Overcoming the Barriers to Implementation of Decommissioning and Environmental Remediation Projects, the CIDER Project – 15160

Horst Monken Fernandes * and Patrick O'Sullivam *
* IAEA - International Atomic Energy Agency

ABSTRACT

Much remains to be done in terms of addressing the legacies from the early development of nuclear energy, including the dismantling of redundant research and fuel cycle facilities, research reactors, and power plants, and the remediation of sites affected by past uranium mining and processing operations. Long-term solutions still need to be found for management of the resulting waste, including development of disposal facilities that meet public acceptance and safety requirements. Some countries are moving forward with dealing with these legacies, and accordingly have built up appropriate technical resources and expertise, but many national programmes still face very significant challenges.

Many are the factors that constrain progress in addressing past legacies. It is recognized the importance of early implementation of decommissioning and environmental remediation (D&ER) programmes in order to safeguard people and the environment from the undesirable effects of ionizing radiation and other hazards associated with these sites. There is also an urgent need to better understand the global status of these activities and to establish mechanisms to analyze and report the barriers impeding the implementation of D&ER programmes, with the aim of outlining actions that may improve the current situation.

The IAEA has thus launched the CIDER Project (Constraints to Implementing Decommissioning and Environmental Remediation) with the broad aim of contributing to improve current levels of performance on D&ER programmes through promoting greater cooperation amongst its Member States and relevant international organizations. This paper provides early results from the first phase of the project. During this phase, a survey on the global situation of D&ER was undertaken in order to better understand why these programmes proceed faster in some countries than in others; to identify major constraining factors that affect the implementation of D&ER programmes and how these impediments might be overcome. The paper aims to address policy-level issues, regulatory aspects, technological aspects, and stakeholder involvement in the decision-making process. In the next phase of the project it is intended that specific actions and/or innovative approaches will be proposed at international, regional, or national levels with the goal of facilitating progress in programme implementation.

INTRODUCTION

Managing the legacies from industrial development has been a challenge ever since the Second Industrial Revolution began during the last half of the nineteenth century. Such legacies need to be viewed as resulting from technological developments that indisputably brought improvements to human living conditions. But these developments took place in circumstances in which the protection of the environment did not have the same importance as it does today. Although the Industrial Revolution resulted in many positive outcomes for society, there were also many negative consequences for the environment, including the depletion of natural resources, increased carbon emissions, general pollution and resulting human health problems [1]. Social consequences of these major transformations in the production mode had also significant social implications. Many of these impacts were left to be addressed by succeeding generations.

The origins of the nuclear industry on a significant scale are closely related to the development of atomic

weapons during and following the Second World War and the very substantial research and test programmes that were associated with these activities. The 1950s marked the beginning of the civil nuclear industry, involving the development of nuclear reactors for the production of electricity in countries with relevant expertise in weapons programmes. This development was promoted by the significant increase in energy demand that also led to the development of different uranium mining projects and the extraction of oil and gas, which has resulted in significant accumulations of naturally-occurring radioactive materials (NORM). The decades after the Second World War also saw an increase in the development of facilities for the production of radioisotopes for medical, industrial, and educational applications. These facilities and residual materials also contributed to the legacy of radioactive materials which now needs to be addressed. During this period the approach taken by the industry to the environmental impact resulting from the industrial projects it was promoting, were similar to the more general situation described above, i.e. environmental impacts of industrial developments were typically regarded as marginal elements of a particular project and decisions on the disposition of waste did not always adequately take into account the potential for contamination of soil and groundwater.
Additional countries began their own nuclear research activities during the 1960s and 1970s, leading to the construction of a large number of nuclear plants for electricity generation. This trend continued until the Chernobyl accident in 1986, which contributed to decisions in many countries to curtail or abandon their nuclear programmes due to public concerns about the safety of the Nuclear Power Plants (NPP's). Other factors also contributed to the decrease in the construction of new NPP's, e.g. the slowing rate of electricity growth, which in many countries declined during the 1980s and influenced decisions about capacity additions throughout the electricity sector. Finally, the high cost of building NPP's and associated financing constraints resulted in significant problems for many developing countries. In these countries a suitable infrastructure and manufacturing capability was not available and therefore there was a higher reliance on imports. Lack of convertibility of many national currencies resulted in greater reliance on loans from foreign banks or institutions [2]. Research programmes associated with military applications of nuclear energy were also reduced in size following the ending of the Cold War at the end of the 1980s .

