissioning operations. For countries without decommissioning experience and corresponding infrastructure, it is used widely. Since some employees' experience or skill-sets are not adaptable to decommissioning, special consideration to provide job opportunities in the community or elsewhere may be required.

B.2.1. Job training for decommissioning

In anticipation of plant shutdown, many owner/licensees should notify employees of the impending employment termination and take proactive steps to prepare them for the shutdown actions. Those employees needed to support the decommissioning are given specialized training to prepare them for their new responsibilities. This may include sending them to special or related courses so they can virtually step into their new jobs as decommissioning workers when the time arrives. Those not needed to support decommissioning are provided with outsourcing opportunities to interview with potential new employers. Often, these new prospective employers are invited to the nuclear site to set up temporary offices and to interview workers to make it as convenient for them as possible.

Another important aspect of this "social decommissioning" is the need to address organized labour work rules. Most labour unions have strict work rules that prescribe the type of work each worker classification may perform, and no other type of work. Such rules were intended to protect the workers, and to provide steady and reliable work opportunities for the union. In decommissioning, many of these work classifications are no longer needed once the systems are shut down. The skill sets for this type of work are greatly reduced and the broad varieties of work classifications are no longer needed. Most owner/licensees have been successful in negotiating with union leadership for a reduced number of worker classifications, and a mechanism to switch workers from one category to another without violating union agreements. This has been an effective method to maintain productivity without union job actions (labour strikes).

B.2.2. Retention funds to keep key employees on project

Prior to announcing the permanent shutdown of a nuclear facility, management needs to identify those employees who are key to decommissioning operations. These employees are usually offered attractive incentive plans to retain them through specific milestones of the project. These incentive plans are set up so employees earn the incentive annually, but receive only a partial annual payment or no annual payment until the project or specific milestone is complete. It is important to secure these employees prior to shutdown announcement, thereby discouraging them from seeking employment elsewhere. For facilities with a defined annual budget, additional efforts must be spent by decommissioning management to receive appropriate financing support from the government for key employees. Shutdown of the facility results in losses of functions and corresponding financing support.

B.2.3. Severance funds to furlough (terminate) redundant employees

Those employees who are not required to perform the activities for decommissioning are usually offered employment in other parts of the company, or offered a severance package and a specific date of termination. The severance package may be the company standard severance amount, or it may be increased to give full credit for years earned as if the employee had worked until the normal retirement age.

B.2.4. Job re-training for furloughed (terminated) employees

In many cases, companies have provided job re-training, either on site or at special courses offered at local universities and private schools. This re-training is aimed at providing a new opportunity for those loyal employees who have done well but are not needed for decommissioning. Such re-training programs go far in maintaining good relations within the community and the remaining employees. In recent years, the United States of America has seen a rash of wrongful discharge lawsuits. Since these are costly and time-consuming for both the company and employee, any benevolent efforts on the part of the company to avert or diminish these lawsuits would be more cost-efficient.

B.3. Indirect social and economic impacts of decommissioning

As noted earlier, local communities formed by the construction and subsequent operation of the facility are also affected by its decommissioning. Shutting down the facility greatly affects the local community and its long-term survival. The effect is felt on the employment levels, local business and services, schools, police and fire organizations, and on local entertainment facilities.

B.3.1. Local effect on unemployment

For large facilities employing 500 to 1,000 employees, shutdown could result in 500 or more employees put out of work. In most countries, they would be eligible for unemployment insurance payments to carry them until re-employment is secured. However, such unemployment payments are usually significantly lower than the wages and benefits obtained during employment. A high unemployment rate in a community might attract new industries, or it might deter them if it is perceived that the community is not growing and would need significant cash influx from the new industry. These factors often affect a town’s credit rating for borrowing new funds to support public works.

B.3.2. Effect on local service companies

Construction of the facility in a community usually spawns the influx of new service businesses including vendor companies offering such services as office supplies, computer services, copier services, hardware and equipment, specialized machine shop services, security staff and equipment, and plant laundry and uniform suppliers. All such companies will be affected by plant shutdown. The snowballing effect of such loss of services will certainly also affect area unemployment, as jobs for spouses, siblings, and extra income employment opportunities disappear.

B.3.3. Effect on local small businesses

Shutdown of the facility will also affect food stores, restaurants, clothing suppliers, home and personal services, automobile services, and utilities (electricity, water, telephone, cable TV, etc.) that serve the needs of the community residents. If the former employees are forced to leave the community to seek employment elsewhere, these small businesses will also feel the effect of a shutdown.

B.3.4. Effect on schools, police, fire, and hospital services

If many leave the community to seek employment elsewhere, the need for a large school system, police force, fire brigade, and hospital services will also diminish. This may force consolidation of local towns to share such resources, with the consequent inconvenience of having to travel for schooling and hospital services, or risking the response time delay for police and fire services. The secondary effects of loss of jobs for teachers and administrators, police, firemen, and doctors, nurses and administrative personnel cannot be ignored.

B.3.5. Effect on local entertainment businesses

Plant shutdown and unemployment will also affect local entertainment businesses and facilities (theaters, sports arenas, libraries, recreational activities). With reduced income (unemployment insurance income), attendance at local movie and stage theaters will drop off, and perhaps force closure of these sources of entertainment. Sports arenas such as ballparks, soccer fields, skating rinks, etc. are also likely to be affected. Libraries depend on user late fees, donations, and town tax income for survival. These are all subject to reductions following a facility shutdown. Recreational facilities such as on-site fishing and boating access ramps, campsites, hiking trails, picnic grounds will be affected by the reduced income of residents and reduced sources of income from taxes or owner/licensee donations.

B.3.6. Local city or town tax needs and services

Facility shutdown is likely to have a great effect on the contributions to town taxes. Often the owner/licensee is a large contributor to the local municipality’s tax base. Reduction or loss of this income could drive the town into a downward spiraling financial position, jeopardizing its survival. As a result of the loss of tax income, there may be reductions in services and increases in the tax burden on other businesses and on residents.

B.3.6.1. Reduction of tax income from facility licensee

The original local tax basis of the facility may have been established on various bases. One such possibility is on the value of the real estate, and more importantly on the value of the capital equipment and income-generating potential. During decommissioning, the land value remains essentially the same but the value of the capital equipment and income generating potential drops as equipment is removed for disposal. This forms the basis for the owner/licensee to reduce the tax payment to the local community, and consequently reduce the cost of decommissioning. Other forms of local tax base may exist in different countries, but it is generally the case that the value of the tax base will decrease as decommissioning proceeds.

Some owner/licensees have recognized the potential impact on the local town’s tax base and have been proactive in reducing the impact. In some cases where multiple nuclear units exist on the same site where another is being decommissioned, owner/licensees have transferred some of the tax base to the operating units to compensate towns for the tax loss from the shutdown unit. This provides the town with additional time to address replacement of tax income, perhaps by attracting new industries to the community.

B.3.6.2. Reduction of town services

From the town's perspective, a reduction or loss of taxable income from nuclear plant shutdown can only result in reduction of services provided to the community. Town administrative jobs may be reduced, roadway services such as repairs and snow plowing will be reduced, cutting grass in public places such as parks, road dividers, school ball parks, etc. may all have to be reduced. These reductions all begin to affect the quality of life in the community, and become a detriment to new industries locating their facilities in the community.

B.3.6.3. Increased tax burden on residences, businesses

The reduction in tax income from the owner/licensee, and potentially from the terminated workers, places an additional tax burden on other residents to carry the tax load to maintain town functions. Local businesses are usually more heavily taxed in any community, and an increased tax assessment to cover the nuclear plant income tax loss can drive some of the business away from the community to seek lower tax towns and reduce their operating costs. This has the snowballing effect of losing additional job opportunities in the community.

B.3.7. Relocation of residential families

Those former employees who cannot find employment in the local communities may be forced to relocate their families to other regions. This has the impact of disrupting family ties, where offspring who have settled into the community would undergo personal hardship in the uprooting of relationships. Relocation may require selling homes at below their normal market value to generate cash to purchase a replacement home in another community. The secondary effect of numerous homes coming on the market simultaneously is that it drives down the value of homes in the area. This might attract new business if the community is perceived as a growing community. If not, it could be detrimental to the economic survival of the remaining residents.