The coincident policy decisions towards the end of the 1980s to reduce reliance on nuclear energy for civilian and military purposes meant that many nuclear facilities established since the 1950s became redundant. Other facilities and sites associated with the use of nuclear energy, including facilities for the extraction and conversion of uranium and fuel fabrication and reprocessing facilities, also became redundant. The earliest nuclear plants, related to both military and civilian applications, reached the end of their original design lives and many were shut down, although in many other cases the design lives were extended, allowing the plants to continue operation for a further 1-2 decades. Simultaneously, many uranium mining and processing operations that were developed to sustain military programmes were terminated, leaving behind huge areas of contaminated land. These developments meant that sites and facilities existed in many countries which no longer served a useful purpose and which were contaminated at such levels that significant resources were required to ensure the continuing safety of the general public.

The cost of decommissioning a NPP are very substantial [3]. On a global basis, the numbers of disused facilities and sites that present a potential risk to public safety is significant; the expected total cost of dealing with these liabilities, including the cost of decommissioning disused nuclear installations, are expected to be well in excess of a trillion U.S. dollars. If NORM industries that may be associated with significant levels of contamination by radioactive material or that led to the contamination of the environment by natural radionuclides are included, the cost will be still greater. Even in those countries with the most advanced capabilities for undertaking decommissioning and environmental remediation (D&ER), the timeframe for reducing contamination levels at all relevant sites to levels that align with international recommendations is of the order of several decades.

The legacies from past use of nuclear energy are often a state responsibility, e.g., in the case of military applications and in countries where uranium mining and/or electricity production is undertaken by state-owned organizations. In other cases, facilities may be owned by the private sector, e.g., commercial power reactors in countries where electricity production is not undertaken by the state. In the former case, the cost of managing the legacy facilities or sites is charged to the annual state budget. Therefore, in those countries in which the economy is not strong enough to afford the costs of D&ER, these activities are severely restricted unless resources are made available from sources outside the country (e.g. from bilateral or multilateral sources). In the latter case, funds were typically set aside by the operating organization to defray some or all of the cost of decommissioning the facility or remediating the site. But such provisions have often proved inadequate or, in some cases, the funds have been reallocated for other purposes [4].

Given the need to protect the public from risks emanating from sites that are radioactively contaminated, it is of paramount importance that either the contamination is reduced to non-significant levels, or that arrangements are made to maintain institutional control of the site until the contamination is removed or attenuates naturally.

This paper identifies and describes the common constraints that impede progress in D&ER and describes actual experiences and solutions for overcoming these constraints.

THE CIDER SURVEY

The CIDER project started with the implementation of a survey that was designed to collect information on the following categories of facilities:

- Licensed nuclear installations and sites;
- Radioactively-contaminated research and disused defence sites;
- Uranium mining and milling facilities/sites;
- NORM facilities/sites;
- Sites affected by major accidents; and
- Interim waste storage facilities/sites.

The survey was implemented on a web-based platform, CONNECT (‘Connecting the Network of Networks for Enhanced Communication and Training’), which has been developed by the IAEA to facilitate information sharing among people who work on issues related to radioactive waste management.
The survey was structured into three parts: (1) a glossary of terms; (2) general information on current and future decommissioning and environmental remediation programmes in the relevant Member State; and (3) information about the specific barriers faced in the relevant Member State.

The survey results confirmed that Member States have many and varied sites and installations that require D&ER. In general, for most Member States, the major factors that promote the implementation of D&ER programmes are:

- Existence of national policy;
- Availability of regulatory requirements; and
- Existence (or perception) of an imminent risk to the environment.

Regarding the barriers, the survey again revealed similarities between D&ER projects. The main reported barriers were:

- Lack of funding;
- Lack of confirmed site end state;
- Lack of technology;

- Lack of qualified personnel;
- Lack of infrastructure for the safe management of resultant wastes; and
- Lack of national policy.