B.3.7.1. New job opportunities elsewhere

Those employees anticipating facility shutdown before the announcement may seek employment at other facilities in other locations. No one wants to be the last man standing. As mentioned earlier, the potential loss of key personnel is a major issue for decommissioning. From an employee's standpoint, the potential loss of a retention payment may be a small price to pay for a more lucrative position at another company. Locking in that new position in another company before any of the employee's peers may be a decision maker for the employee.

B.3.7.2. Relocation to lower tax communities

Former employees desiring to remain in the general area may relocate to adjoining communities where tax rates are lower and the cost of living is within the employee's income from termination and retirement savings. Nevertheless, the effect on the community is the same as those leaving to seek other employment.

B.3.7.3. Pursuit of same or improved standard of living

Relocation may also be driven by the desire to maintain the same or an improved standard of living. An employee anticipating the social effects discussed in these sections may take the proactive course and relocate prior to, during, or after the shutdown and decommissioning of the facility. The effect on the local community is the same.

B.3.8. Relocation of existing local businesses

Local businesses affected by the plant shutdown are likely to take the same or similar course of action as terminated employees. Businesses thrive on income and growth. Without these two factors, businesses are likely to relocate, causing the spiraling effect on the community.

B.3.8.1. New business opportunities

In some cases, local businesses will relocate to seek new business opportunities in related industries in adjoining communities. In other cases, it may result in business closings and layoffs of local employees and the associated effects on the unemployment rate in the community. The related technologies with possibility to use the infrastructure of former nuclear object must be stipulated.

B.3.8.2. Change of business focus/services/supplies

Some businesses may be able to change their focus and apply the workforces to a new business opportunity. Such changes would be highly site-specific and would depend on the types of services or supplies, the size of the community, the number of other industries present, and the suitability of the workers to change their job functions.

B3.8.3. Lower-tax communities

With the bulk of taxes paid by local businesses following shutdown, remaining businesses will be assessed higher taxes to make up for the shortfall from the owner/licensee of the facility. One solution for the local businesses is to relocate to lower tax communities either in adjoining communities or in other regions. The impact to the existing community will be as discussed earlier.

B.3.9. Attraction of replacement businesses

One way to offset the impact of facility shutdown and closure is for the local community to attract replacement industries. Owner/licensees can be instrumental to assisting town planners in making this happen. Through their own companies, replacement generating stations can be constructed using the existing infrastructure at the site, complete with electrical transmission equipment and power lines, water resources, and a ready labour pool. The value of these nuclear sites for replacement electrical power generation is well acknowledged, and the continued job opportunities for the existing workers would solve many of these social issues. Beyond that, the existing owner/licensee can be influential by working with the town and other industries to promote the relocation of other industries to the community.

B.3.9.1. Short-term/long-term tax advantages

One relatively simple technique to attract new industries to a community is to offer short and long-term tax advantages to the prospective new industry or business. Such low cost incentives can be a major attraction to new startup companies to reduce their cash flow needs during the early developmental period. Longer-term tax advantages can offer the incentive to stay in the community after the industry has matured, and is a means for the community to secure long-term income from its working residents. Such long-term employment virtually guarantees tax income to the town to maintain its services.

B.3.9.2. New low-cost construction loans

Another technique is for the town and owner/licensee to work with the local banking institutions to offer low-cost construction loans to potential new industries. This can be a major incentive for new companies to more effectively use existing capital to concentrate on business development, hire qualified personnel, and market its products or services. Town-backed loans or parental guarantees may be available to secure such low-cost loans for attracting new businesses.

B.3.9.3. Favorable political climate for growth

The town, working with the owner/licensee may be able to offer an attractive political climate for growth in the community. Such climate would be focused on and endorsed by the community leaders to encourage new industries to relocate to the region. Laws controlling operations of the new industry can be a major deterrent if they unduly constrain operations and costs for generating profit. A favorable political climate can be an attractive element in the decision to relocate.

B.4. Cost evaluation of social needs

Owner/licensees, and for that matter regulators, local political leaders, and governmental agencies need to consider the cost effects of decommissioning during each phase of the process. Decisions regarding the strategy to be applied for immediate dismantling or deferred dismantling greatly affect the workers and local communities. Early planning should consider the foregoing issues and evaluate methods to minimize the impact arising from decommissioning.

It is difficult to determine a priori who should be held responsible, and to what extent, for the costs of these indirect impacts. In the case of a facility built in a pre-existing community, the indirect costs may be borne entirely by the community, as would be the case for any other business in the region. In the case of a purpose-built community, it may be decided that the operator should contribute financially to the resolution of the indirect effects. In all cases, however, it is likely that the decision will be finalized only when the facility is shut down, and that the resolution of these issues may be a time-consuming process. It is therefore difficult to include such indirect costs in the financial provisions required to be set aside during the operational stages. Nevertheless, it is important that the indirect cost issues be identified, evaluated, and discussed as early as possible in the planning process for decommissioning, because of the significant impacts they can have on the decommissioning strategy and costs.

B.4.1. Prior to shutdown

As soon as possible after the owner/licensee decides to terminate operations, meetings should be held between the owner/licensee, regulators, local political leaders, and governmental agencies to discuss shutdown options and the impact on the local community. As part of that discussion, the owner/licensee should evaluate the cost impact on the community, taking into consideration the foregoing factors that effect workers, residents, local businesses, and the community at large. Decisions made at this time are critical to the impact on the community, and the cost of each decommissioning alternative can be a determining factor in these decisions.

Several owner/licensees and local community leaders have taken the initiative to start early decommissioning planning even before the plant shuts down. This planning included a Transition Plan to deal with the plant staff and hourly workers with respect to identification of key personnel to be retained, redundant personnel to be terminated, and incentive and severance packages. These Transition Plans also identify the early facility modifications to be made to prepare the facility for decommissioning. Considerations as to the social impact to the community are addressed at least in a preliminary manner.

B.4.2. Immediately following shutdown

Immediately following shutdown, the near-term issues dealing with retention of key employees and termination of redundant employees must be evaluated for the cost impact to the project budget. The cost of re-training existing employees to perform decommissioning activities instead of operational activities should be determined. This determination should include whether it would be more cost effective to contract with an experienced decommissioning contractor to lead the project activities, with the support and oversight of the owner/licensee. These contractors have the experienced personnel, and often some of the equipment, to implement the project. Such turnkey approaches have shown significant cost savings in the past, and the contractors often employ existing personnel to supplement their staff and workers during implementation.

B.4.3. During transition from operations to decommissioning

During the transition from operations to decommissioning, cost evaluations should include the social impacts of terminating employees as they complete their milestones to safely shut down the facility and prepare it for decommissioning. As the realization materializes that the plant will no longer operate, falling morale can affect productivity. Disgruntled workers can be detrimental to the attitudes of other workers, and can lead to the failure to meet safety goals, or even accidents. Management must be keenly aware of these signs, and take extra precautions for additional training and communication with workers and the community. These are subtle costs associated with decommissioning that are not often publicized, but represent a real risk to the owner/licensee and the workers from a safety standpoint.

B.4.4. During decommissioning implementation

Similarly, attention to worker morale is important during decommissioning implementation activities. The costs to maintain worker safety must be considered to prevent the public (local community) from losing confidence in the capability of management to protect the workers and community.

B.4.5. Following license termination and project completion

The facility license termination and project closeout costs must also be considered. This not only addresses de-mobilization of the site, but also the social impacts of the remaining workers joining the unemployed. Owner/licensee attention to these issues can be a strong public relations boost for the company and allow it to leave the site on a positive note.

B.5. Cost analyses

In summary, responsible project planning and implementation may need to address the social impacts of decommissioning. Perhaps this is best accomplished by performing cost analyses for each of the effects addressed in this section. They can be summarized as follows:

- Job effects — Impact to the employees and families
- Social needs — Impact to the community with respect to inability to maintain a customary standard of living
- Town tax needs — Impact on the ability of the town to maintain its services for the remaining residents and businesses
- Primary and secondary effects of residential relocation — Impact on the available tax monies to pay for town services, and the loss of real estate value should numerous homes go on the market simultaneously
- Primary and secondary effects of business relocation — Impact of the loss of local businesses to other communities, and the corresponding loss of attractiveness of the community for new business
- Attracting new businesses — Impact of the potential lack of growth in the community as new businesses hesitate to enter a community where the trained workforce may have relocated elsewhere.

It is not possible to list all the potential impacts or the nature of the cost analyses that should be performed in each case. The purpose of this section was to identify the types of considerations that should be examined and the nature of the impacts that are possible.

B.6. Additional reading

Some additional relevant reading material can be found in the bibliography of this Appendix, all of which are available on the Internet.

REFERENCE TO APPENDIX B

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APPENDIX C

SELECTED EXAMPLES OF FUNDING PRACTICES

C.1. Overview of funding practices in the European Union

C.1.1. Background

Nuclear energy is used for power generation in the majority of the 25 Member States of the European Union (EU). Overall, the European nuclear generation pool is ageing, with the result that the number of power plants that are definitively closed and undergoing decommissioning is steadily increasing. The decommissioning of nuclear plants is set to become an increasingly important issue in the years ahead. It is a fair assumption that more than one third of the 166 reactors currently operating in the enlarged European Union will need to be shut down by 2025.

As regards the mid-term evolution of the EU nuclear industry in the electricity market, there are two opposing trends to be considered. The first one is the progressive substitution of nuclear capacity with traditional sources such as natural gas, complemented with an increasingly important contribution of renewable technologies and energy efficiency measures. The other trend consists of the combined effect of life extension schemes widely implemented in safe and economically viable plants, together with the increase of capacity in some plants from engineered modifications. The future contribution of nuclear energy remains uncertain for the EU-25 energy system, although its share in the electricity generation has remained approximately constant at around 33% between 1990 and 2002. The Green Paper [C1] of the European Commission “Towards a European strategy for the security of energy supply” raised the issue of the position of nuclear energy amongst other energy sources in the European Union. The final report on the Green Paper [C2] concluded that the range of choices available to the Member States has to be as wide as possible. The nuclear option remains open to those EU Member States who would like it.

As regards the plans that the EU countries have for building new capacity, there are several variants. Firstly those countries where nuclear generation remains an open option, like in Finland and France both of which have recently decided to build a new power plant. A second group of countries such as Belgium, Germany, the Netherlands and Sweden have adopted legal decisions in view of the progressive abandonment of nuclear energy and have set out concrete calendars for the closure of the power plants. Others with no currently operational nuclear power stations have started investigating the possibility of using this option.

There are growing signs that the emergence of — and confidence in — an improved and inherently safer design of nuclear plant accompanied by an increasing awareness of environmental considerations could enhance public acceptance and investor interest in nuclear energy.

C.1.2. Decommissioning legal framework in the EU

The nuclear safety policy of the European Community promotes a transparent and harmonized system of regulations and standards across the Union with the aim to provide assurance to the public at large. It enables all players to work effectively towards the common objective of ensuring the safety of the public and the workforce and the protection of the environment both now and in the future. Decommissioning activities must be carried out in a safe and efficient way, in compliance with the national and international requirements.

However, there is no EU common set of rules for the decommissioning of nuclear power plants (NPP). In fact, the only generally applicable European requirement by law [C3] that explicitly mentions the decommissioning of nuclear installations regards the need to perform an Environmental Impact Assessment[1].

The European Community has over the last 15 years actively promoted the application of high safety standards on an international level. Given the concern of the international Community in relation to the first generation Soviet design NPPs deemed not to be economically upgradeable to the required level of safety as well as the exceptional financial burden the decommissioning of such an inherited NPP may represent to a country, not necessarily commensurate with its size and economic strength, the early closure of the Bohunice, Ignalina and Kozloduy NPPs received special attention in the context of the accession negotiations of Bulgaria, Lithuania and Slovakia to the EU. Consequently, the Treaty of Accession of Lithuania, Slovakia [C4] and subsequently that of Bulgaria to the European Union [C5] introduced specific provisions in the context of the early closure of certain reactors. Lithuania committed to the early closure of Units 1 and 2 of the Ignalina NPP; Slovakia, for its part, has committed to the early closure of the Bohunice V1 NPP; Bulgaria, having already closed in line with its commitments Units 1 and 2 of the Kozloduy NPP, committed to the similar early closure of Units 3 and 4. For its part, the Community committed to provide these states with significant financial assistance in support of their efforts to the decommissioning of the respective nuclear power plants and to address the consequences of the early closure and decommissioning.

While the decommissioning of nuclear installations is an exclusive national competence, the national decommissioning funds became subject to discussions in the context of the Directive [C6] on the common rules for the internal market in electricity. The European Parliament expressed its concerns on the possible adverse effects of the misuse of financial resources earmarked for the decommissioning of nuclear plants and management of their waste. Subsequently, the European Commission committed to publish an annual report on the financial resources set aside for decommissioning and waste management activities [C7]. The main points to be investigated in the annual report are the adequacy of these resources; their availability; their use for the purpose for which they have been established; and the transparency in their management. The first report on the use of financial resources earmarked for the decommissioning of nuclear power plants was published in 2004 [C8] (COM(2004)719 Final, ref approved on October 26, 2004). This report includes a summary table on the financial resources set aside for decommissioning by the member states who have nuclear power plants as of 2004. The scope of the report will be extended in future years both in terms of installations covered (from nuclear power plants to all facilities using radioactive material) and countries (from the 14 "nuclear" to all EU Member States). Ultimately, an in-depth up-to-date overview on decommissioning funding practices in the European Union will be at the Community's disposal.

Of course, each country has its own legal framework that covers all the aspects of the life cycle of the nuclear installations, including the compliance with the existing nuclear legislation at the EU level. The Member States and the EU itself are also signatories of international treaties and conventions fostered by the IAEA. Yet it should be stressed that there is a high level of convergence in the contents of the legal frameworks regulating the key

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[1] While a non-binding act, the recommendation on the application of Article 37 of the Euratom Treaty also explicitly requires to describe the decommissioning and dismantling of the installation [C9].

aspects of the end of the nuclear cycle and in particular decommissioning. The key elements of the legal framework for decommissioning, as broadly accepted in the EU countries, are the decommissioning policy, including the creation of specialized organizations and determination of responsibilities; the decommissioning strategy; the decommissioning funding; the waste management, clearance and exemption rules, use of site; and the international agreements.

Last but not least, the methods of decommissioning financing in the various Member States are expected to be harmonized in due course. To that end the European Commission is expected to publish a recommendation on the use of financial resources earmarked for decommissioning.

C.1.2.1. Decommissioning strategies

Decommissioning is a technically complex operation requiring considerable funding. The sums involved are so large that as soon as a nuclear installation's productive life begins the operator has to factor in not just the technological, social and economic components of production costs but also the financial viability of the project as a whole, including the installation's decommissioning. The chosen management strategy will determine the scale of the investment.

Six Member States have opted to decommission nuclear plants as soon as they are shut down. They are Finland, Germany, Italy, Lithuania, Slovenia and Spain. This option requires provision to be made for substantial financial resources to be available as soon as decommissioning work starts.

Four Member States have opted for a strategy of deferred decommissioning. They are the Czech Republic, Hungary, the Netherlands and Slovakia. This strategy does not require sums as large as those needed for immediate decommissioning to be made available as soon as a plant is shut down. Once spent fuel has been removed, the plant is placed in safe storage for several years to allow radioactivity levels to decrease.

Four Member States have not yet opted for a national decommissioning strategy. They are Belgium, France, Sweden and the United Kingdom.