It has been recognized that technical assistance and creative solutions are necessary to resolve issues in the areas mentioned above. The conclusions of the survey suggest that there are significant potential benefits to be gained from greater collaboration between programmes, including the provision of direct bilateral assistance in some situations and multilateral assistance in others.

It is evident that, in general, ongoing programmes are expected to continue to address current liabilities for the next 50 years or more. For the specific cases of decommissioning and remediation of waste disposal sites, uranium mining and milling sites, and smaller nuclear remediation sites, shorter timeframes - on the order of 15 years - may be feasible in many cases.

OVERVIEW OF CONSTRAINTS THAT POSE BARRIERS TO DECOMMISSIONING AND REMEDIATION PROJECTS

Political commitment is generally a major driving force for implementation of D&ER and, without this, significant progress is unlikely to occur. Even with strong political motivation, constraints of different types may cause delays or impede project implementation and, therefore, these constraints should be identified and available lessons learned should be examined to facilitate more effective planning.

The most significant identified constraints to D&ER may be grouped into four main categories:

1. National policy, legal, and regulatory framework, including:
    a) Lack of national policy;
    b) Lack of regulatory framework;
    c) Lack of ownership/responsibility for legacy sites;
    d) Low national priority (perceived or real); and
    e) Other site priorities; e.g., on-going operations versus decommissioning activities.

2. Financial constraints including logistics, resources and the system for management of the available funds.

3. Technology and infrastructure impediments. This category includes:
    a) Lack of technology;
    b) Lack of quality personnel;
    c) Lack of transportation system for radioactive waste;
    d) Uncertainty or unknown risks;
    e) Complexity of tasks;
    f) Known risk to workers; and
    g) Impact of/on neighbouring sites/areas/countries.

4. Stakeholder opinion/resistance
    a) Stakeholder engagement needs to be addressed and emphasized throughout the lifecycle of planning and implementing D&ER projects.

National Policy and Legal and Regulatory Framework

National Policy

National policy generally provides the basis for development of relevant regulations, and is usually an important precursor for implementation of D&ER programmes. Even in the presence of a fully defined framework including a waste management system and other relevant infrastructure, progress may not be possible without strong political commitment. In situations where the requirement for D&ER is very limited, e.g. a small disused laboratory, D&ER may be undertaken even on the basis of a very limited national policy and associated institutional and legal framework.
Countries with large numbers of contaminated sites should define prioritization mechanisms in their national policy. Prioritization needs to take account of many factors, including:

- Comprehensive risk assessment;
- Availability of resources (both existing and anticipated);
- Decisions on the scope of the D&ER programmes, optimizing benefits and risk reduction; and
- Cost.

Legal and Regulatory Framework

The legislation and regulation with respect to D&ER can be ‘dedicated’ or ‘embedded’ in more wide-ranging national energy (or nuclear energy) policy, legislation and regulations. The requirements can be established at various levels of primary or secondary legislation: in an act, decree, or licence, or even in a guidance document or standard. This will vary from country to country and depends on the national legislative context. The complexity of the required legal and regulatory framework is also dependent on the extent and complexity of the liabilities that exist in the Member State. Consideration should be given to applying a graded regulatory approach that is commensurate with the status of the installation/site to be decommissioned or remediated.

An important pre-requisite for implementing D&ER projects is to have certainty about the identification of the problem owner and about their responsibilities, as well as the responsibilities of other key stakeholders such as the regulatory authorities. This certainty can only be provided via the legal framework, which also needs to define the process for defining the end state or desired result of D&ER projects. Legal requirements provide a significant catalyst for action.
Within the legal and regulatory framework provisions should be made in order to:

- Define adequate criteria for the whole process;
- Review and assess the D&ER programmes;
- Define the role and responsibility of national entities dealing with D&ER;
- Grant permits or other authorizations ;
- Develop and oversee funding mechanisms;
- Provide a waste management system;
- Obtain stakeholder engagement;
- Provide methods to assess the adequacy of remedial actions;
- Establish and implement quality assurance programmes; and
- Impose restrictions on the use of areas post-remediation and establish requirements for monitoring and surveillance programmes.

There are some sites worldwide that have a higher than average likelihood of producing a challenging situation. For example, in the scenario that a site contains two power plants and a decision is made to decommission one of them. The regulatory regime applying to both plants should be different. In that sense, the regulatory body will also have to be prepared to deal with such particularities.