While the above classification may correctly characterize national strategies in general, some exceptions can always be found, in particular in case of a modification or adjustment of the national strategy. Two outstanding examples might be the deferred dismantling strategy as applied to the KWL nuclear power plant in Lingen, Germany and the present re-assessment of the decommissioning strategy of Bohunice nuclear power plant's V1 unit. These examples prove that the selection of strategy is installation and context specific and one single strategy can hardly be applied to all cases.

Whatever strategy is chosen, it is essential to ensure that the chosen mode of management guarantees that adequate financial resources will be available when required.

C.1.2.2. Collection of financial resources

The EU Member States have put in place specific legal provisions addressing the need for financing decommissioning of nuclear installations and for the management of the radioactive waste remaining. The first report [C8] on the use of financial resources earmarked for the decommissioning of nuclear power plants concluded that as a result of the past, the financing of decommissioning is a complex issue, where the existence of various approaches shall be noted. While the existing schemes, though diverse, have been generally working satisfactorily until now, the creation of the internal market has brought an increased need for transparency and harmonization in the management of these financial resources.

Experience with numerous decommissioning projects that have been started in the EU in the last two decades shows that adequate financial resources are available. These installations of all types and sizes, some of which have already reached the final stage of decommissioning involving a wide range of stakeholders, have proven that decommissioning activities can progress in a safe and efficient manner.

Although the national systems vary from one Member State to the other, they all share the polluter pays principle, e.g. that the operator, who has obtained the benefits of the installation, must set aside adequate reserves for covering the estimated costs of decommissioning and related waste management. The reserves for decommissioning and waste management are generally made from periodic contributions from the operators, obtained from charging the consumers from the sale of electricity. Not all the countries have the same system of contributions. In the case of power plants, some operators apply a percent to the kWh sold, while others determine a fixed levy on each kWh. Whatever the modality of contribution to the fund or provisioning the reserves, the level of that contribution is revised periodically (typically every year) to take into account the short-term variables, such as the evolution of the electrical market (prices) and the production of each of the installations.

The goal amount the reserves to be met is revised less frequently (every three to five years), and involves the revision of the estimates of the future costs of decommissioning and waste management. These re-estimates are made in relation to a given strategy or disbursement forecast, also taking into consideration the key financial parameters (inflation, discount rate) and allowing for some long-term contingencies. Whatever the approach, the objective is to reach an adequate level of funds when the time comes to carry out the decommissioning activities.

C.1.2.3. Management of financial resources

Ten Member States have chosen the option of external management, i.e. separate from the accounts of the nuclear operator. They are the Czech Republic, Finland, Hungary, Italy, Lithuania, the Netherlands, Slovakia, Slovenia, Spain and Sweden. This mode of management offers a great transparency and therefore it is easier to verify whether the financial resources are available, adequate and used for the intended purpose. In general, externally managed resources are invested in financial instruments; therefore the prospective return is a factor of the risks taken. The risk taken in terms of the chosen financial investment form is minimized, and consequently only low return levels can be envisaged. Nevertheless, in case the operator goes bankrupt, it offers a good guarantee that adequate financial resources remain present for decommissioning purposes.

In France and Germany, financial resources earmarked for decommissioning are entered in the accounts of the electricity producers in the form of provisions. It means that the same entity, in this instance the nuclear operator, has both financial and technical responsibility, and the resources are managed internally. The latter way of managing financial resources allows their very flexible use. While the combination of financial and technical responsibility may provide good assurance of the faithful management of financial resources, this method does not offer the same transparency as external management. Therefore a considerable effort is needed to make a proper judgment on whether the financial resources are available, adequate and in particular used for the purpose for which they have been established. The return on these financial resources is expected to be higher than those from externally managed funds. Provided the financial resources are traceable and identifiable, this effectively makes the financing of decommissioning cheaper and more efficient. Technically, the options for using these resources are vast and could possibly give rise to anti-competitive practices on a unified electricity market.

Belgium has found an original solution specifically for nuclear power plants. Until 2003 the financial resources were held in the accounts of the nuclear operator [C10]. Since a specific law was enacted in 2003, these resources have been held in the accounts of the nuclear operator in the form of provisions in which the State holds a "golden share", enabling it to enter a veto if it considers that the management of the resources is liable to compromise their security.

In the United Kingdom, the structures and methods of financing nuclear liabilities are being reconstructed. While the situation at British Energy is more complex because of the company's restructuring, liabilities from the nuclear research sites of the 1940s-60s (run by BNFL and UK Atomic Energy Authority) as well as the Magnox fleet of 1960s-70s (run by BNFL) were transferred to the newly created Nuclear Decommissioning Agency (NDA), operational since 1 April 2005. The NDA will not carry out decommissioning itself; its mission is to develop and to put in place an overall and national decommissioning strategy.

C.2. Management of decommissioning funds in Belgium

C.2.1. Background

Seven commercial nuclear reactors of the PWR type are operated in Belgium by ELECTRABEL, leading to a total installed capacity of 5.7 GWe. In Belgium SYNATOM, a private company is the owner of the fuel loaded and unloaded in the Belgian NPPs. The Belgian State has recognized the exclusivity of this company with regard to the management of the nuclear fuel cycle including the management of the spent fuel.

By convention with the Belgian State [C10], since 1985 ELECTRABEL was setting up provisions for the decommissioning of its NPPs. Midyear in 2003, a new law was published concerning the settlement and management of provisions for ultimate decommissioning of the seven NPPs including the management of the spent fuel from these power plants. The provisions will both be centralized at SYNATOM, which has meanwhile been transformed into a 100% subsidiary of ELECTRABEL. The Belgian State owns a golden share in SYNATOM, which is one share that has the power to veto decisions of the major shareholders.

C.2.2. Collection and management of funds

The funds for decommissioning and spent fuel management are charged to the consumer in the selling price of electricity. The funds are collected from the consumers by ELECTRABEL and transferred to SYNATOM.

A Surveillance Committee has been created as a legal entity entrusted with control of the settlement and the management of the funds entrusted to SYNATOM. These Committee activities include the methodology of the settlement of the funds, the investment policy, and the refunding of the invested funds.

The advice formulated by the Surveillance Committee is binding for SYNATOM. With regard to its advice on the existence and sufficiency of the funds for decommissioning and management of the spent fuel, the Surveillance Committee has to follow the unanimous opinion that ONDRAF/NIRAS [C11] has formulated on this matter. The committee is composed of six members, who are:

- the General Administrator of the Administration of the State Treasury;
- the President of the Commission for the Regulation of Electricity and Gas;
- the Director of the Office for the Control of Insurances;
- the Director of the Administration of the State Budget;
- the Director of the Administration of Energy;
- a person designated by the National Bank of Belgium.

The General Managers of the Waste Management Agency (ONDRAF/NIRAS) and the Federal Agency for Nuclear Control (FANC) assist the committee with a consultative vote.

SYNATOM will take over the legal responsibility for decommissioning. The management of nuclear fuel was already its responsibility.

The funding must cover the whole decommissioning and fuel management programmed at the time the NPPs are definitively shut down, i.e. after 40 years of operation. The funding for management of the spent nuclear fuel is being set up annually in proportion to the amount of spent fuel generated. If the accumulated funds are insufficient, the utilities have to provide the outstanding balance to SYNATOM.

SYNATOM may lend to ELECTRABEL, at the market price for industrial credit, the counterpart of up to a maximum of 75% of the constituted funds, as long as the solvency of ELECTRABEL responds to well defined criteria (the indebtedness ratio compared to the company's capital, and the scale of international credit rating). The Surveillance Committee may reduce this 75% ratio if the defined criteria are not met. The remaining 25% of the fund is placed by SYNATOM in assets not linked to the activities of ELECTRABEL, in such a way that the risks are minimized.

SYNATOM has to conserve at any time sufficient cash in the form of liquid or available assets for financing all expenditures during the following three years.