Financial Constraints

Undertaking D&ER generally requires the use of significant resources and is therefore expensive. The cost of a D&ER programme depends on the size of the project, the technology to be used, the project management strategy adopted, and the definition of the end state. Stakeholder demands may cause escalation of costs, e.g. in cases where lower residual levels of contamination or other adjustments are required beyond those envisaged in the original plan. The cost of implementing a D&ER project may increase over time, in real terms, and this needs to be a consideration in lifecycle planning [5].

The responsibility for D&ER lies with the identified problem holder/owner or with the state. Lack of funding may result from problem holders/owners or state authorities not taking appropriate actions in the past to accrue the necessary decommissioning/remediation funds, poor management of available funds, or redirecting reserved funds to address other demands.

Technology and Infrastructure Constraints

In this report, the term technology is used to represent a specific solution or methodology that should be applied in a D&ER project. The term infrastructure is related to all the enabling pre-conditions that are needed so that a chosen technology can be applied; e.g., having access to trained personnel and having an adequate waste disposal route.

Many countries have already dealt successfully with D&ER for different types of facilities and sites under diverse conditions. Therefore, taking benefit from these experiences, a useful approach to executing D&ER would be to select and apply appropriate proven technologies, ensuring there is sufficient infrastructure - including contract management arrangements - to implement them. It is notable that in many cases, especially for decommissioning, the necessary technology already exists and can be acquired and applied to the specific site condition.

Regarding technology for D&ER, there will be a need for decontamination procedures, demolition equipment, waste collection and disposal methods, radiation detection instrumentation, and laboratory facilities, among others. In addition, for environmental remediation, technology selection may need to address site characterization and monitoring, hydrogeological modelling, cover design, and water treatment.

Moreover, an appropriate, well-defined, infrastructure has to be established in a timely manner so that a D&ER project can be successfully carried out, including providing training of personnel to execute and regulate the activities, as well as establishment of auxiliary tools. For example, regarding radioactive waste, it will be very important to establish an infrastructure for handling, conditioning, transporting, and disposing of such materials.

Careful planning of the entire D&ER process with proper re-evaluation is important since it can be time consuming to develop or acquire expertise and establish technologies. Even after a D&ER project is completed, it might be necessary to maintain some of the created infrastructure in order to fulfil long-term

monitoring requirements. It should be noted that the regulatory regime plays an important role in the planning and execution of D&ER, as it will establish requirements for technology needs.
The location of the facility to be decommissioned or the site to be remediated might itself influence the selected end state. This will in turn impact on dose targets, release limits, and levels of stakeholder engagement, e.g. if a site is located in a highly populated area or in an area with high environmental visibility such as close to the sea. There may be additional technological and/or infrastructural concerns connected to these more restrictive conditions.

Stakeholder and Political Challenges

The CIDER survey showed that stakeholder opinion/attitude is an important element of the decision-making process for D&ER projects and can represent a significant barrier to their implementation, e.g. lack of knowledge or education may drive an excessive demand for a potentially unnecessary level of clean-up. Exaggerated perceptions of risk by involved communities can negatively influence decision-making; conversely, the lack of public engagement and proper channels of communication can damage risk perception. Stakeholders with different degrees of understanding of technical and programmatic issues can strongly influence project implementation, both positively and negatively. It is clear that a lack of mutual trust can disrupt any process of negotiation.

The specific barriers in this category will vary depending on site-specific considerations. These include, but are not limited to: the public adopting a NIMBY mind set ('not in my backyard'); limited capability for long-term, effective, public engagement; complexity of procedures for engagement; opposing or conflicting views; lack of national policy and framework; limited access to information; and lack of independent assessment. These constraints and barriers may relate to the problem holder and/or the stakeholders themselves.

STRATEGIES TO OVERCOME BARRIERS AND PROMOTE DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION ETHODS

It is evident that some critical elements can become important constraints in the implementation of D&ER projects. This section describes good practices that can facilitate the implementation of D&ER projects. Careful consideration needs to be given to how these are applied in any particular situation.

Clear Identification of Roles

Roles and responsibilities of national entities dealing with D&ER should be clearly assigned in accordance with national legislation, and in such a way that there will be no duplication or void. Relevant institutions concerned with the management of D&ER include:

1. National government;
2. Local/state governments;
3. Regulatory authorities (and technical support organizations -TSOs);
4. Facility operators and problem owners; and
5. Implementing organizations.

The ultimate role of the national government should be to develop a national policy and establish an effective legal and regulatory framework for the implementation of D&ER, while at the same time protecting present and future generations from the harmful effects of ionizing radiation.
The regulatory body has certain critical functions concerning communication and cooperation with other

governmental authorities (regarding a broad range of environmental, social, and economic factors) and conducting early and intense public consultation regarding direct effects of risks and D&ER activities on population and land-use. It should be noted that substantial changes in organization, funding, staff, and training may be required if a regulatory body that is accustomed only to overseeing small-scale radiation protection problems (e.g. radiological sources, the medical sector) is then faced with large scale D&ER projects.

The facility operator or problem holder, in accordance with national regulations, shall provide D&ER plan to the regulatory body(ies) for authorization before implementation. Furthermore, to fulfil the requirement to cooperate with the D&ER implementing organization, the facility operator or problem holder is responsible for providing technical data, such as an 'as built design' and configuration management data. The facility operator or the problem holder shall remain responsible for safety, security, and safeguards during the entire D&ER process.

The implementing organization's main role is to manage an effective implementation of the D&ER programme. Its responsibilities should include maintaining safety and security conditions during the whole process of D&ER in accordance to the contract and submitting reports to problem owner or operating organization, both periodically during the entire process and promptly in the case of incident and/or accident.

In addition to all of the above entities, consideration should be made to involving the following institutions in D&ER programmes:

- Environmental protection authorities;
- Authorities responsible for industrial safety or for public and occupational health and safety;
- Authorities for planning the use of water resources and land;
- Transport authorities;
- Fire protection authorities;
- Authorities responsible for public liability issues;
- Law enforcement bodies;
- Waste management organizations;
- Organizations with responsibilities for civil engineering structures and buildings, and electrical and mechanical equipment; and
- Other organizations with responsibilities for disaster management or emergency preparedness.

Adopting and Affordable and Graded Approach

Identification of Cost-Effective Strategies

Cost benefit analyses should be conducted and supported by risk-informed technical decisions in determining the strategy for D&ER project optimization. This is particularly important when D&ER projects face important funding constraints.
D&ER projects have to be planned and implemented in such a way that their end-state enables exclusion or at least minimization of future long-term service costs. Monitoring probable contamination left on a non-operational site is generally not as costly as construction, licensing, and operation of a new onsite waste storage facility for D&ER waste if the following factors are taken into account:

- Degradation of waste packages and the facility structures with time;
- Need for efficient and constant security measures;

- Uncertainty of future relocation/transportation routes and final disposal of the waste in terms of cost, timescale, and possible changes in legislative environment;
- Need for future decommissioning of the storage facility with a possible secondary waste stream;
- Difficulties connected with reuse/redevelopment of the site with waste storage; and
- Safety considerations for abnormal events and weather conditions.

In situations of large legacy sites with high levels of contamination, where cleanup to unrestricted use may be extremely expensive and environmentally detrimental, it may sometimes be more environmentally sustainable to construct a waste disposal facility on the site, e.g. as part of an entombment strategy for compact radioactively contaminated structures and/or former waste disposal pits. Properly designed and constructed protective engineering barriers to prevent intrusion and radionuclide migration may achieve the required level of public and environment protection for a long time period, though it should be borne in mind that this option will require long-term institutional control to ensure safety. An analysis of risk and associated cost may be helpful in evaluating the appropriateness of this option.

Graded Approach

The extent of the infrastructure (including facilities, legal and regulatory framework, efforts and resources) put in place by a particular country should be commensurate with the liability that the country faces. Different factors influence the extent of the infrastructure needed: the number and size of the liabilities, their diversity and complexity, and the associated level of risk.