C.2.3. Other nuclear installations

The financial provisioning for decommissioning of nuclear facilities other than commercial power plants is regulated by the law and the royal decree of 1991 [C12], and the law of 1997 [C13] related to the missions of the national agency ONDRAF/NIRAS. The agency has to control the existence and the sufficiency of funds to be set up by the operator or the owner of nuclear facilities and sites contaminated by radioisotopes. Nevertheless, the legal responsibility for building up sufficient provisions and for the management of the funds remains with the operator or the owner. If the agency is of the opinion that the funds are insufficient, the Minister in charge of Energy may enforce the operator or the owner to take the necessary actions based on the recommendations of ONDRAF/NIRAS. The cost evaluations and the mechanism for funding are analyzed by the operator, presented to the agency within the decommissioning plans, and summarized within the questionnaire for the national inventory. Decommissioning and remediation costs, as well as the annual necessary financial funding levels, are re-evaluated every five years.

The financing of the ongoing decommissioning Programmes with no provisions made in the past is provided by annual endowments from the Federal government and contributions from the electricity users.

Until now, four Nuclear Liability Funds have been raised by the federal government. These funds concern the decommissioning and remediation Programmes of the former EUROCHEMIC reprocessing plant, the former waste processing site of the Nuclear Research Centre SCK•CEN, the Nuclear Research Centre sites, and the Institute for Radio-elements.

The National Agency for Radioactive Waste and enriched Fissile Materials, ONDRAF/NIRAS was established by law of August 8, 1980, which was amended by the laws of January 11, 1991 and December 12, 1997. The role of the agency is the safe management of all radioactive waste and enriched fissile material wherever it is produced in the country.

C.3. Management of decommissioning funds in Latvia

C.3.1. Background

The Salaspils Research Reactor (SRR) is a 5 MW(th) pool type research reactor. It achieved initial criticality in September 1961. Decommissioning started immediately after shutdown in 1998. The facility is fully State owned and no decommissioning fund was established. In 1999, the operator was changed (the facility was transferred from the Ministry of Education and Science to the Ministry of Environmental Protection and Regional Development). A near-surface disposal site for radioactive wastes is now in operation in Latvia.

The Government of Latvia allowed the start of decommissioning activities in 1998. First, the initial decommissioning plan was prepared in 1999 [C14] and updated in 2003 [C15]. In October 1999 [C16], the Government accepted the strategy that the decommissioning of the SRR would be a green field condition during the next 10 years. The total decommissioning cost was estimated to be $20 million. The government assigned the responsibility for decommissioning of the facility and the financial mechanism for planned measures to the Ministry of Environmental Protection and Regional Development, and the operator [C16]. The operator is a state company called, The State Radioactive Waste Management Agency (RAPA). In 2004, RAPA was assigned responsibility for both the radioactive waste disposal site and the SRR.

International support for decommissioning of the SRR is a very important factor for promotion of decommissioning activities. The EC, IAEA, Denmark, Sweden and United States of America were counterparts for the following common activities:

- preparation of the initial decommissioning plan;
- safety assessment and installation of physical safety systems in SRR and the disposal site;
- upgrading of the SRR’s systems for decommissioning activities;
- preparation of the dismantling plan for the SRR.

The consulting support of international institutions significantly facilitated the decision made for decommissioning of the SRR, and permitted the optimization of decommissioning expenses. IAEA expert missions and associated transfer of knowledge created the premise for successful decommissioning of the SRR.

C.3.2. Collection and management of funds

Allocation of funds for decommissioning purposes was performed using the following sources:

- a state budget was established subject to acceptance by the Parliament investment project;
- the Environmental Protection Foundation of Latvia using short-term projects; and
- additional financial support from international donors.

For management of decommissioning of the SRR, a steering group was formed in the Ministry of Environment. The steering group reviews and approves the plans each year and defines the budget for planned activities. The state budget is included in state programme 12.05.00 on “Management of Radioactive Materials,” [C17] as part of an accepted investment project on EV69-04 “Decommissioning and Dismantling of the Salaspils Research Reactor"[C18]. Management of the State programme is a responsibility of RAPA.

This financing model makes it possible to execute the decommissioning of the SRR. The main role in decommissioning of a facility is the responsibility of the state, since decommissioning funds do not exist. After shutdown, decommissioning activities can be easily combined into a unique radioactive waste management system. Such an approach gives additional savings that can be used for decommissioning purposes.

State programme on “Management of Radioactive Materials” includes funds for two components:

- The safe maintenance of the disposal site and research reactor (independent component), and
- The decommissioning of the research reactor (variable component).

Such a scheme ensures the safe maintenance of facilities and the decommissioning of the SRR, depending on each year’s funding allocation. This component is sensitive to the political and economic situation in Latvia.

C.3.3. Additional funds for decommissioning of the Salaspils Research Reactor

To ensure the successful decommissioning of the SRR, an upgrade of the disposal site is necessary. The following upgrades will be performed:

- construction of additional vaults for the radioactive waste generated from the decommissioning of the SRR;
- construction of interim storage facilities for long-lived radioactive waste and sealed sources; and
- modernization of the radiation protection systems.

The decision of the government in 2003, “Radioactive Waste Management Concept,” C.3.6 defines all activities and necessary financial resources for the upgrade of the radioactive waste disposal site during the years 2004–2007. A subsidy for the municipality is defined in the Government decision [C19].

C.4. Management of decommissioning funds in Canada

C.4.1. Background

There are 22 commercial CANDU-PHWR nuclear power reactors in Canada, run by four operating companies. Of the four, three are provincially owned utilities: New Brunswick Power (NB Power) operates Point Lepreau in New Brunswick; Hydro-Québec operates Gentilly-2 in Québec; and twelve reactors at the Darlington and Pickering sites in Ontario are operated by Ontario Power Generation (OPG). The eight reactors at the Bruce Nuclear Power Development in Ontario are owned by OPG, but are operated by Bruce Power, Inc., a private corporation, under a commercial lease. Under the terms of the lease, OPG is responsible for all decommissioning planning, implementation, and costs.

In addition to the operating power reactors, there are also three prototype power reactors in Canada. These facilities have undergone initial decontamination and removal of fuel and are now in a state of storage-with-surveillance pending final dismantling. These three facilities are owned by Atomic Energy of Canada Ltd. (AECL), a federal government agency. AECL also owns and operates the Chalk River nuclear research laboratory site, where there is a wide range of facilities from isotope production reactors to radiochemical laboratories. AECL’s Whiteshell Laboratory site is currently being decommissioned.

There is one 5 MW pool-type research reactor at a Canadian university, and five 20 KW SLOWPOKE research reactors at universities and research laboratories. Two other SLOWPOKEs have already been decommissioned and the sites have been released for unrestricted use.

There are several operating uranium mines, uranium processing facilities, fuel fabrication facilities, and isotope production facilities in Canada, and all are privately owned. In addition, a number of sites have radioactive residues from former uranium and radium mining and processing activities that may require further decommissioning work ranging from monitoring and minor maintenance programs to major remediation projects. Some of these legacy sites are under private ownership and some are in government hands.

C.4.2. Regulatory requirements

As authorized under the Nuclear Safety and Control Act [C20], the Canadian Nuclear Safety Commission (CNSC — the nuclear regulatory body in Canada) has placed conditions in licenses for major nuclear facilities in Canada that require the operators to supply financial guarantees for the costs of decommissioning, including costs of management of the radioactive waste from operations and decommissioning. The licenses also include conditions requiring the decommissioning plans, cost estimates, and financial guarantees to be reviewed and updated at regular intervals or as necessary.

The CNSC’s criteria for financial guarantees are described in a regulatory guidance document G-219, “Financial Guarantees for the Decommissioning of Licensed Activities” [C21] The CNSC does not prescribe a particular type of guarantee, but judges each licensee’s proposal on criteria of liquidity, certainty of value, adequacy of value and continuity. Various types of financial guarantee have been accepted, including segregated or external funds, bank letters of credit, and government guarantees.

The financial guarantees referenced in CNSC licenses are fully funded or prepaid. After taking into account discounting where that is appropriate, the financial guarantees must cover the entire costs of decommissioning and of long-term management of spent fuel and radioactive wastes. Therefore, there is no build-up of external funds permitted unless they are supplemented by other forms of guarantee. In effect, this means that the costs of establishing an external fund are treated similar to the capital costs of the facility.

When financial guarantees are in the form of external funds, decommissioning costs may be paid out of the funds as the costs are encountered. The CNSC approves the legal agreements governing the funds, including the general arrangements for disbursements, but does not require approval for individual payments. Licensees are not permitted to make withdrawals or borrow from the funds for purposes other than decommissioning.

When a financial guarantee is in the form of a bank letter of credit, the actual costs of decommissioning are paid out of operating funds, not from the guarantee. The value of the letter of credit is adjusted periodically, usually annually, to take into account the completion of decommissioning work and/or the arising of new decommissioning liabilities arising from changes at the facility, as necessary.

Two types of government guarantee are possible. One is a legal agreement under which a government undertakes to pay a defined amount of money to the CNSC if the licensee for the facility in question fails to meet its obligations. This type of guarantee is similar to a bank letter of credit. The second type of government guarantee is one in which the government in question undertakes to meet the entire responsibility for decommissioning.

C.4.3. Establishing the amounts of financial guarantees

The amount of a financial guarantee is based on a cost estimate from a preliminary decommissioning plan. The regulations require that such decommissioning plans be submitted by applicants for licenses. Once the cost estimate has been reviewed and agreed to by the CNSC, the licensee proposes a financial guarantee that, when accepted, is incorporated into a license condition.

For nuclear power reactors and major research facilities, the decommissioning plans involve extended periods of time, both before decommissioning starts and during the decommissioning itself. Discounted or present-value cost estimates are used to establish the amounts of financial guarantees for these facilities. If a decision is made by the operator to change the decommissioning dates, for example as a result of a decision to close the station prematurely, the operator will be required to make up any change to the financial guarantee caused by changes in the estimated discounted value of the decommissioning costs.

For other facilities where such extended decommissioning time periods are not involved, the financial guarantees are based on non-discounted or constant-dollar costs. In the case of uranium mines, decommissioning costs are not discounted, but post-decommissioning maintenance and monitoring costs for mill tailings are evaluated on a discounted basis, reflecting the long time scales for these post-decommissioning activities.

C.4.4. Financial guarantees in practice

The Ontario provincial government is the only shareholder of OPG, the owner of the Bruce, Darlington, and Pickering stations. OPG has chosen to furnish external funds as the financial guarantee for all of these stations and their associated waste management facilities. The funds are being built up by OPG over a period of approximately ten years. Until they reach a fully funded condition, the provincial government has provided a supplemental guarantee to the CNSC for an amount covering the as-yet unfunded portion of the estimated costs. The provincial government also guarantees the rate of return on the investments in OPG's decommissioning funds.

The financial guarantee for NB Power's Point Lepreau station is an external fund covering the discounted present value of the total decommissioning and waste management costs. In the case of Hydro-Québec, the provincial government has supplied a direct guarantee to the CNSC for an amount equivalent to the estimated total costs of decommissioning and waste management discounted to the planned shutdown date for the Gentilly-2 station.

The federal government has not set aside funds for decommissioning of AECL's facilities, which include two research laboratory sites and three prototype power reactors. The government pays for the decommissioning costs out of budgetary appropriations when the actual expenses are incurred.

The existing financial guarantees for fuel cycle and isotope facilities are mostly in the form of bank letters of credit. For the operating mines in the province of Saskatchewan, the letters of credit are payable to the provincial government rather than to the CNSC, reflecting the fact that the province is the land owner and will be the institution responsible for safety and environmental protection once the mining company finishes operations and is released from its licensing obligations. For a number of legacy waste sites, governments rather than private agencies are responsible for the costs of decommissioning, remediation and/or follow-up monitoring and maintenance, and in these cases, the financial guarantees are usually unrestricted government guarantees.

The decommissioning financial guarantees for research reactors at universities and research facilities other than AECL's include a combination of external funds, bank letters of credit, government guarantees and self-guarantees from universities. This diversity reflects the diverse ownership of these facilities.

C.4.5. Nuclear fuel waste

At any time, the estimated discounted costs of long-term management or disposal of the nuclear fuel irradiated up to that time must be included in the financial guarantees for reactors.

A disposal or long-term management strategy for spent nuclear fuel has not yet been chosen in Canada. The choice of strategy will be made following the process prescribed in the Nuclear Fuel Waste Act [C22], under which the Nuclear Waste Management Organization must present a recommendation to the federal government by November 2005. Until an option is selected, the CNSC has required the operators of nuclear power stations to supply guarantees to cover the costs of the most expensive of the options currently under consideration. At present, the most expensive option, based on discounted costs, is geological disposal, and this is the option that has been assumed for purposes of evaluating the amounts of the financial guarantees.

Under the Nuclear Fuel Waste Act [C22], the nuclear utilities are required to establish and contribute to external fuel waste trust funds in amounts prescribed in the legislation. The financial guarantees to the CNSC and these fuel waste trust funds are harmonized by subtracting the amount of funds accumulated in the fuel waste trust funds from the total required amounts in the decommissioning financial guarantees.

C.5. Management of decommissioning funds in Kazakhstan

C.5.1 Background

Kazakhstan operates 5 nuclear reactors, 4 research reactors and one commercial reactor. The research reactors are in operation; commercial fast neutron sodium cooled BN-350 reactor, which was operated from 1973 to 1998, is being decommissioned. In April of 1999 the Government of Kazakhstan decided it should be permanently shut down and accepted the following strategy of the plant decommissioning [C23]:

- The plant will be prepared and placed into a SAFSTOR configuration;
- SAFSTOR will be for 50 years;
- Final dismantling and site remediation will be performed after the SAFSTOR period.

BN-350 was state owned for the entire period of its operation and shutdown. In 2004 its management was transferred from the State Enterprise Mangystau Atomic Energy Complex (MAEC) into the National Atomic Company "Kazatomprom" (100% state owned). From the beginning of the reactor operation MAEC (Now MAEC-Kazatomprom) was the only operator of the BN-350.

C.5.2 Regulatory requirements

No special regulatory requirements for decommissioning existed in Kazakhstan at the time of the reactor shutdown. In order to create a legal framework for the decommissioning, two Special Technical Requirements (STR) for the BN-350 Decommissioning have been developed [C24, C25] The first one establishes the main provisions of the BN-350 decommissioning process, and the second one lists the requirements for the BN-350 Decommissioning Plan. Recently Kazakhstan developed regulatory documents related to spent nuclear fuel safe storage and transportation, to low- and intermediate-level radioactive waste storage and to sodium processing. A number of Regulatory Documents Concerning BN-350 Reactor Decommissioning have been prepared and consummated [C26–C28].

During the development and implementation of the BN-350 Decommissioning Plan, all project participants are required to act in accordance with the laws, regulatory acts, and normative-technical documentation valid in the Republic of Kazakhstan.

The Government of Kazakhstan has pledged to supplement its own nuclear regulatory basis with the guidance and recommendations of the IAEA in those areas where the regulations of Kazakhstan are not adequate to guide the decommissioning process. However, many specific activities that must be performed in decommissioning the BN-350 reactor are activities with associated hazards similar to those activities encountered while the reactor was in operation. In the absence of explicit decommissioning regulatory guidance, such activities may be carried out in compliance with sanctioned operational rules, provided formal approval by the regulatory agencies is obtained.

The BN-350 operator does not have a general license for the decommissioning. Instead, it has to apply for the licensing of any specific project and to obtain regulator approval after review of the project-specific safety analysis report and environmental impact assessment.

C.5.3 Collection and management of funds

After the collapse of the Soviet Union, the fund, which was gathered during the years of the BN-350 reactor operation and could be used for the plant decommissioning, become unavailable. In order to maintain reactor safety and to start the BN-350 decommissioning process, Kazakhstan Government determined the following funding sources for BN-350 reactor decommissioning:

- Funds of MAEC-Kazatomprom (former MAEC) for the maintenance of important safety systems. These expenses are included in the rate (6.4% from the electricity energy rate), approved by Kazakhstan Antimonopoly Committee;

- Funds of Kazakhstan budget, obtained in the framework of [C29];

- Assistance from donor countries.