The extent of the infrastructure that will need to be made available for a particular D&ER project(s) will obviously depend on the number of sites and facilities to be remediated and/or decommissioned. In general, this infrastructure requires the existence of waste management equipment, waste storage and disposal facility(ies), sufficient machinery for decommissioning and remediation, tools and instruments for characterization and monitoring, sufficient resources and skilled workers, and a strong, capable, and well prepared regulatory authority to oversee D&ER project(s). If the relevant liabilities in a particular country are not large or complex, or have analogous or almost identical characteristics among themselves, the legal and regulatory framework, and the capacity of the country relating to the preparation, implementation, and oversight of D&ER does not need to be particularly complex. In such situations it would be sufficient to have a limited but reasonable infrastructure to address the liabilities over an appropriate timeframe.

Risk-based Prioritization

Addressing and prioritizing D&ER projects should be fundamentally based on risks, although other conditions, such as the availability of resources and the capability of the different players in D&ER in a certain country, will be important factors to consider. To fulfil this objective, two fundamental premises are required: one is to have a complete inventory of the facilities and sites that could need to be decommissioned and/or remediated (plus their risks and the cost of any alternative solutions), and the second is to establish an appropriate scheme or methodology for prioritization in order to ensure an optimized use of the available resources while appropriately addressing the legacies.

Importance of inventory

A national inventory of the facilities and sites that could need to undergo D&ER will allow a country to establish a baseline of legacies that would later be addressed and evaluated to prioritize their decommissioning and environmental remediation.

It is essential that the inventory is complete, and include all relevant information needed to perform a sound risk assessment and to define the cost of alternatives for decommissioning and environmental remediation. Information about national inventory of facilities and sites in one country should be collected and maintained centrally by an organization nominated by the Government to undertake that role. Although this information will depend on the specificities of the facility or site in question, it should include, as a minimum: physical, demographic, socio-economic, hydro-geological, and environmental data; location; extension; type of facility/activity/site; number, size, and type of buildings, containments, and other structures; type and condition of machinery; description of tailings; number and condition of waste storage facilities or waste dumps; characterization data (type, nature, concentration, and distribution) of hazardous substances (radiological and chemical).

Gathering a complete inventory might be challenging, especially in legacy sites in which records, documents, and drawings might not be available, sites in which a minimum infrastructure (i.e. to carry out on-site measurements) is not in place, sites in remote areas, etc. In these cases, careful analysis of existing information, contacts with local authorities, exploratory missions, measurements, and tests can make up for the shortage of information.

Prioritization and Sequencing Scheme

Once the relevant information has been collected, the competent authorities can elaborate a prioritization scheme, in line with the objectives of the national policy. This should take into account not only the status of the installation or site in question, but also many other factors reflecting the national context, e.g. the availability of resources and expertise, the political strategy with regard to remediation and international relations.

These and other factors influence the sequence of the D&ER projects. For instance, one country could favour the strategy of strengthening skills and increasing knowledge by carrying out simpler projects before undertaking a more complex one. Similarly, a different country could establish a higher priority for projects that have risks that could lead to trans-boundary consequences.

Regardless of the rationale used to define the priorities and establish the sequence scheme, decisions must be based on complete and sound information about the legacy sites, their risks, and their feasible remediation alternatives. Having a complete inventory and a well-founded prioritization and sequence scheme is fundamental to being able to address national legacies. In addition, high-quality project management is vital to be able to undertake successful implementation of D&ER programmes.

Funding Sources

Three main types of funding models have proved effective and are in use in different countries: direct funding from government, internal segregated or non-segregated funds, and external segregated funds.

Funding from government applies when the facility is owned by the state, which is the case for many research reactors and legacy sites. The established mechanism will either pay the costs from the state annual budget, or may contribute to accumulating a decommissioning fund over time.

In the *internal segregated or non-segregated funds* models, the operating organizations are responsible for amassing and managing the financial resources. The segregated model refers to having a separated fund from the operating organization budget, whereas the non-segregated model means that the funds are integrated with the normal budget of the operator. The management of these funds are usually subject to very specific and strict rules to ensure an adequate management and full transparency (i.e. that the funds are used D&ER activities).

In the *external segregated fund* model, the funds are managed externally by a private or public entity, and can be centralized (i.e. to fund all the D&ER activities of a country), or dedicated to each operator. There are several options to raise the necessary funds. This can be done by annual payment during the operational life of the facility, a prepayment before start up, setting aside a fraction of the revenues from the commercial activity of the facility, or paying a levy (or tax) of the benefits of the commercial activity of the operator.