The preliminary estimation of the total cost of the BN-350 decommissioning is approximately 500 million US dollars [C30]. The total cost includes the cost of the work, which began in 1999, cost of the activities for placing of the reactor into the SAFSTOR state, cost of the maintenance for the 50-year SAFSTOR period and cost of the final dismantling and site restoration. The cost of the BN-350 decommissioning first stage (placement into SAFSTOR state) is approximately estimated 225 million US dollars [C30].

International support for the BN-350 decommissioning is now a key factor of the BN-350 placement into SAFSTOR status. Main counterparts of this activity are IAEA, USA, EU (through the TACIS projects), UK, and Japan. This activity includes:

- Preparation of the BN-350 decommissioning plan for international peer review;

- Spent fuel handling (including SF packaging and placement for long-term storage);

- Liquid metal coolant handling (including draining and processing of bulk sodium, its placement for long-term storage, and sodium residuals removal from the reactor vessel and circuits);

- Solid and Liquid Radioactive Waste handling; and

- Reactor maintenance (fire equipment, emergency batteries, upgrade of radiation monitoring and safety systems).

All the plan maintenance and decommissioning activities which are being carried out at the BN-350 and its funding are combined in the Plan of Priority Measures for BN-350 Reactor Decommissioning (PPM) [C31]. The funds distributed according to the PPM were governed by an external company KATEP, delegated by Kazakhstan Ministry of Energy and Mineral Resources, from 1999 till 2004. The PPM was reviewed and updated on a biannual basis. At the present time the 5th version of PPM, which covers the period 2005-2006, is approved by Kazakhstan Government. Management of funds during this transition period will be realized by KATEP, according to Kazatomprom requests and approvals. Kazatomptom is taking over the responsibility for decommissioning and prepares the request for funding from Kazakhstan budget.

In order to facilitate information exchange and to manage the funds, received from different sources, a special coordination group for the BN-350 decommissioning was established. It includes representatives from regulator, plant owner, plant operator and other stakeholders, who participated in the decommissioning process funding and implementation. The decisions of the Coordination Group are then approved by the Minister of Energy and Mineral Resources. This group also provides for continuity during the change of the BN-350 owner.

C.6. Management of funds in the United States of America

C.6.1. Background

There are 103 operating power reactors in the United States of America (US) consisting of 68 pressurized water reactors (PWRs), and 35 boiling water reactors (BWRs). There are six power reactors currently undergoing major decommissioning activities, in the planning stages or early dismantling phases of decommissioning. Other power reactors are in safe storage. In addition, several research reactors are currently shut down and in safe storage waiting decommissioning. In some cases, these are located within a heavily used university complex, or in a remote location where there is no pressing need to initiate decommissioning at this time.

These power reactors and research reactors are licensed and regulated for operations and decommissioning by the US Nuclear Regulatory Commission (USNRC). During the mid-1980s, the USNRC promulgated regulations for decommissioning licensed reactors and provided specific guidance on the assurance that adequate funding would be available when decommissioning activities would begin. As noted earlier in the Introduction to this report, several power utility companies were facing or experiencing bankruptcy brought about by the high cost of construction of new NPPs, the new regulatory requirements evolving within the USNRC, and the cost impact of the Three Mile Island (TMI) Unit 2 accident. To guard against licensees declaring bankruptcy and avoiding their responsibility for decommissioning, thereby potentially putting the public at risk for the safety of the facility the USNRC imposed prescriptive measures to assure adequate funding would be available.

The federal government's former weapons facilities complexes also present a large decommissioning liability to be addressed. These government-owned weapons facilities were turned over to the US Department of Energy (USDOE) for decommissioning and remediation. There are also national laboratories located at several sites throughout the United States of America that have research reactors and nuclear materials processing and disposal facilities.

C.6.2. Regulatory requirements

C.5.2.1. US Nuclear Regulatory Commission

The USNRC regulations on decommissioning cost estimates and funding are contained in Title 10 of the Code of Federal Regulations (CFR) Part 50 – 10 CFR 50 [C32], Sections 10 CFR 50.75 and 10 CFR 50.82), and have been further defined and expanded in USNRC SECY-98-164, "Final Rule on Financial Assurance for Decommissioning" [C33]. The Final Rule establishes the following requirements for assuring the funds for decommissioning will be available when the reactor is decommissioned.

In accordance with 10 CFR 50.82(a)(1)(i) [C32], a licensee who has decided to permanently cease operations is required to submit written certification to the USNRC within 30 days of that decision. Once the fuel has been permanently removed from the reactor vessel to the spent fuel pool in conformance with the facility's technical specifications, and a certification of this event has been received and docketed by the USNRC, the Part 50 license will no longer authorize operation of the reactor or allow the movement of fuel into the reactor vessel. This would entitle the licensee to an USNRC fee reduction and would eliminate the obligation to adhere to certain regulatory requirements needed only during reactor operation.

For power reactor licensees, 10 CFR 50.82(a)(3) [C32] states that decommissioning must be completed within 60 years of permanent cessation of operations. Completion of decommissioning beyond 60 years will be approved by the USNRC only when necessary to protect public health and safety. The "Final Generic Environmental Impact Statement (GEIS) on Decommissioning of Nuclear Facilities”, NUREG-0586 [C34], describes alternative methods for decommissioning (DECON, SAFSTOR, and ENTOMB) and the environmental impacts associated with decommissioning of reactors. The licensee may elect to use a combination of DECON and SAFSTOR, such as a partial decontamination of the facility before a storage period followed by the completion of the decontamination. During the decommissioning process, the licensee must comply with all other applicable rules and regulations.

In addition to maintaining reasonable financial assurance for decommissioning, there are requirements related to developing, submitting, and USNRC review of decommissioning cost estimates:

10 CFR 50.75(f)(2) [C32] requires that a licensee “...shall at or about 5 years prior to the projected end of operations submit (to the USNRC) a preliminary decommissioning cost estimate, which includes an up-to-date assessment of the major factors that could affect the cost to decommission”. A licensee must also include plans to adjust funding levels to demonstrate a reasonable level of financial assurance, if necessary, in the preliminary cost estimate.

10 CFR 50.82(a)(4)(i) [C32] requires a licensee to provide “...an estimate of expected costs...” for the activities being proposed in the Post-Shutdown Decommissioning activities Report (PSDAR). The PSDAR will include a description of the licensee's planned decommissioning activities, with a schedule for the accomplishment of significant milestones and an estimate of expected costs. The PSDAR is to be submitted prior to or within two years following permanent cessation of operations. Financial assurance must be (1) the amount of decommissioning funds estimated to be required based on a minimum amount, as currently reported on a calendar-year basis at least once every two years to the USNRC, (2) a site-specific cost estimate, (3) an estimate based on actual costs at similar facilities that have undergone similar decommissioning activities, or (4) a generic cost estimate.

10 CFR 50.82(a)(8)(iii) [C32] requires a licensee to provide a site-specific decommissioning cost estimate within two years following permanent cessation of operations. In addition, 10 CFR 50.75(c) [C32] specifies that the initial certification amount of funds for decommissioning be based on the minimum funding amount (described later) that applicant and licensees must meet. Alternatively, however, a licensee may submit a certification based on a site-specific cost estimate that is equal to or greater than that calculated in the minimum funding amount.

10 CFR 50.82(a)(9)(ii)(F) [C32] requires that a licensee provide "[a]n updated site-specific estimate of remaining decommissioning costs..." as part of a License Termination Plan (LTP), which must be submitted at least two years before termination of the license date.

Licensees of operating nuclear power reactors must provide reasonable assurance that funds will be available to accomplish decommissioning within 60 years from the date of permanent cessation of operations. These requirements ensure that a licensee has financial assurance in effect for an amount that may be more but not less than the minimum funding amount (MFA).

Specifically, this table says that if P equals the thermal power of a reactor in megawatts (MW(th)), the MFA (in millions, January 1986 dollars) is:

For a pressurized water reactor (PWR): MFA = (75 + 0.0088P)

For a boiling water reactor (BWR): MFA = (104 + 0.009P)

For either a PWR or BWR, if the thermal power of the reactor is less than 1200 MW(th), the value of P to be used in these equations is 1200, whereas if the thermal power is greater than 3400 MW(th), a value of 3400 is used for P. That is, P is never less than 1200 nor greater than 3400.

The financial assurance amounts calculated in the above equations are based on January 1986 dollars. To account for inflation from 1986 to the current year, these amounts must be adjusted annually by multiplying by an escalation factor (ESC). This ESC is:

ESC (current year) = (0.65L + 0.13E + 0.22B)

where L and E are the ESC from 1986 to the current year for labour and energy, respectively, and are to be taken from regional data of the US Department of Labor, Bureau of Labor Statistics, and US Department of Labor, Producer and Prices Index [C35, C36], and B is an annual ESC from 1986 to the current year for waste burial and is to be taken from the most recent revision of NUREG-1307, "Report on Waste Disposal Charges: Changes in Decommissioning Waste Disposal Costs at Low-Level Waste Burial Facilities" [C37]. NUREG-1307 is updated from time to time to account for disposal charge changes. In January 1986 (the base year), using disposal costs from the USDOE's Hanford Reservation waste disposal site, L, E, and B all equaled unity; thus the ESC itself equaled unity. Thus, the minimum funding amount (MFA) is:

MFA (in millions, current year dollars) = MFA * ESC (current year)

For example, an 2536 MW(th) boiling water reactor (BWR) decommissioning cost in 1986 for immediate dismantling would have been $126.82 million (97.55 million euros), and in 2002 with the escalation factors applied would be $424.36 million (326.43 million euros). The escalation factor calculation is as follows:

ESC = 0.65 L (1.922) + 0.13 E (1.135) + 0.22 B (8.86) = 3.346

A licensee is required by 10 CFR 50.75(f)(1) [C32] to report, on a calendar-year basis at least once every 2 years, the status of its decommissioning funding.

Although activities in support of decommissioning may occur, no major decommissioning activities (as defined in 10 CFR 50.2 [C32]) may be performed until 90 days after the USNRC receives the PSDAR. The purpose of the 90-day period is to allow sufficient time for the

USNRC staff to examine the PSDAR, to publish notification of receipt of the PSDAR in the Federal Register, to hold a public meeting in the vicinity of the facility to discuss the licensee's plans for decommissioning, and to conduct any necessary safety inspections prior to the initiation of major decommissioning activities.

Ninety days after the USNRC receives the PSDAR, and after certification of permanent cessation of operations and permanent removal of fuel from the reactor vessel, the licensee may begin major decommissioning activities without specific USNRC approval by using the process described in 10 CFR 50.59 [C32] (requires an evaluation be made to ensure there will be no unreviewed safety issues with the proposed activities). Major decommissioning activities are defined as "any activity that results in permanent removal of major radioactive components, permanently modifies the structure of the containment, or results in dismantling components for shipment containing greater than class C waste …". Major radioactive components are defined as "the reactor vessel and internals, steam generators, pressurizers, large bore reactor coolant system piping, and other large components that are radioactive to a comparable degree".

An application for termination of a Part 50 license must include a license termination plan. The license termination plan must be a supplement to the Final Safety Analysis Report (FSAR), or equivalent, and must be submitted at least two years prior to the expected termination of the license as scheduled in the PSDAR.

The licensee's ability to use these funds is dependent on reaching certain milestones in the decommissioning process. This limitation on the accessibility of the decommissioning funds is designed to ensure there are always sufficient trust funds available to place the facility in a safe, stable condition that ultimately leads to decommissioning and license termination. The licensee may use up to 23 percent of the amount (specified in 10 CFR 50.75 [C32]) of the decommissioning trust funds for decommissioning activities prior to submitting a site-specific decommissioning cost estimate. Included in this 23 percent is an initial 3 percent that can be used by the licensee, even prior to permanent cessation of operation, for planning the decommissioning. The remaining 20 percent may be used for actual decommissioning or readying the facility for long-term storage. This 20 percent may be used only after the licensee has submitted the permanent shutdown and reactor defueling certifications, and after the 90-day period following the submission of the PSDAR. The remaining decommissioning trust funds would be available for decommissioning activities after the licensee submits a site-specific decommissioning cost estimate to the USNRC. Section 50.82 [C32] requires the licensee to submit the site-specific cost estimate no later than 2 years after permanent cessation of operation.

The USNRC recognizes that during planning for decommissioning it is necessary to consider activities leading to license termination and the storage of spent fuel. The USNRC also recognizes that many licensees have chosen to accumulate funding for spent fuel maintenance and storage (as required by 10 CFR 50.54(bb) [C32]) as part of the decommissioning trust fund. However, the amounts set aside for radiological decommissioning as required by 10 CFR 50.75 [C32] should not be used for the maintenance and storage of spent fuel in the spent fuel pool, or for the design or construction of spent fuel dry storage facilities, or for other activities not directly related to the long-term storage, radiological decontamination or dismantling of a facility, or decontamination of the site.

C.6.2.2. State public utility commissions

In states where power utilities are regulated, the state public utility commission is charged with the responsibility for determining the amount of funds to be established for decommissioning. The commission generally holds public hearings where the utility will present testimony on the cost for decommissioning, and the amount of funds needed to be collected and deposited in an external trust. A financial institution usually manages the trust and investments may be made in equities (stocks) or secure financial instruments that will earn dividends or earnings to build the fund to levels equal to the escalated decommissioning cost at the time of decommissioning.

C.6.2.3. Non-regulated utilities

In states where utilities are not regulated, the owner/licensee may also place the funds for management by a financial institution, or may retain the funds internally. Usually, non-regulated utilities will determine the amount of funds needed at the time of decommissioning, and establish an internal reserve for that purpose. If the amount in the reserve falls below the projected cost of decommissioning, the utility may either defer the start of decommissioning until the fund balance grow sufficiently, or may add a supplemental payment to meet the minimum required for decommissioning (called a "topping-off payment").

C.6.2.4. US Department of Energy

Funding for the decommissioning of USDOE facilities and remediation of the sites comes from the USDOE budget, which is allocated by Congress annually from the federal budget (collected from taxpayers). In the past, each project submitted its request for funding to accomplish its objectives within the fiscal year. If budget reductions were enacted, the scope of work planned was reduced to match the funding available. In recent years, the USDOE has initiated acceleration programs to clean up these facilities and sites earlier than originally planned. To ensure adequate funds were available, the USDOE identified specific sites as "closure projects," wherein budget funding is established for the entire facility and will extend over the entire period of decommissioning. In that manner, the on-site contractor can commit the resources and subcontracts to implement the program expeditiously without interruption or delay because of funding. This funding approach has proven highly successful in accelerating the projects.

C.6.3. Nuclear fuel waste

The Nuclear Waste Policy Act of 1982 [C38] established that spent nuclear fuel will be stored in an underground federal repository, and the facility was to be operational by 1998. The government has identified Yucca Mountain in the State of Nevada as the site to be developed. The site is being evaluated for adequacy for such storage, but the State of Nevada has sued the government to block completion and use of the facility. Operation of the facility is behind schedule, and nuclear power utilities have had to construct on-site dry storage facilities to store fuel to allow continued operation of the power plants. Many of the utilities have sued the federal government to recover the cost of on-site storage.

Funding for development of the federal facility is collected from NPPs at the rate of one mil (a tenth of a cent) per kilowatt-hour of energy generated. The funds are deposited in the federal treasury. Development and construction monies are authorized annually by Congress to fund work on the site disposal facility. To date, approximately $16 billion has been deposited in the fund to pay for development of the facility. However, the US government has borrowed from this fund to pay for other programs not related to spent fuel storage.

In response to this government delay, a private initiative began to develop temporary off-site surface storage facilities in the State of Utah. Funding for this initiative comes from the utilities that have elected to join in the development of the facility. This initiative is also delayed, due to lawsuits from the State of Utah and Native American tribes against locating this facility on Native American land.

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