But, regardless the specific advantages and disadvantages of each of the funding models and mechanisms to raise the funds (for instance, an external segregated fund could have advantages with regard to transparency), it is important to emphasize the requirements and risks for adequate funding. Without being exhaustive, to ensure appropriate funding, it is essential to have a complete inventory and an accurate estimation of the cost of the D&ER activities. This depends on a number of factors of which the D&ER strategy is one of the most important. Accurate assumptions about relevant future price inflation, discount rate, value of the asset, shutdown date (including the risk of premature shutdown), etc., are also significant factors to consider when designing efficient and successful funding arrangements.
A thorough analysis of the options, requirements, and risks as described above, together with the characteristics and nature of the D&ER projects to be funded, is needed to select the most convenient funding arrangement for a particular country.

Potential Complementary Funding Sources

Some countries that have been active in the nuclear energy fuel cycle since the 1950s may have little experience of remediation projects. The involvement of international funding institutions can provide access to international expertise and international best practice. Their involvement can also lead enhanced credibility in terms of increased openness and involvement by local communities in environmental remediation activities. If funding provided by these international organizations were not available, it is probable that some countries will have difficulty in mobilizing internal funding to either complete the works at a given site in a timely fashion, or to put into place the required capacity and programmes for technical design, international review, environmental consultation and awareness campaigns to address the necessary remediation measures.

Lifecycle Planning

The project lifecycle refers to a logical sequence of activities from the conception through to the completion of a project, including dealing with any required post-project remediation. Any project, regardless of scope or complexity, will include a series of stages. Those stages are generally described as initiation, planning, execution, and closure. Lifecycle management approaches consider each stage of a project not as an isolated event, but as one phase in an overall lifecycle. Robust and thoughtful lifecycle planning is one of the primary elements that will determine the success of a D&ER project, and transparent and formalized project planning must be undertaken at the outset. By applying good lifecycle planning, there is greater assurance that potential risks that could delay or even prevent the successful completion of the project are identified and addressed prior to project execution.

A critical element of lifecycle planning is the early engagement with stakeholders (including regulatory authorities, local government officials, and interested members of the public). Frequent and transparent communications with stakeholders may help avoid an overly burdensome bureaucracy that can present a barrier to project execution.

D&ER Project Management and Organizational Culture Change

The management and organizational culture required for decommissioning of nuclear facilities and remediation of contaminated sites is different from that for operation of such facilities and sites. Operation is essentially a process based on a reasonably standard routine and training can easily be planned and tested. In D&ER projects, the nature of tasks is constantly changing and as a result more flexibility is required to adapt to unexpected situations. A cooperative attitude is required by management and workers of the organization which is responsible for development and implementation of such projects, as well as by contractors and regulatory authorities, to ensure that lessons learned are openly discussed and rapidly fed back into the system.

Irrespective of the organizational structure, a number of fundamentals must be addressed, including financial commitment, accountability for safety, effective resource management, and innovation:

- Financial commitment: the organization should agree to implement the project within a maximum cost value by a set date;
- Accountability for safety: strict safety and environmental targets are to be set and at no time can these be compromised in order to meet the financial commitment or gain financial incentives;
- Effective resource management: the organization should consider and incorporate effective resource management, including effective communication systems, streamlined contracts and external supplier processes, and responsible demobilization plans as the project facility or site moves from stage to stage and is closed;
- Innovation: The organization should actively seek efficient and creative ways of handling any challenges or even routine tasks associated with a decommissioning or remediation project; and
- Accountability for security: Avoid over classifying equipment or components that are already available for conventional uses to eliminate unnecessary constraints related to regulatory requirements on ‘nuclear’ equipment.

It is also essential to establish efficient interface management arrangements with all stakeholders in order to minimize the socio-economic impact of decommissioning and remediation projects and to create a sustainable future for affected communities.

Communication and Stakeholder Engagement

Good communication strategies will establish trust, cooperation and understanding between different interested parties in D&ER projects. Involvement of affected or interested persons can prevent fear-driven reactions, potentially damaging public response, and the creation of undue expectations or unnecessary anxiety. For all D&ER cases there is a risk that the process will fail if it does not respect the local social, environmental, political, and economic dimensions. This requires open, clear, and agreed-upon lines of communication among stakeholders within a well-defined legal framework. A general recommendation is to involve them at a very early point in the process and throughout the lifecycle of the project. In some cases, public participation in decision-making processes regarding the living environment is mandated by regulatory requirements, environmental policies of international organizations, and more broadly, even by international conventions, particularly the ‘Convention on Access to Information, Public Participation in Decision-making, and Access to Justice in Environmental Matters’ (the ‘Aarhus Convention’). [24]. Therefore, the fundamental goal of stakeholder involvement is to facilitate a consensus between the public, the project owner, and the regulatory agency on an acceptable D&ER approach. It should be borne in mind that the biggest challenge is for stakeholders with a range of technical and social backgrounds to come to some form of consensus on the implementation of ER project. What can be obtained here is informed consent, i.e., the willingness of those initially sceptical to agree upon a course of action based on information provided and assessed over the course of the decision-making process.

Engagement with Political Representatives

D&ER projects may have a high level of political sensitivity, e.g. because of the high costs involved and the potential socio-economic impacts on local communities, including local employment. These projects may therefore be significantly affected by changes in the political environment. Such changes can mean, for example, that projects that once received strong political support are given lower priority and this, in turn, may lead to important changes in the level of funding being provided. Also, requirements with regard to the levels of acceptable environmental impact from projects, or to the anticipated end state, may be changed, resulting in significant changes to the cost and/or timeframe for project implementation.
In general, early engagement of relevant local representatives and political institutions should be a formal part of the early planning and approval phases of D&ER programmes. It is important that appropriate levels of interaction are continued throughout the development of details project plans and their subsequent implementation.

In practice, political influences may be experienced during project implementation and therefore plans should be sufficiently flexible to allow changes in the political environment to be accommodated wherever possible. It may be helpful that risks relating to changes in the political environment are identified during the planning stage and strategies developed to address the identified risks.

CONCLUSIONS

This report presents an analysis of fundamental requirements necessary for the successful implementation of D&ER projects, as well as the factors that may constrain progress, and discusses options for overcoming these constraints and thereby facilitate better implementation. The analysis concludes that fundamental requirements for implementation of these programmes include:

- The existence of an adequate legal, regulatory and funding framework;
- Availability of sufficient funds; and
- Having access to appropriate technologies and the associated human resources necessary for utilization and oversight of these technologies.

Other factors that generally also play an important role are the availability of an appropriate institutional framework, including in particular: facilities for the treatment, transport, and storage or disposal of radioactive waste and spent fuel, and mechanisms for authentic stakeholder involvement in important decisions concerning the programme. The converse of this is that the absence of these factors represents a very severe constraint to programme implementation.

Approaches that will serve to mitigate the identified constraining factors include:

- Undertaking project planning in such a way that takes into consideration the entire lifecycle of the project. Such an approach will give implementers and stakeholders in general a precise understanding of the steps to be taken to complete the project, up to and including post-closure management actions;
- Employing risk-based approaches to decision-making, thus ensuring that the available resources are utilized in the most efficient manner. In this context, an adequate knowledge of the radioactive inventory at legacies sites and facilities to be decommissioned is of paramount importance. A

characterization programme, enabling the inventory to be determined at successively greater levels of accuracy, will facilitate for proper prioritization of the tasks to be accomplished and the apportioning of funds;

- Adopting a graded approach in which the institutional and legal framework is commensurate with the scale of the problems to be addressed;
- Identifying clear roles and responsibilities of the relevant stakeholders (including site/facility owners, implementers, regulators and funding agencies). It is important that all stakeholders understand their responsibilities and have at their disposal the necessary instruments/infrastructure to succeed;
- Sharing experiences, good practices, and lessons learned in comparable programmes through independent reviews; and
- Giving consideration to the potential for bilateral or multilateral support may improve the availability of funds in certain situations. The international donor organizations have an important role in such considerations.

Large D&ER programmes are expensive to undertake and implement and may have significant socioeconomic impacts, both positive and negative, on local communities. Political considerations will therefore often play an important role in determining how quickly a particular programme will proceed. Significant attention therefore needs to be given to addressing these considerations.

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